WOOD & GRIEVE ENGINEERS

Goulburn Hospital Redevelopment

Acoustic Report

Construction Noise & Vibration Management Plan

Main Works

Prepared for:

[redacted]
Hansen and Yuncken

Prepared by:

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1. Introduction

Wood & Grieve Engineers (WGE) have been engaged by Hansen and Yuncken to prepare a Construction Noise and Vibration Management Plan (CNVMP) for the proposed construction works of Goulburn Base Hospital located at 130 Goldsmith Street, Goulburn NSW 2580. The proposed work will involve the construction of a new public medical facility and relocation of some hospital car parks as part of Goulburn Base Hospital Redevelopment Program.

This report addresses the requirements established by the Goulbourn Mulwaree Council for the grant of the construction certificate allowing the work on site to commence.

The main works as described below is expected to occur across approximately 18 months of work. The works are to be split into three periods which are:

1. Demolition
   - Existing building demolition
2. Excavation
   - Shoring
   - Bulk excavation
   - Piling
   - Detailed excavation
3. Construction
   - Construction of the new buildings
4. Fitout
   - Fitout of building shell

Certain tasks will be carried out concurrently with other tasks for particular time periods. In a given combination of events, the noise emitted by performing the tasks simultaneously will be considered.

This Construction Noise and Vibration Management Plan provides:

1. Criteria for the noise and vibration generated during the main works phases.
2. A quantitative assessment of the airborne and ground-borne noise generated by the work for the proposed development and its impact on nearby receivers.
3. Strategies to mitigate the noise and vibration generated during the construction works phases.
4. Complaints handling and community liaison procedures.

This assessment discusses the predicted impact of the construction noise and vibration generated by the construction equipment on the nearest most-affected receivers.

This report has been prepared with the following references:

- Goulburn Mulwaree Development Control Plan (DCP) 2009
- Interim Construction Noise Guideline (ICNG), NSW DECC, 2009
- Construction Noise Strategy, Transport for NSW, 2013
- Noise Policy for Industry (NPI), NSW EPA, 2017
- Assessing Vibration: A Technical Guideline, NSW DEC , 2006
- AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*
- British Standard BS 5228: Part 1:1997 *Noise and Vibration Control on Construction and Open Sites*
- British Standard BS 7358:1993 *Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground-borne Vibration*
- German Standard DIN 4150-Part 3 *Structural vibration in buildings – Effects on structures*

The predicted noise levels are based on the proposed construction program and equipment lists provided in this report.

2. Project Description

2.1 Site Description and Noise & Vibration Sensitive Receivers

The Goulburn Base Hospital is located at 130 Goldsmith Street, Goulburn, NSW 2580. The site is bound by residential properties to the northeast and southeast, Goulburn Aquatic and Leisure Centre to the southwest, and Goulburn High School to the northwest. Refer to Figure 1 for categorisation of all surrounding receivers.

The acoustic issues relating to the development are as follows:

- Noise intrusion from vehicle movements on Goldsmith, Faithful, Clifford, and Albert Street into the developments habitable areas.
- Noise emissions from mechanical plant from the development to the surrounding receivers.

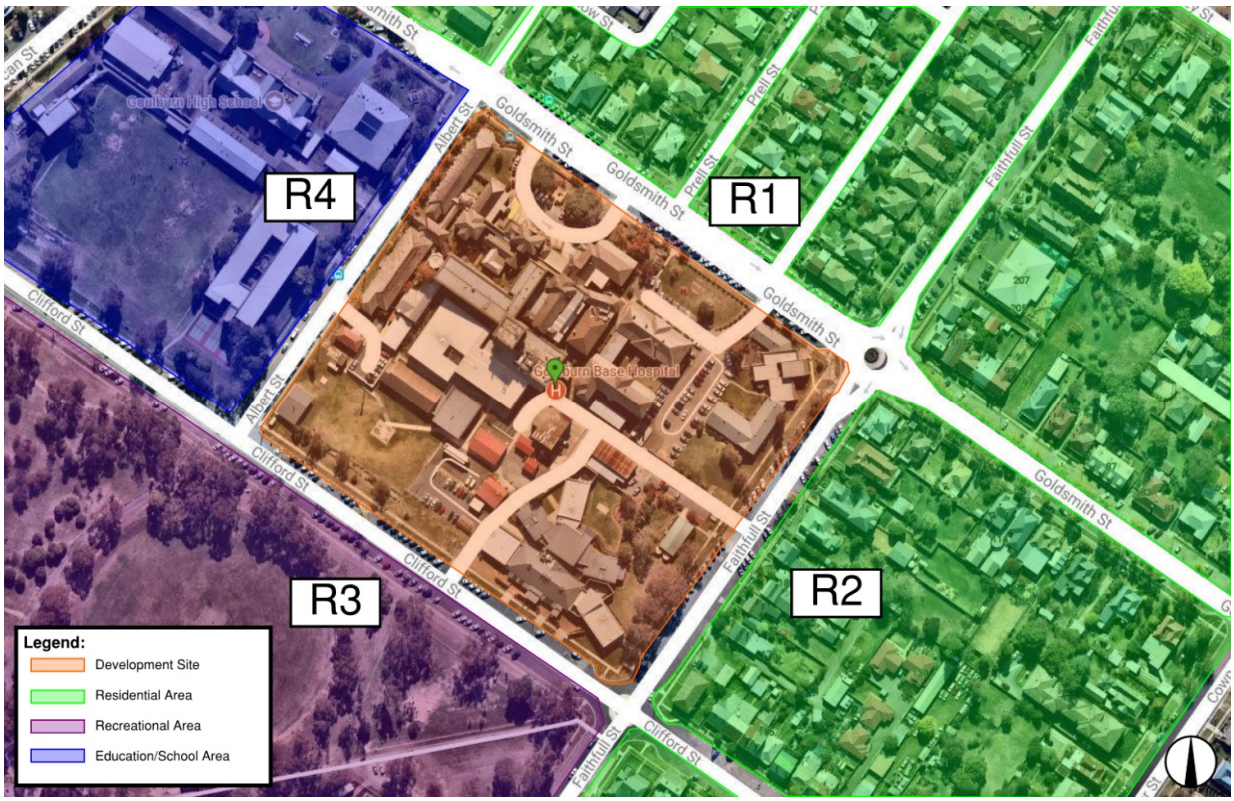
The nearest potentially affected noise receivers are shown in Figure 2 and located as follows:

- R1, Residential properties across Goldsmith Street
- R2, Residential properties across Faithful Street
- R3, Victoria Park recreational area across Clifford Street
- R4, Goulburn High School across Albert Street

Figure 1: Overview of the Site

Source: nearmap.com

Figure 2: Nearest Receivers



Source: nearmap.com

2.2 Existing Noise & Vibration Environment

The existing background noise is typical for a suburban area that has local traffic characteristically intermittent traffic flows with some limited commerce or industry. It can be seen from the decreasing noise levels in the night period and the night ambient noise levels defined by the natural environment and infrequent human activity.

