SJOG Richmond Hospital

Acoustics Report

Construction Noise and Vibration Management

Prepared for: St John of God

Attention: Brent Railton

Date: 26th March 2021

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001	19/11/2020	Draft	DSP	ORFG
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003	1/12/2020	Update	DSP	ORFG
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Contents

Contents

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1. Introduction

Stantec have been engaged by St John of God Health Care Inc (SJGHC) to prepare a Construction Noise and Vibration Management Plan (CNVMP) for the proposed construction works at St John of God Richmond Hospital, 177 Grose Vale Road North Richmond NSW 2753.

Under NSW State Environmental Planning Policy (State and Regional Development) 2011 (SEPP), the development is deemed a State Significant Development and therefore requires approval by the NSW Environmental Protection Agency.

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

The early works as described below is expected to occur across approximately a 12-month period. The works are to be split into stages which are likely to be:

Stage 1 – Minor refurbishments

Stage 2 – Demolition of Existing Buildings Phase 1.

Stage 3 – Construction Phase 1.

Stage 4 – Commissioning Phase 1.

Stage 5 – Refurbishment Xavier Building and Belmont House

Stage 6 – Refurbishment Administration and Reception building

Stage 7 – Demolition Phase 2

Stage 8 – Refurbishment old gym building

Certain tasks will be carried out concurrently with other tasks for time periods that are significant in duration. In each combination of events, the noise emitted by performing the tasks simultaneously will be considered.

Drawings describing the extent of works for each stage are attached in the Appendix C.

This Construction Noise and Vibration Management Plan provides:

- Criteria for the noise and vibration generated during the early works phases
- A quantitative assessment of the airborne and ground-borne noise generated by the work for the proposed development and its impact on nearby receivers
- Strategies to mitigate the noise and vibration generated during the construction works phases
- 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.

The acoustic assessment is also based on the following reference documents:

- Hawkesbury Development Control Plan 2002.
- NSW Protection of the Environment Operations Act 1997 (POEO Act)
- NSW State Environmental Planning Policy (Infrastructure) 2011 (SEPP)
- NSW Noise Policy for Industry (NSW NPI), issued on October 2017 by the NSW Environmental Protection Authority (NSW EPA)
- NSW Road Noise Policy (NSW RNP), issued March 2011 and published by the Department of Environment, Climate Change and Water NSW, now part of the NSW EPA

- NSW Interim Construction Noise Guideline (NSW INCG), issued July 2009 and published by the Department of Environment and Climate Change NSW (DECC), now part of the NSW EPA
- NSW Health Infrastructure - Engineering Services Guidelines (GL2016_020 dated 26 August 2016), including Design Guidance note no. 13 rev A July 2017 issued 19/07/2017 with Section 13 Acoustics July 2017 update
- AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*
- Australian Standard, AS 2021-2000 Acoustics - Aircraft noise intrusion - Building siting and construction.
- Air Services Australia, "Environmental principles and procedures for minimizing the impact of aircraft noise".
- "Fly neighbourly guide", produced by the Helicopter Association International.
- Development Near Rail Corridors and Busy Roads – Interim Guideline (DNRCBR-IG), by the NSW Department of Planning which is now part of the NSW Department of Planning & Environment (issued December 2008)
- Assessing Vibration – A Technical Guideline (NSW AV-TG), issued February 2006 by the Department of Environment and Conservation NSW, now part of the NSW EPA
- Construction Noise Strategy, Transport for NSW, 2013
- 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 typical equipment lists provided in this report.

2. Project Description

2.1 Proposed Redevelopment

This Enabling Works stage for the redevelopment of St John of God Richmond Hospital comprises numerous stages as described in the SJOG RFP 14 June 2019. Stage that are likely to create construction noise are:

Stage 2 – Demolition of Existing Buildings Phase 1.

Stage 3 – Construction Phase 1.

Stage 7 – Demolition Phase 2

At this early stage of planning, no specific details for noise sources exist.

2.2 Site Description

The existing hospital premises are located at 177 Grose Vale Rd, North Richmond NSW 2753. It is set in a rural landscape surrounded by grazing land. The hospital sits atop Richmond Hill, overlooking Clarks Island in the Hawkesbury River to the southeast, North Richmond to the northeast, Grose Wold to the southwest and Grose Vale to the northwest. The nearest public roads are Grose Vale Road, which at its closest point is 500 m away to the north, and Grose River Road to the northwest of the property. There are neighbouring properties on the north-eastern and south-western sides, which also contain the nearest residences.