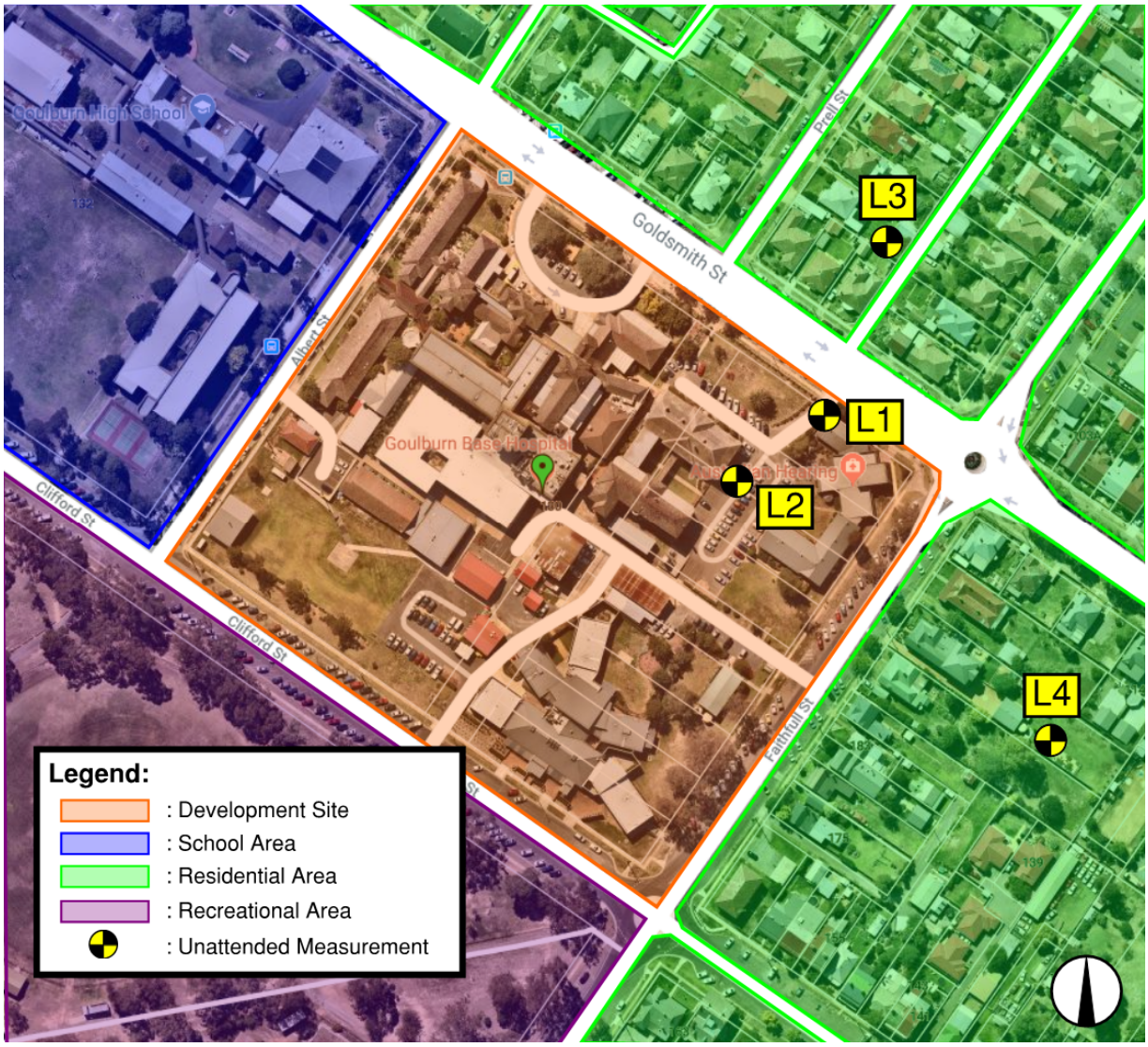
The EPA Noise Policy for Industry (NPI) 2017 requires that the level of background and ambient noise be assessed separately for the daytime, evening and night time periods.

The NPI defines these periods as follows:

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

Noise monitoring locations are illustrated in Figure 3.

Figure 3: Overview of the Site and Measurements Location



Source: nearmap.com

3. Background and Ambient Noise Monitoring

3.1 Instrumentation

The following equipment used to conduct the noise logging:

- Casella CEL-63X Environmental Noise Logger S/N 1488204
- Casella CEL-63X Environmental Noise Logger S/N 4257387
- Type 1 hand-held sound level meter Brüel & Kjær 2250 S/N 2709742
- Brüel & Kjær Sound Calibrator Type 4231, S/N: 2709826

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request. All equipment is of Type 1 accuracy.

3.2 Unattended Noise Survey

Noise loggers were placed at positions L1 and L2 as shown in Figure 3 to measure the traffic and background noise respectively of the area. The loggers were installed from the 9th of December to the 15th of December 2015. Due to bad weather conditions (hail and thunderstorms) forecasted for Wednesday, 16th December 2015, the loggers were picked up one day earlier than the typical noise monitoring period specified on NSW 2017.

Further unattended measurements of background noise were taken from the 29th of August to the 4th of September 2018, at positions L3 and L4 shown in Figure 3.

The traffic noise levels outside the building are presented in Table 1 and the background noise at different locations is shown in Table 2. Residential noise limits for construction and operation phases have been set using the most conservative results for each receiver, measured at locations L3 and L4.

The background noise environment is dominated by traffic noise throughout the majority of the day, evening and night periods. The variation in traffic noise level throughout the day is shown in Figure 4. The variation in background noise level at L3 is shown in Figure 5.

Table 1: Pre-construction traffic noise level

Location	$L_{Aeq,period}$		
	Day	Evening	Night
L1	58	56	51

Table 2: Pre-construction background noise levels

Location	Rated background noise level RBL			$L_{Aeq,period}$		
	Day	Evening	Night	Day	Evening	Night
L2	43	40	33	56	54	48
L3	38	32	30	61	41	40
L4	40	35	30	51	42	43

Figure 4: Long term noise monitoring results at location L1-traffic noise measurement

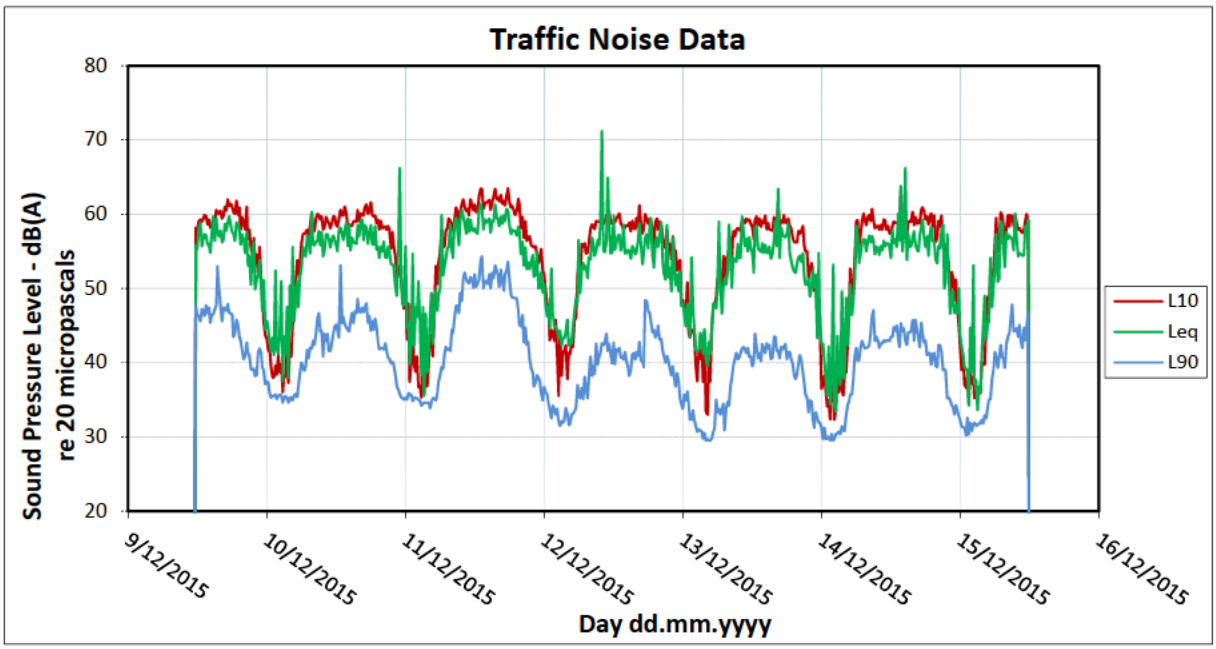
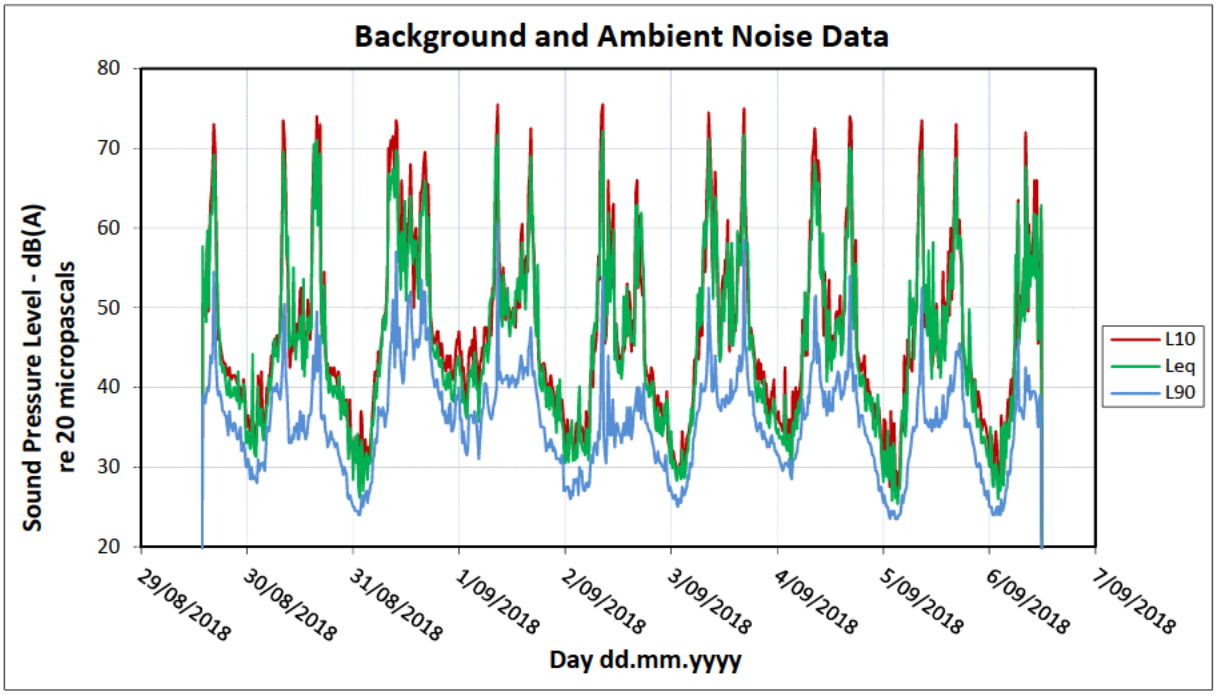


Figure 5: Long term noise monitoring results at location L3-background noise measurement



4. Acoustic Criteria

4.1 Construction Noise Criteria

The *Interim Construction Noise Guideline* (ICNG) by NSW DECC recommends the following standard hours of construction:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sunday and public holidays: no work

In this report, it is assumed that all works are performed during these standard hours.

The noise criteria for residential receivers in the vicinity of construction work and related activities are shown in Table 3, reproduced from Table 2 in Section 4.1.1 of the ICNG. The noise criteria for non residential receivers as outlined in the ICNG (section 4.1.3) is reproduced in Table 4.

Table 3: Construction Noise Criteria at Residences

Time of Day	Management Level $L_{Aeq,15min}$	How to Apply
Recommended Standard Hours	Noise Affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: 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	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2. of the ICNG

Note: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30m 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 4: Construction Noise Criteria for Other 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)
Active recreation, parks	External noise level 65 dB(A)

For recreational areas, the external noise level should be assessed at the most affected point within 50 metres of the area boundary. The Project Specific Construction Noise Management Levels for all receivers are summarised in Table 5.

Table 5: Project Specific Construction Noise Management Levels ($L_{Aeq,15min}$)

Land Use	Receivers	Management Level, $L_{Aeq,15min}$
Residential	R1	38 dB(A) + 10 dB = **48 dB(A)**
Residential	R2	40 dB(A) + 10 dB = **50 dB(A)**
Park	R3	External noise level **65 dB(A)**
Schools	R4	Internal noise level **45 dB(A)**

4.2 Construction Vibration Criteria

Vibration in buildings must be limited both to avoid structural damage and to avoid human discomfort. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of day. The vibration caused by construction works should not exceed the limits presented in Table 6 through Table 9.

4.2.1 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from construction activities that will not damage surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity. The human comfort criteria are also often exceeded before a risk of structural damage.

Structural damage criteria are presented in German Standard DIN 4150-Part 3 *Structural vibration in buildings – Effects on structures* and British Standard BS 7385-2:1993 *Evaluation and Measurement for Vibration in Buildings*. The British Standard BS 7385-2:1993 establishes vibration values for buildings based on the lowest vibration levels above which damage has been credibly demonstrated. These values are evaluated to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as 95% probability of no effect. The aforementioned values are summarised in Table 6.

Table 6: Transient Vibration Guide Values for Cosmetic Damage – BS 7385-2:1993

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial or light commercial type buildings	50mm/s	N/A
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s	20mm/s (50mm/s at 40Hz and above)

Table 7 indicates the vibration limits presented in DIN 4150-Part 3 to ensure structural damage does not occur.

Table 7: Guideline Value of Vibration Velocity (v_i) for Evaluating the Effects of Short-Term Vibration – (DIN 4150-Part 3)

Line	Type of Structure	Vibration velocity, v_i, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100Hz *	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 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 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied.					

4.2.2 Human Comfort – Continuous and Impulsive Vibration Criteria

The guide for vibration limits for human comfort have been extracted from the NSW DECC *Assessing Vibration: A Technical Guideline* (2006). The criteria for continuous and impulsive vibration are summarized in Table 8.

Table 8: Criteria for Exposure to Continuous and Impulsive Vibration

Place	Time	Vibration Acceleration (mm/s^2)			
		Preferred		Maximum	
Continuous Vibration		**z axis**	**x and y axis**	**z axis**	**x and y axis**
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices	Day or night time	0.020	0.014	0.040	0.028
Workshops	Day or night time	0.040	0.029	0.080	0.058
Impulsive Vibration		**z axis**	**x and y axis**	**z axis**	**x and y axis**
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices	Day or night time	0.64	0.46	1.28	0.92
Workshops	Day or night time	0.64	0.46	1.28	0.92

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. The criteria applicable when considering periods of intermittent vibration are presented in Table 9.

Table 9: Acceptable Vibration Dose Values for Intermittent Vibration (1.75 m/s)

Location	Daytime		Night time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
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

5. Construction Noise Assessment

5.1 Proposed Construction Activities

In this assessment, the noise impact from the main construction works are considered. In the absence of the detailed construction schedule, the following stages have been assumed:

1. Demolition
   - Minor demolition works not completed during the early works phase
2. Excavation
   - Shoring
   - Bulk excavation
   - Piling
3. Construction
   - Construction of the new building
4. Fitout
   - Fitout within building shell

The hours of work are expected to occur during standard daytime hours, as follows:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sunday and public holidays: no work

5.2 Expected Construction Equipment

The noise sources assumed to be associated with the works listed above are presented in Table 10. The equipment noise levels have been extracted from AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*.