The proposed new building, which is part of this redevelopment, will be located approximately on the footprint of existing buildings currently occupying the south-western side of the property. These buildings will be demolished to make way for the new building.

The acoustic issues relating to the redevelopment are as follows:

- Noise emissions from demolition of existing buildings and preparation of the site
- Noise emissions from construction of new buildings
- Noise emissions from mechanical plant and emergency electrical systems from the development to the surrounding receivers

It has also been noted that existing ambient noise levels are relatively quiet and similar on all sides of the hospital site. Residential receivers on all sides are subject to similar ambient noise conditions.

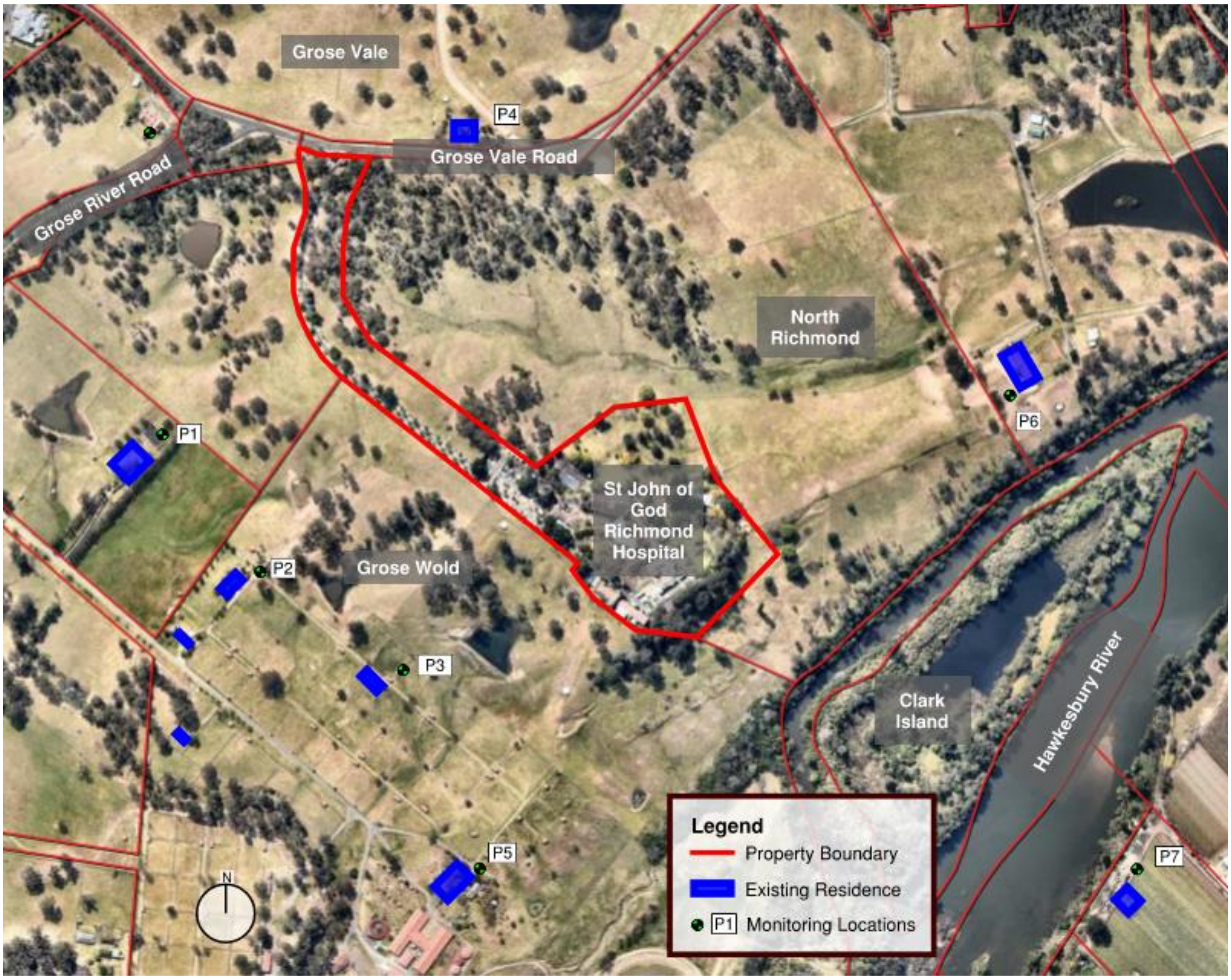


Figure 1: Site location overview showing site boundary and nearby residences, and potential construction noise monitoring locations. Map source: Nearmap.com

3. Acoustic Survey

3.1 Existing Noise Environment

The existing background noise is typical for a rural area and characteristically dominated by natural sounds. 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. During the day, within the hospital grounds, low level mechanical noise from the hospital's services is the dominant source of noise.

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

The INP 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 2.

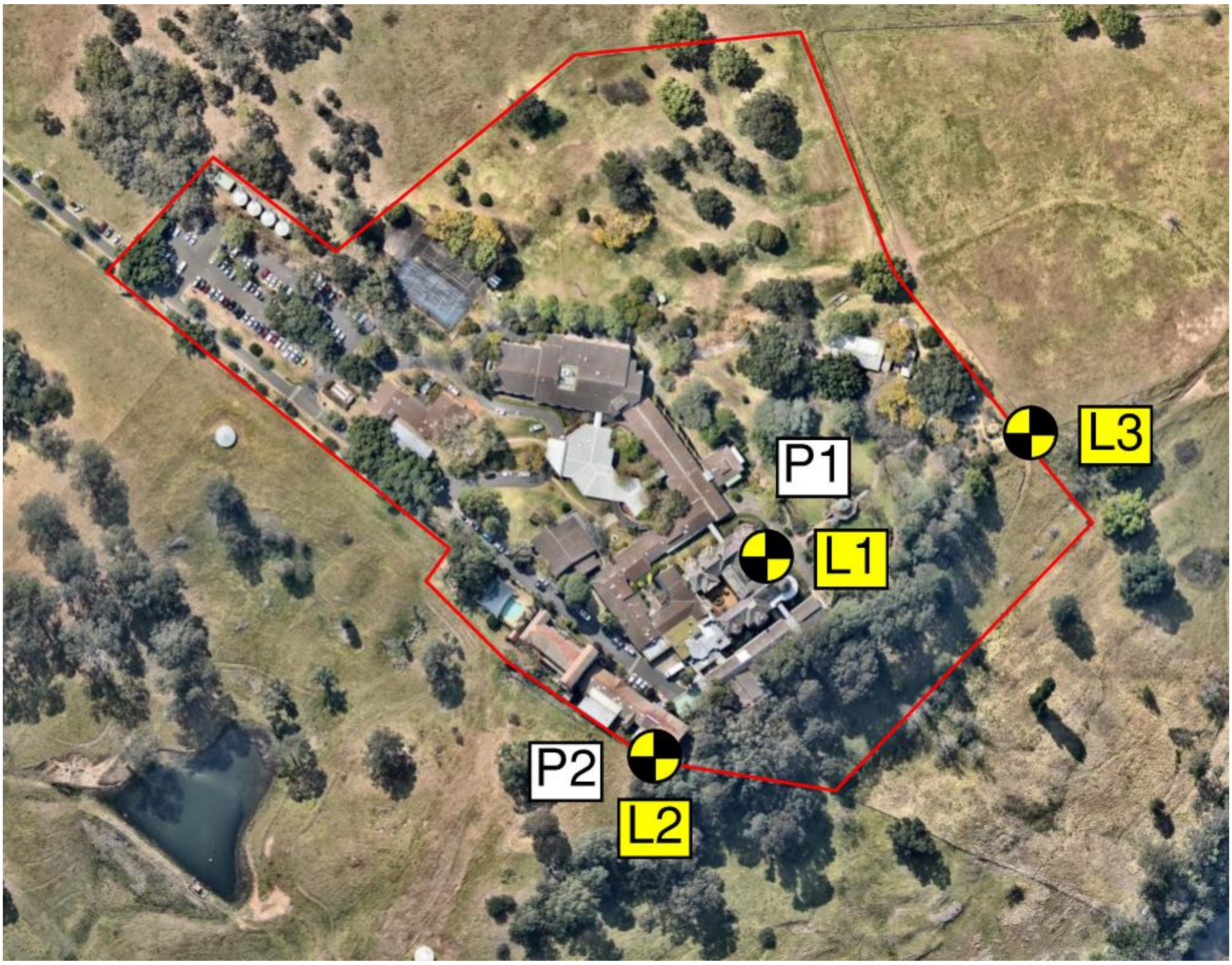


Figure 2: Background noise measurement locations. Loggers indicated L1, L2 & L3, Short-term measurements P1 & P2. Map source: Nearmap.com

3.2 Instrumentation

The equipment used for the noise survey was the following:

- Hand-held sound spectrum analyser - Brüel & Kjær 2250 S/N 3027679
- Environmental Noise Logger - Calsella CEL-63X S/N 1488204 indicated as L1 in Figure 2
- Environmental Noise Loggers - NL-42EX S/N 00885459 indicated as L2 in Figure 2
- Calibrator - Brüel & Kjær, 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.