Table 10: Construction Equipment Noise Levels

Stages	Equipment	Quantity	Sound Power Level dB(A)
Demolition	Jack hammer	1	121
	Powered hand tools	3	102
	Truck	1	107
Excavation Phase 1	Excavator with hydraulic hammer (20t)	1	115
	Truck	1	107
	Bulldozer	1	108
	Skid steer/tracked loaders	1	105
Excavation Phase 2	Piling Rig	1	111
	Truck & Dog	1	107
	Vibrating rollers (pad foot and smooth drum)	1	105
	Concrete line and boom pumps	1	106
	Concrete trucks (agitators)	1	109
	Concrete pencil vibrators	1	100
Construction Phase 1	Concrete line and boom pumps	1	106
	Concrete trucks (agitators)	1	109
	Concrete pencil vibrators	2	100
	Powered hand tools	2	102
	Fork lifts/Manitous/Telehandlers	1	106
	Truck	1	107
	Tower Crane	1	105

Stages	Equipment	Quantity	Sound Power Level dB(A)
Construction Phase 2	Powered hand tools	2	102
	Fork lifts/Manitous/Telehandlers	1	106
	Truck	1	107
	Tower Crane	1	105
Fitout	Fork lifts/Manitous/Telehandlers	1	106
	Truck	1	107
	Powered hand tools	4	102

5.3 Noise Model

To assess the noise impact from the site during the various stages of construction, a noise model was developed in the commercial software SoundPLAN v8.0. SoundPLAN is a comprehensive software package used for estimating environmental noise impacts. Using the software, a 3D model of the site and its surroundings was constructed, including the nearby buildings and the relevant noise sources associated with each stage of construction. Within the model, the effects of the environment (built and natural) on propagation of sound were taken into account to estimate the resulting noise effects on the surrounding receivers.

The noise model represents the 'reasonable' worst case periods of construction activities, assuming that all equipment listed within each phase in Table 10 is operating simultaneously during a 15-minute observation period.

The following assumptions were made within the model:

- The predicted noise levels at the nearby receivers have been assessed with the acoustic recommendations in Section 7.1 implemented. This includes erecting a three metre noise barrier as outlined in Appendix B of this report
- The noise barrier is to enclose all equipment associated with construction, including mobile machinery such as trucks
- The predicted noise levels represent the worst case scenario for each receiver
- All sources and receivers have been assumed to be 1.5m above ground level
- The noise levels have been assessed using neutral weather conditions

5.4 Construction Noise Results

Noise modelling has been conducted for the excavation, construction, and fitout stages of the main works. Due to the minor scale and brief duration of demolition during the main works stage, demolition works have not been formally included in the modelling. However, noise management levels are likely to be exceeded for any works conducted in close proximity to residential receivers, or using especially loud equipment such as jackhammers. Where this occurs, the following recommendations should be considered to minimise community disturbance:

- Works should be performed between 10am and 4pm
- Works should include respite periods as per works program

The predicted construction noise levels at each receiver during the remaining stages have been presented in Table 11 to Table 15. Noise contour maps for the proposed works are shown in Appendix B of this report.

Table 11: Predicted Noise Levels – Excavation Phase 1

Excavation Phase 1					
ID	**Receiver**	**Predicted Noise Level $L_{eq,15min}$ dB(A)**	**Noise Management Level at The Façade $L_{eq,15min}$ dB(A)**	**Noise Management Level Exceedance (dB)**	**Compliance With Highly Noise Affected (<75db(A))**
R1	Residential	56	48	8	Yes
R2	Residential	56	50	6	Yes
R3	Victoria Park	49	65	-	Yes
R4	Goulburn High School	<48	70[1]	-	Yes

Note: 1. Assumes a 25dB(A) loss through the façade of the classroom with windows closed.

Table 12: Predicted Noise Levels – Excavation Phase 2

Excavation Phase 2					
ID	**Receiver**	**Predicted Noise Level $L_{eq,15min}$ dB(A)**	**Noise Management Level at The Façade $L_{eq,15min}$ dB(A)**	**Noise Management Level Exceedance (dB)**	**Compliance With Highly Noise Affected (<75db(A))**
R1	Residential	52	48	4	Yes
R2	Residential	52	50	2	Yes
R3	Victoria Park	48	65	-	Yes
R4	Goulburn High School	<48	70[1]	-	Yes

Note: 1. Assumes a 25dB(A) loss through the façade of the classroom with windows closed.

Table 13: Predicted Noise Levels – Construction Phase 1

Construction Phase 1					
ID	**Receiver**	**Predicted Noise Level $L_{eq,15min}$ dB(A)**	**Noise Management Level $L_{eq,15min}$ dB(A)**	**Noise Management Level Exceedance (dB)**	**Compliance With Highly Noise Affected (<75db(A))**
R1	Residential	52	48	4	Yes
R2	Residential	51	50	1	Yes
R3	Victoria Park	<48	65	-	Yes
R4	Goulburn High School	<48	70[1]	-	Yes

Note: 1. Assumes a 25dB(A) loss through the façade of the classroom with windows closed.

Table 14: Predicted Noise Levels – Construction Phase 2

Construction Phase 2					
ID	**Receiver**	**Predicted Noise Level $L_{eq,15min}$ dB(A)**	**Noise Management Level $L_{eq,15min}$ dB(A)**	**Noise Management Level Exceedance (dB)**	**Compliance With Highly Noise Affected (<75db(A))**
R1	Residential	48	48	0	Yes
R2	Residential	48	50	-	Yes
R3	Victoria Park	<48	65	-	Yes
R4	Goulburn High School	<48	70[1]	-	Yes

Note: 1. Assumes a 25dB(A) loss through the façade of the classroom with windows closed.

Table 15: Predicted Noise Levels – Fitout

Fitout					
ID	**Receiver**	**Predicted Noise Level $L_{eq,15min}$ dB(A)**	**Noise Management Level $L_{eq,15min}$ dB(A)**	**Noise Management Level Exceedance (dB)**	**Compliance With Highly Noise Affected (<75db(A))**
R1	Residential	48	48	0	Yes
R2	Residential	<48	50	-	Yes
R3	Victoria Park	<48	65	-	Yes
R4	Goulburn High School	<48	70[1]	-	Yes

Note: 1. Assumes a 25dB(A) loss through the façade of the classroom with windows closed.

5.5 Recommendations

Based on the results of this assessment, the following observations were made:

- Residential receivers R1 and R2 experience noise levels slightly above the noise management level but below the highly affected noise level during all stages when the proposed noise attenuation wall is installed
- The highest noise levels are expected during excavation phase one. Lowest noise levels are expected during the fitout stage.
- To reduce the effect of noise on the community during excavation stage, screw pilers should be used in preference to impact pilers
- To reduce the impact of noise on the community during construction and fitout stage the northwestern section of façade (facing R1) should be installed first, followed by the northeastern façade (facing R2)

6. Construction Vibration Assessment

The vibration intensive plant that are assumed to be used in each of the construction stages are:

- Rotary Bored Piling Rig
- 20t Excavator (with hammer)
- 30-40t Excavator (with hammer)

The Transport for NSW's *Construction Noise Strategy* (2013) provides safe working distances for vibration intensive plant and are quoted for both "cosmetic" damage (in accordance with BS 7385) and human comfort (in accordance with *Assessing Vibration – a technical guideline*). The recommended safe working distances for each of the plant listed above are provided in Table 16.