3.3 Attended Noise Survey Result

Attended noise measurements of 15-minute duration were conducted on site to characterise the acoustic environment for noise intrusion into the development and to determine any noise impact on the surrounding receivers. The measurement results were used in conjunction with the Unattended measurement data to calibrate and determine variations in different spots around the site. A summary of the attended noise measurements taken at the site are shown in Table 1 refer to Figure 2 for measurement locations.

Table 1 - Summary of short-term measurements

Measurement Location	Date/Start Time	$L_{Aeq,T}$ dB(A)	$L_{A90,T}$ dB(A)	Background Noise Description
P1	24th September 2019 12:15 PM	49	47	Ambient & Mechanical Noise
P2	24th September 2019 12:48 PM	50	35	Ambient & Mechanical Noise
P1	3rd October 2019 11:08 AM	45	41	Ambient & Mechanical Noise
P2	3rd October 2019 11:36 AM	45	35	Ambient & Mechanical Noise

3.4 Unattended Noise Survey Results

Unattended noise measurements of existing ambient noise levels were conducted between 24th Sept 2019 and 3rd Oct 2019. The measurements were undertaken using a Calsella CEL-63X and an NL-42EX Environmental Noise Loggers indicated in Figure 2 as L1 and L2 respectively.

The loggers were set to measure continuous measurements at 15-minute intervals. The instruments were calibrated prior to and after the survey using a noise calibrator which emitted a calibration tone of 94dB(A) at 1 KHz. No significant drift was noted during the calibration procedure.

Additionally, in order to confirm that the measurement data was obtained during favourable weather conditions, weather data such as rainfall and wind speed was obtained from the nearest meteorological station which is located at Richmond RAAF Base (Station ID: 067105). Consequently, measured noise information was excluded if:

- Rain was observed during a 15-minute measurement period; and/or;
- Wind speed at 1.5 m above ground exceeded 5 metres/second.

Please note the measured noise data is defined in terms of equivalent continuous (L_{Aeq}) noise levels and rated background (L_{A90}) noise levels. For definition of these noise parameters, please refer to the Glossary section at the end of this report.

Table 2 - Summary of unattended noise measurements

Location	Rating Background Noise (RBL) Level L_{A90}			Equivalent Continuous Noise Level L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
L2	36	33	30	49	41	45
L3	35	33	30	47	45	43

Figure 3 and Figure 4 show visual representations of the measured noise levels during the unattended noise survey for Logger 2 and Logger 3 respectively. Logger 2 was positioned within the Hospital grounds to determine the existing noise environment for use in designing the new building and to determine the existing ambient environment at sensitive receivers. Logger 3 was positioned on the eastern boundary corner to determine the general background noise levels in the area away from the influence of normal hospital operations.

The logger data shows a very rapid and substantial rise in sound level in the early hours of the mornings, then a gradual decline throughout the day. After investigation this rise further we determined that this is attributed to bird activity.