Table 16: Recommended safe working distances for vibration intensive plant

Plant Item	Safe Working Distance (metres)	
	Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Pile Boring	2m (nominal)	N/A
12 to 18t excavator	7m	23m
18 to 34t excavator	22m	73m

The nearest sensitive receivers are the residential premises across Goldsmith and Faithfull Street. Both are located at least 25m from the site boundary and are therefore within the safe working distance for cosmetic damage and human response if excavators under 18t are used. If excavators heavier than 18t are used, the threshold for cosmetic damage will not be exceeded however there may be some community reaction to vibration.

It is also important to note that there are several heritage-listed buildings currently located within the Goulburn Hospital Campus. In order to prevent any structural damage to the heritage-listed buildings, the safe working distance should always be maintained and attended vibration monitoring should be conducted at the commencement of excavation work in order to verify the safe working distances. If the levels are compliant with the vibration limits as listed in Section 4.2, then work may proceed based on the implementation of the measures as detailed in this report. If there are exceedances, reasonable and feasible mitigation measures and additional vibration monitoring should be conducted. The measures to prevent cosmetic damage to surrounding structures are provided in Section 7.

When the safe working distance cannot be achieved, continuous vibration monitoring should be conducted in order to ensure that the vibration caused due to the redevelopment program will not affect the surrounding sensitive receivers.

7. Noise & Vibration Management Strategies

7.1 Project Specific Recommendations

Project specific recommendations and required mitigation methods have been listed below. For further noise mitigation and management measures refer to Section 7.2 in order to comply with the standards outlined in this report.

7.1.1 Noise

The excavators with the hammer attachment are predicted to produce the highest noise levels during the main works phases. Methods should be sought to manage the noise emanating from the construction site to the surrounding most affected sensitive receivers, being the residential receivers at R1 and R2.

A three metre high sound attenuating barrier should be erected along the site boundaries as per Appendix B of this report. The construction of the barrier should be without gaps and cracks, and should be comprised of acoustically suitable materials such as 17mm thick plywood. The barrier is expected to reduce noise levels at the residential premises directly across Goldsmith Street and Faithful Street by 3-6dB. Locating site amenities on top of the barrier further increases its effective height and shielding capability. It is also recommended that a hoarding be erected around the whole site to decrease the noise levels within Goulburn Hospital Campus.

In addition to the sound attenuating barrier, at least one respite period of an hour from 12:00pm – 1:00pm should be offered per day during the most intensive periods of hammering and rock breaking. More details regarding communication with the community can be found in Section 7.3.

7.1.2 Vibration

Due to the close proximity of demolition works to the existing hospital buildings (including the heritage-listed buildings), there may be exceedances of the cosmetic damage and human comfort criteria. Prior to the use of the excavators with rock breakers, attended vibration measurements should be conducted to determine if there is an exceedance of the vibration limits set out in Section 4.2.

Upon any exceedances in vibration levels, reasonable and feasible measures should be considered to lessen the impact, such as alternative means of excavating or reducing the capacity of the excavator to achieve a safe working distance.

In order to further diminish the vibration impact, the respite period recommended for noise impact reasons should also apply for vibration.

CFA piling and other activities are not expected to result in the exceedance of vibration limits to the surrounding residential receivers, provided the safe working distances are complied with.

7.2 General Acoustic Recommendations for Construction

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 the spread of noise and vibrations to the potential receivers.

7.2.1 Noise

Figure 6 demonstrates the preferred order of actions taken to mitigate excessive construction noise emissions. If a process that generates significant noise levels cannot be avoided, the amount of noise reaching the receiver should be minimized. Two ways of achieving this are to either increase the distance between the noise source and the receiver or to introduce noise reduction measures such as screens. 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 transportable can be effective barriers).

(c) Constructing barriers that are part of the project design early in the project to introduce the mitigation of site noise.
(d) Installing purpose built noise barriers, acoustic sheds and enclosures.

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. A few of these methods have been introduced below.

Figure 6: Noise Mitigation Management Flow Chart

Screening

On sites where distance is limited, screening of noise may be beneficial or even the only way to reduce construction noise impacts on the nearby receivers. Below, screening options for various situations have been introduced. Constructing and utilising these screening methods should be taken into account already during the planning stages.

Temporary buildings: One option to introduce screening is to position structures such as stores, storage piles, site offices and other temporary buildings between the noisiest part of the site and the nearest dwellings. Due to shielding provided by these buildings, some of the noise emission from the site can be reduced. If the buildings are occupied, however, sound insulation measures may be necessary to protect site workers inside the buildings.

Hoarding: Another way of implementing screening is to build hoarding that includes a site office on an elevated structure. This option offers superior noise reduction when compared with a standard, simple hoarding. The acoustic performance is further enhanced when the hoarding is a continuous barrier.

Partial building structures: On some sites, partially completed or demolished buildings can be used as noise shields for certain equipment. A noisy, stationary plant can be placed 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 also 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 efficiency when operating the equipment.

Earth mounds and embankments: Where constructing noise barriers and using partial building shells is not practical, 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 any noise sensitive areas from the plant. These mounds can often be designed into the construction schedule or site arrangement for future landscaping.

Long, temporary earth embankments can provide quite an 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 like this may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

Where earth noise barriers are not practical due to lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any equivalent material in surface density.

Equipment operating 24h: When it comes to water pumps, fans and other plant equipment that operate on a 24-hour basis, they may not be an irritating source of noise during the day but can be problematic at night. They should therefore be effectively screened by either situating them behind a noise barrier or by being positioned in a trench or a hollow in the ground. Again, generated reverberant noise must be minimised and adequate ventilation should be ensured.

General remarks:

In many cases, it is not practical to screen earthmoving operations effectively, but it may be possible to partially shield a construction plant at the early stages of the project with protective features required to screen traffic noise.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and the receiver, and the material of which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected by at least ten times the shortest distance from the said property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend beyond the direct line of sight between the noise source and the receiver by 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 already predominantly located within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Crane (diesel operated)

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

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 alternative warning alarms 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 neighbourhood.

(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, provided that 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.

7.2.2 Vibration

Vibration can be more difficult to control than noise, and there are few generalisations 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 building components that had previously been in a stable state.

During the demolition works and the erection of new structures, some vibrations (transmitted through the structure from the demolition sites) are expected, being more of a concern for the surrounding sensitive receivers. Vibrations can also trigger annoyance, which might get elevated into action by occupants of exposed buildings, and should therefore be included in the 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 more 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 are recommended when they are relatively close, depending on the magnitude of the source of the vibration or the distance associated. Relatively simple prediction methods are available in textbooks, codes of practice and standards, however, it is preferable to assess site transmission and propagation characteristics between source and receiver locations through measurements.

Guidance for measures available for the 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 the control of vibration follows a similar approach to that of noise: 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 plants (pumps and compressors), portable plants (jackhammers and pavement vibrators), mobile plants, pile-drivers,

tunnelling 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 when considering the noise propagated from piling.

7.3 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 Goulbourn City Council 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 Goulbourn City Council.
e) Goulbourn City Council 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 complainant
  - 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 complaints will be reported to both Goulbourn City Council and the Contractor. 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.

7.4 Noise & Vibration Monitoring Strategy

7.4.1 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

Both of these approaches are elaborated below.

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, telling them when the noise and vibration criteria are exceeded. Thus, the selection of alternative method on construction or equipment selection is allowed in order to minimise noise and vibration impacts.