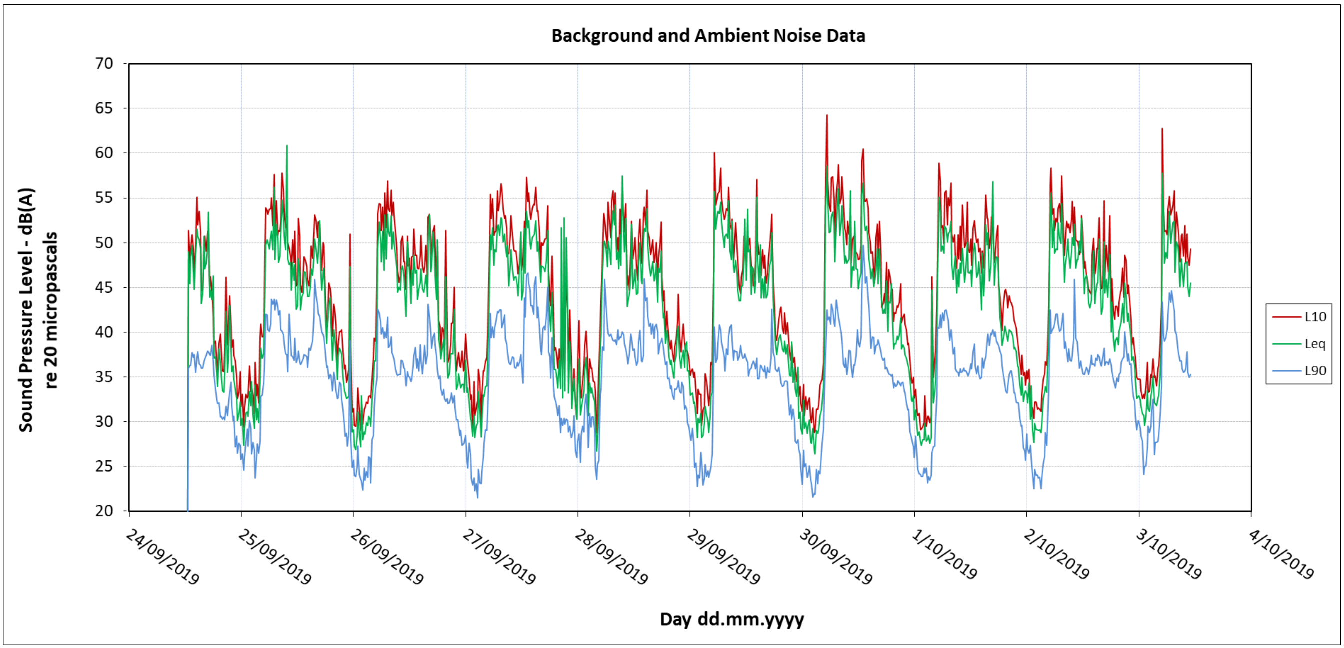


Figure 3: Long-term noise monitoring results at location L2- background noise measurement

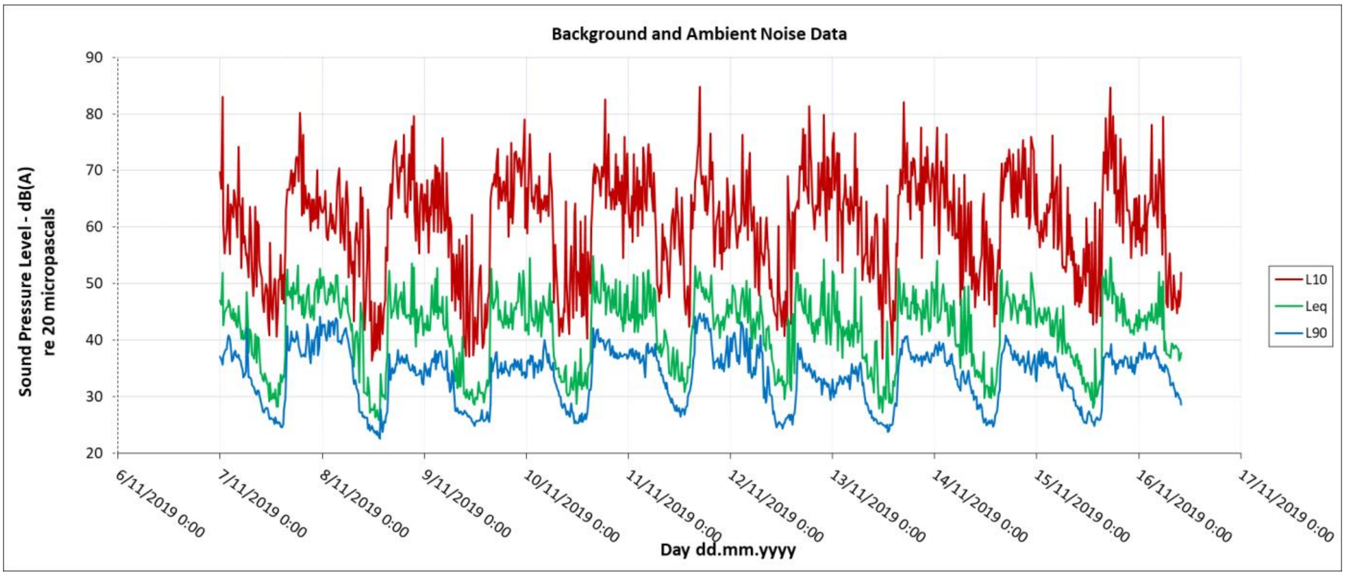


Figure 4 Long-term noise monitoring results at location L3- background noise measurement

4. Construction Noise and Vibration Criteria

4.1 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the *Interim Construction Noise Guideline* (ICNG) by NSW DECC. It is important to note that the recommended criteria are for planning purposes. Numerous factors must be considered when assessing potential noise impacts from construction works.