Long-term monitoring

Similarly to short-term monitoring, long-term monitoring provides real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded. Instead of someone being on site measuring, noise and vibration loggers are used.

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 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.

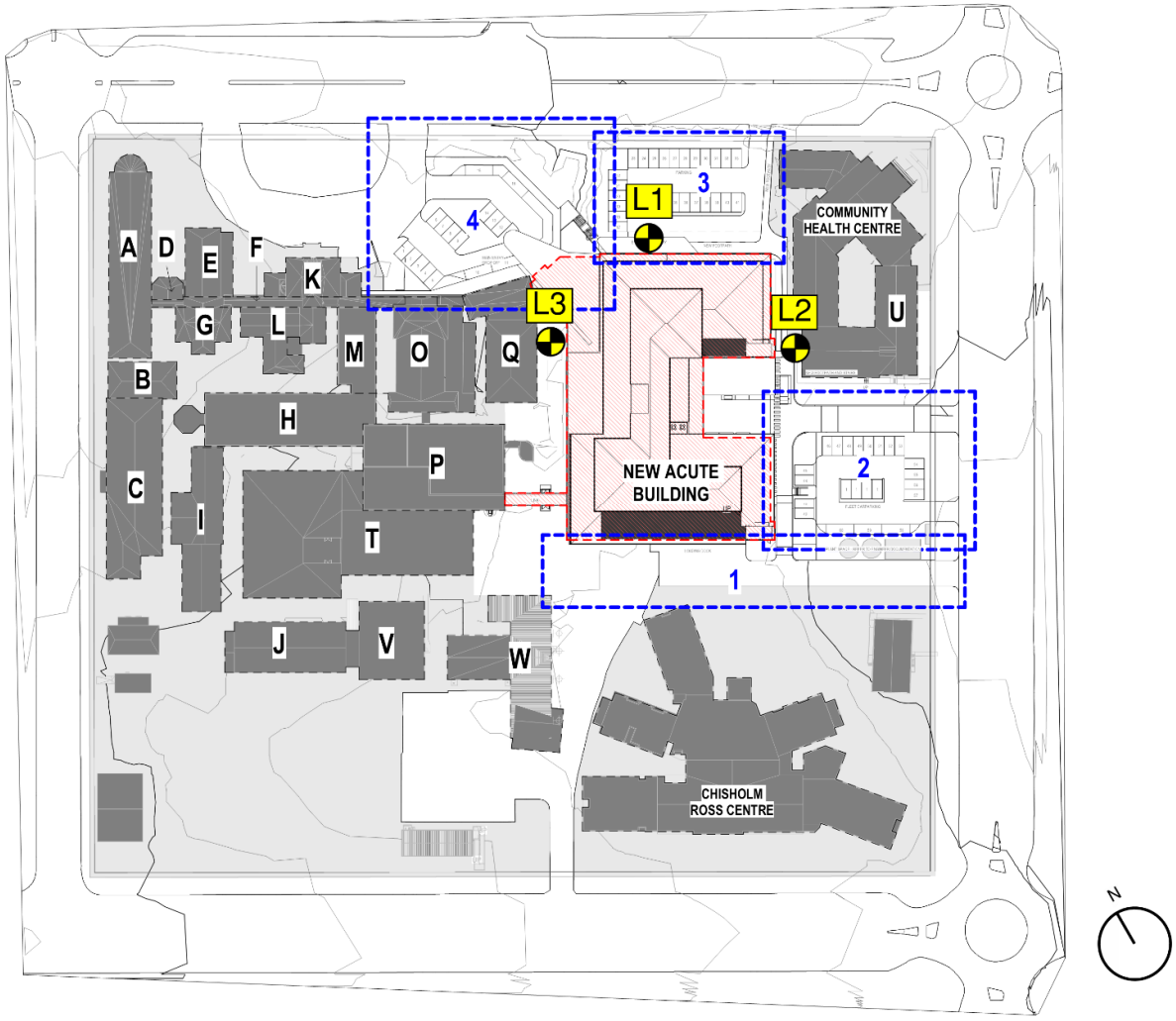
7.4.2 Noise & Vibration Monitoring Program

In order to ensure that the noise and vibration criteria been made, the following monitoring program is proposed for this project. Refer to Figure 7 for the approximate monitoring locations:

1. Attended vibration monitoring during use of the excavator at positions L2 and L3 at the start of the excavation works.
2. Unattended noise monitor installed at position L1 and L2 from the start of the works until the ground level slab is laid.
3. Attended noise monitoring at L1 and L2 during all construction and excavation stages until the northwestern and northeastern facades are installed.

The monitoring programme as shown above is to be carried out during the likely noisiest stages as agreed with the Acoustic Engineer and Contractor.

Figure 7: Attended Noise and Vibration Monitoring Location



8. Conclusion

A Construction Noise and Vibration Management Plan has been provided for the main works construction works to be conducted at Goulburn Base Hospital located at 130 Goldsmith Street, Goulburn NSW 2580.

The details of the noise and vibration assessments undertaken to predict the impacts on sensitive external receivers have been presented in Sections 5 and 6. As shown in Section 5.4, the noise levels are expected to exceed the noise management levels by up to 8 dB at nearby residential receivers during the standard hours of construction during excavation phase one. The vibration levels are predicted to comply with the cosmetic damage criteria but the human comfort levels may be exceeded occasionally during excavation works depending on the power of the excavator used.

In order to reduce the noise and vibration impacts on the sensitive external receivers, noise and vibration management strategies have been proposed in Section 7. Erecting a three metre sound attenuating barrier along the site as per outlined on Appendix B of this report is recommended.

Due to the proximity of heritage listed buildings within the Goulburn Hospital campus, attended vibration monitoring at the start of excavation works is recommended to ensure that the vibration criteria for cosmetic damage are not exceeded.

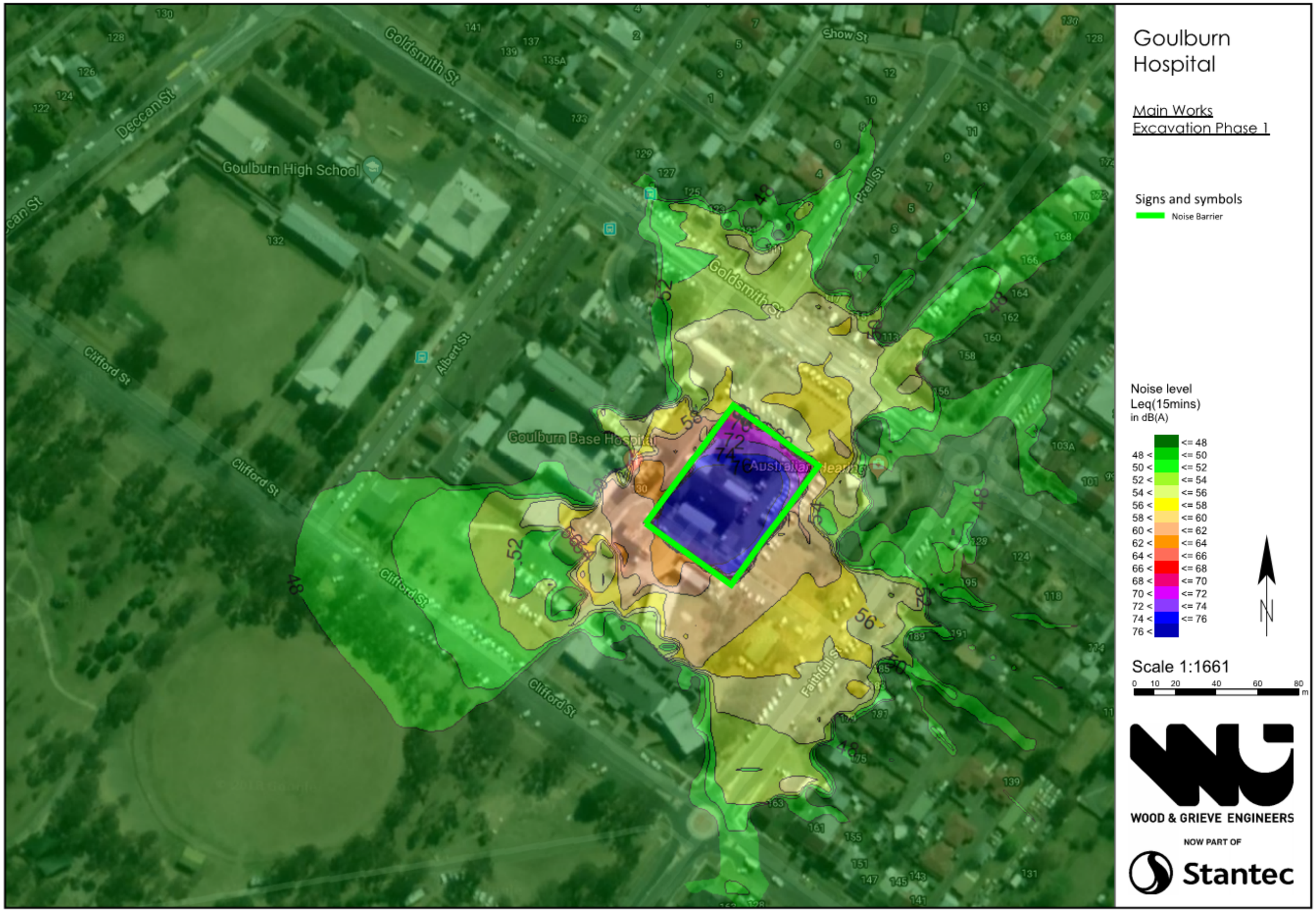
The information presented in this report shall be reviewed if any modifications to the features of the development specified in this report occur, including and not restricted to selection of equipment/machinery and modifications to the main works construction program.

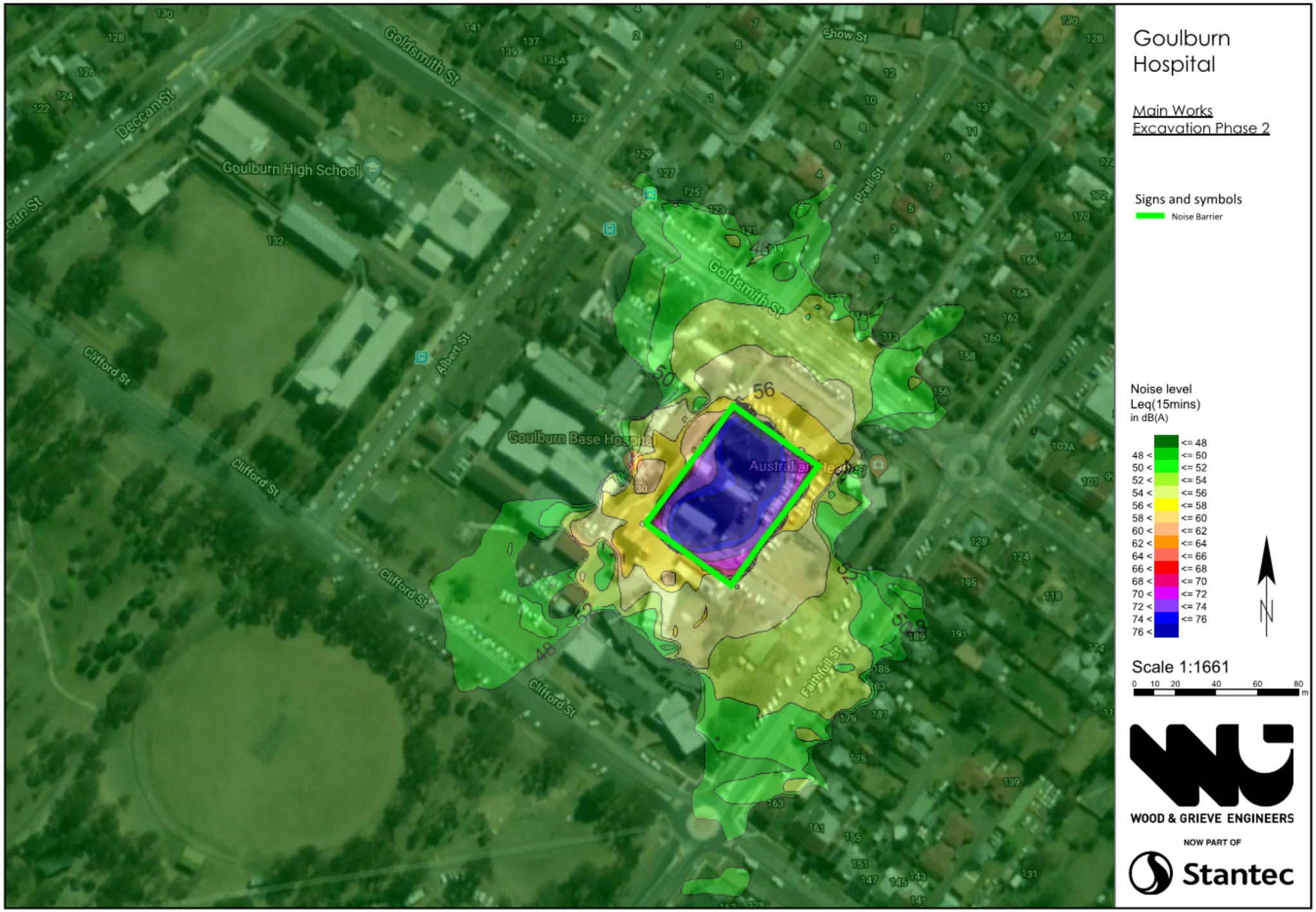
APPENDIX A Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable L_{Aeq} noise level from industrial sources, recommended by the EPA (Table 2.2, NPI). 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 L_{A90} 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.

L_{Amax}	The maximum A-weighted sound pressure level measured over a period.
L_{Amin}	The minimum A-weighted sound pressure level measured over a period.
L_{A1}	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
L_{A10}	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
L_{A90}	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{A90} noise level expressed in units of dB(A).
L_{Aeq}	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
$L_{Aeq,T}$	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 L_{eq} 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.