The NSW ICNG 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 associated with construction and its related activities are shown in Table 3, as presented in Section 4.1.1 Table 2 of the ICNG.

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: - Times identified by the community when they are less sensitive to noise (such as before and after school, for works near schools, or mid-morning or mid-afternoon for works near residences) - If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside Recommended Standard Hours	Noise Affected RBL + 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 below (Section 4.1.3 of the ICNG) sets out the noise management levels for other land uses, including commercial premises. The external noise levels should be assessed at the most affected occupied point for commercial and industrial uses, and at the most affected point within 50 metres of the area boundary for parks.

Table 4: Construction Noise Criteria for Other Land Uses

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilized
Passive recreation, parks	External noise level 60 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

Based on the criteria in the tables above, the following noise management levels in Table 5 should be applied to the receivers. Construction during standard hours has been assumed.

Table 5: Project Specific Construction Noise Management Levels

Land Use	Receiver	Management Level, $L_{Aeq,15min}$
Residential Accommodation	R1	36 dB(A) + 10 dB = **46 dB(A)**

4.2 Construction Vibration Criteria

4.2.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day. The vibration emitted from construction works should be such that it does not exceed the maximum limits set out in the criteria presented in Table 6 to Table 9. The guide on preferred values for human comfort have been extracted from the NSW DEC *Assessing Vibration: A Technical Guideline* (2006). The criteria for continuous and impulsive vibration are summarized in Table 6.

Table 6: 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 Night time	0.010 0.007	0.0071 0.005	0.020 0.014	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 Night time	0.30 0.10	0.21 0.071	0.60 0.20	0.42 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 7.

Table 7: 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

4.2.2 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 8.

Table 8: 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 9 indicates the vibration limits presented in DIN 4150-Part 3 to ensure structural damage does not occur.

Table 9: Guideline Value of Vibration Velocity (vi) for Evaluating the Effects of Short-Term Vibration – DIN 4150-Part 3

Line	Type of Structure	Vibration velocity, v_i, in mm/s			
		Foundation At a frequency of			Plane of floor of uppermost full storey
		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.					

5. Construction Noise Assessment

5.1 Proposed Construction Activities

The St John of God Richmond Hospital redevelopment Enabling Works stage will require construction work to be undertaken while the part of the Hospital is still operating. Additional assessment.

In this assessment, the noise impact from the early construction works are considered. The proposed early construction will consist of the following stages, and is expected to occur over a period of 12 months:

- Demolition
  - Existing building demolition
  - Hardstand demolition
- Excavation
  - Shoring
  - Bulk excavation
  - Piling
  - Detailed excavation
- Structure
  - Basement slab and walls
  - Structure
  - Façade
  - Roof

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 likely to be associated with the works listed in the previous section of this report 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	Sound Power Level dB(A)
Demolition	Excavator with hydraulic hammer (30-40t)	113
	Electronic hand tools	102
	Bobcat	107
	Mobile crane	110
	Truck	108
	Cherry picker	102
Excavation	Excavator 30 tonne	110
	Electronic hand tool	102
	concrete pump	109
	mobile crane	110
	bored piling	110
	generator	104
	Truck	108
Construction	Electronic hand tool	102
	concrete pump	109
	mobile crane	110
	bored piling	110
	generator	104
	Truck	108

5.3 Noise Model

To assess the noise impact from the site during the various construction stages, a noise model was established in the commercial software SoundPLAN v8.1, which is a comprehensive software package for estimating noise impacts in varying situations. In the software, a 3D model of the site and its surroundings was constructed, including the nearby buildings and the construction plant and equipment as the relevant noise sources. Within the model, the effects of the environment (built and natural) on propagation of sound were considered to reliably estimate the resulting noise effects on the surrounding noise sensitive receivers.

The noise model represents the 'reasonable' worst case periods of construction activities, meaning that all the equipment of each stage is operating simultaneously during a 15-minute observation period.