APPENDIX B Noise Contour Maps




Goulburn Hospital
Main Works
Excavation Phase 2
Signs and symbols
Noise Barrier
Noise level
Leq(15mins)
in dB(A)
<= 48
48 < <= 50
50 < <= 52
52 < <= 54
54 < <= 56
56 < <= 58
58 < <= 60
60 < <= 62
62 < <= 64
64 < <= 66
66 < <= 68
68 < <= 70
70 < <= 72
72 < <= 74
74 < <= 76
N
Scale 1:1661
0 10 20 40 60 80 m
WOOD & GRIEVE ENGINEERS
NOW PART OF
Stantec
Goldsmith St
Deccan St
Goulburn High School
Show St
Prell St
Albert St
Clifford St
Goulburn Base Hospital
Faithfull St
48
50
52
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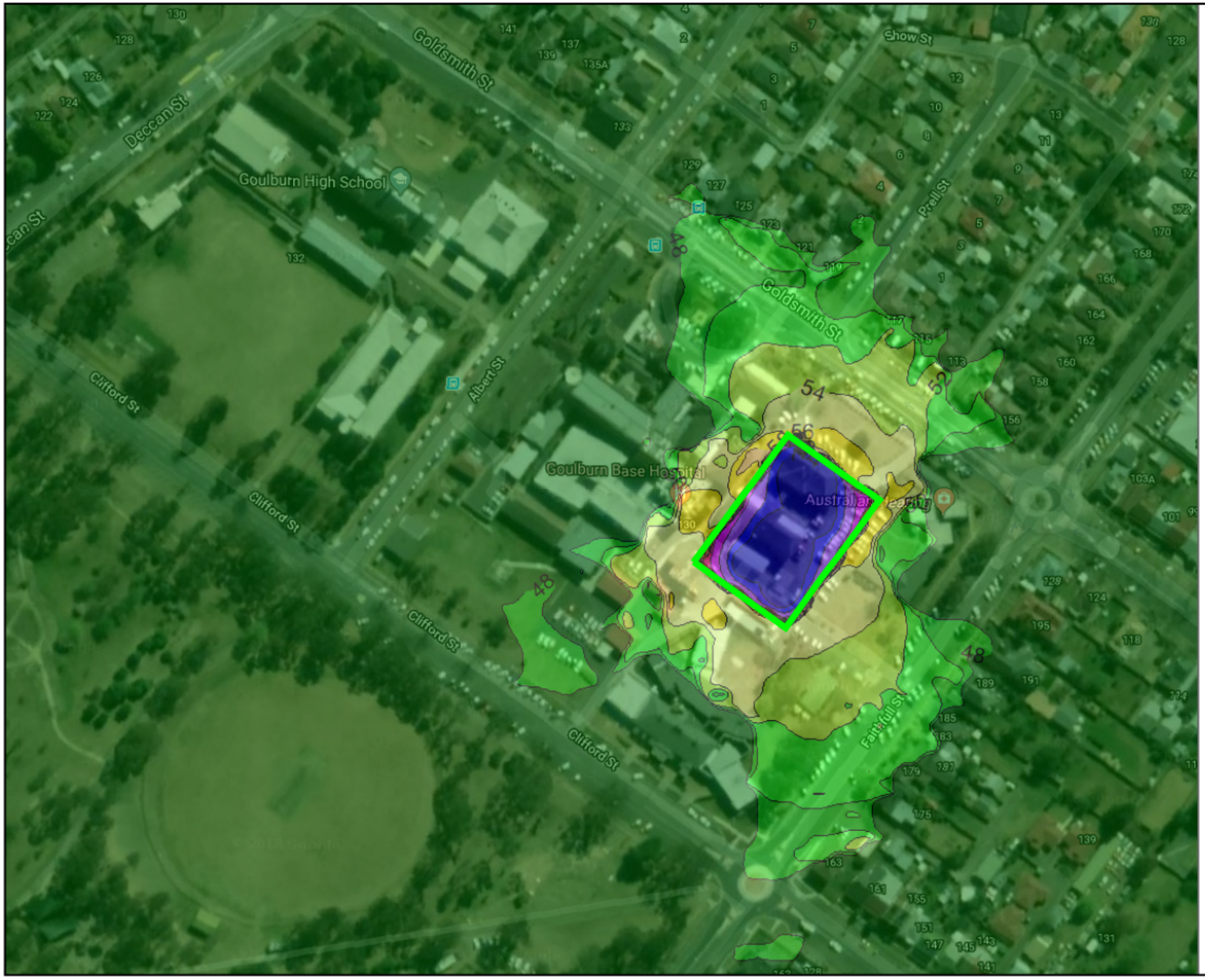
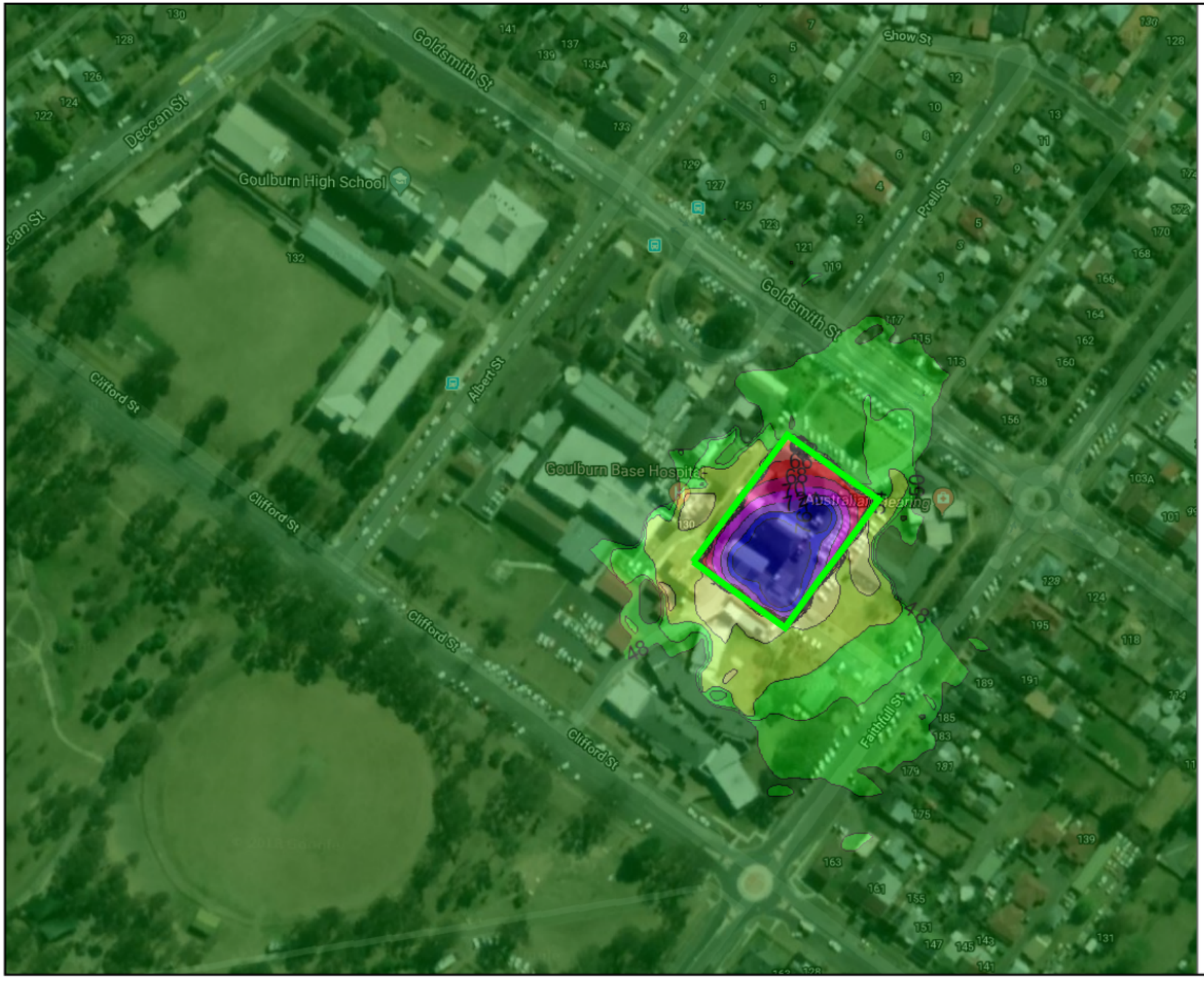


NOISE CONTOUR MAPS



NOISE CONTOUR MAPS

NOISE CONTOUR MAPS