The assumptions that were made within the assessment include the following:

- The predicted noise levels represent the worst-case scenario for each receiver buildings. The most affected receivers from the construction activities are in Grose Wold and North Richmond.
- The height of the receivers has been assumed as 1.5m from ground level.
- The predicted noise levels at the nearby sensitive receivers have been assessed with the acoustic recommendations as shown in Section 5.4.
- The noise levels have been assessed using neutral weather conditions.

The noise levels at the surrounding sensitive receivers have been based on the assumptions and aforementioned sound power levels of the equipment. The results of the predicted noise levels are presented in the following section.

5.4 Construction Noise Results

The predicted construction noise levels have been presented in Table 11, Table 12, and Table 13 in each receiver location for demolition, excavation, and structure stages respectively. For the assessment, worst case location of equipment and a receiver height of 1.5 metres was assumed for each receiver. Noise contour maps for the proposed construction works are shown in Appendix B.

Table 11: Predicted Noise Levels - Demolition

Location	Receiver	Predicted Noise Level (without mitigation) $L_{eq,15min}$ dB(A)	Predicted Noise Level (with mitigation) $L_{eq,15min}$ dB(A)	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Compliance
North-East (P6)	Residential	39-44	37-41	46	0	Yes
North-West (P4)	Residential	24-37	24-37	46	0	Yes
South-East (P7)	Residential	26-38	26-37	46	0	Yes
South-West (P3)	Residential	25-39	25-39	46	0	Yes

Table 12: Predicted Noise Levels – Excavation

Location	Receiver	Predicted Noise Level (without mitigation) $L_{eq,15min}$ dB(A)	Predicted Noise Level (with mitigation) $L_{eq,15min}$ dB(A)	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Compliance
North-East (P6)	Residential	34-41	34-38	49	0	Yes
North-West (P4)	Residential	27-36	27-36	49	0	Yes
South-East (P7)	Residential	26-36	26-35	49	0	Yes
South-West (P3)	Residential	29-44	28-42	49	0	Yes

Table 13: Predicted Noise Levels – Construction

Location	Receiver	Predicted Noise Level (without mitigation) $L_{eq,15min}$ dB(A)	Predicted Noise Level (with mitigation) $L_{eq,15min}$ dB(A)	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Compliance
North-East (P6)	Residential	30-38	30-36	49	0	Yes
North-West (P4)	Residential	26-33	26-33	49	0	Yes
South-East (P7)	Residential	25-32	25-30	49	0	Yes
South-West (P3)	Residential	24-41	24-38	49	0	Yes

* Compliance is achieved through a qualitative assessment. The early works contractor is to implement the acoustic measures shown in Section 7 as well as any other feasible and reasonable measures to reduce any potential adverse noise impact.

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 14.

Table 14: 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
900kg – 12 to 18t excavator	7m	23m
1600kg – 18 to 34t excavator	22m	73m

The nearest sensitive receivers will be other buildings on the site. The nearest residences in Grose Wold and North Richmond and they are located well outside the safe working distance for cosmetic damage and human response when the excavators with rock breakers are used during demolition stages. All residential properties are at a minimum distance of 200 m from the construction works.

In addition, attended vibration monitoring should be conducted at the commencement of work to verify the safe working distances at nearby buildings within the site. 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. These measures to prevent cosmetic damage to surrounding structures are provided in Section 7.

7. Noise & Vibration Management Strategies

7.1 Project Specific Recommendations

Project specific recommendations and required mitigation methods relating to impacts on surrounding occupiers of land 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 early works phases. Methods should be sought to manage the noise emanating from the construction site to the most affected sensitive receivers, being surrounding residences. Modelling suggests that there will be minimal noise impact on surrounding residences however additional noise management may be implemented in the form of barriers if required.

A 2.5-metre high sound attenuating barriers should be erected around construction areas and buildings during all stages of the early works. Locations of barriers to be advised once construction sequence is finalised. The construction of the barriers should be free of gaps and cracks, which would compromise its performance, and it should be comprised of acoustically suitable materials such as 18 mm plywood.

In addition to the sound attenuating barrier, at least one respite period 12:00pm – 1:00pm should be offered per day during the most intensive periods of hammering and rock breaking. Frequent and proactive communication with surrounding residents and hospital staff and patients is also encouraged, thus enabling tuning the works schedule to accommodate and prepare their expectations on the changing noise environment. More details regarding communication with the community can be found in Section 7.3.

7.1.2 Vibration

Due to the distance of demolition works from receivers, it is unlikely there will be any exceedances of the cosmetic damage and human comfort criteria.

To further diminish the vibration impact, the respite period from 12:00pm – 1:00pm 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 5 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:

- Increasing the distance between noise sources and sensitive receivers.
- 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).
- Constructing barriers that are part of the project design early in the project to introduce the mitigation of site noise.
- 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.

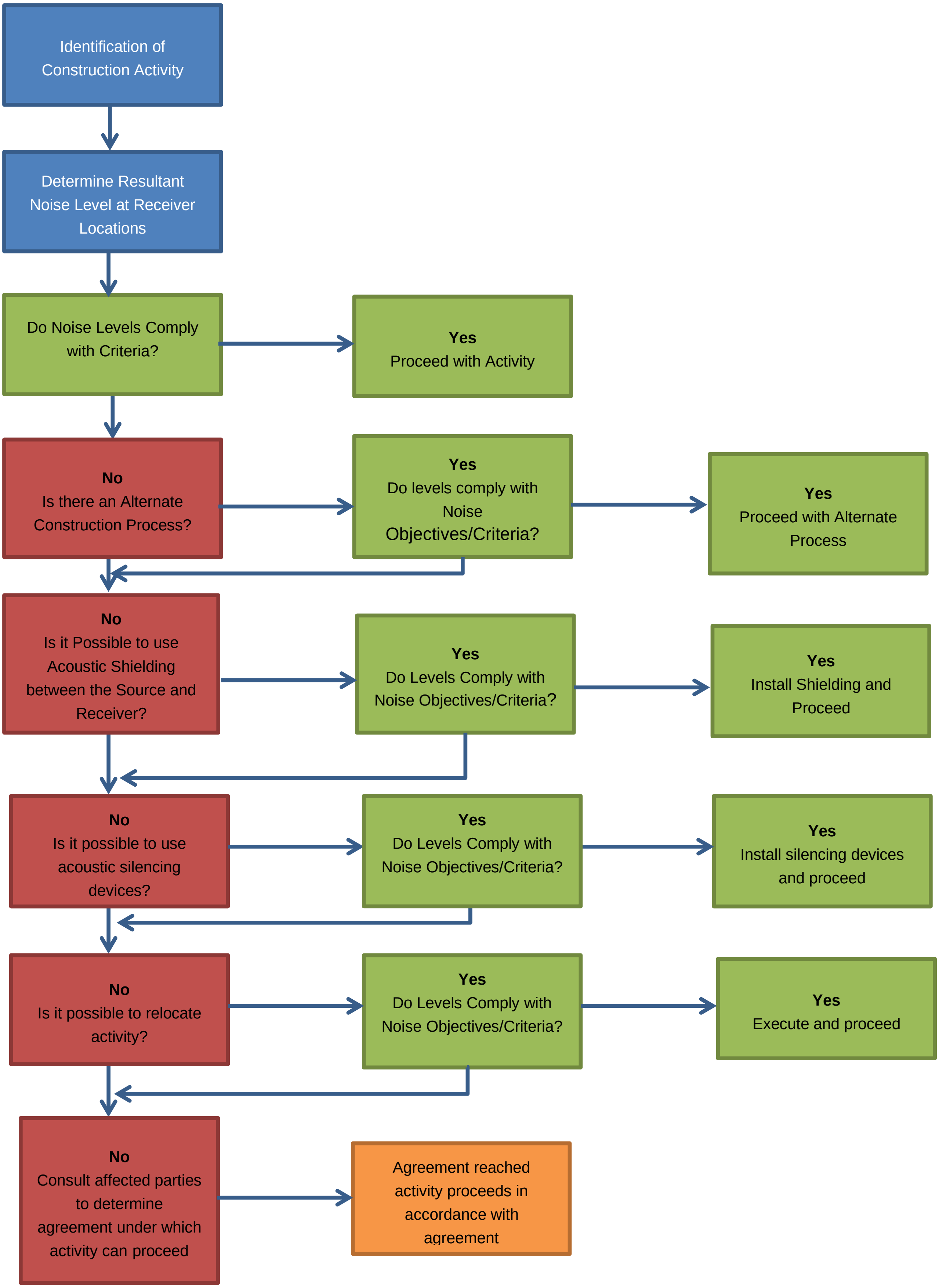


Figure 5: Noise Mitigation Management Flow Chart

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 considered 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:

- 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.
- Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
- Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, provided that safety considerations are not compromised.
- 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.
- 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 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:

- The contact details for a nominated representative to make noise / vibration complaints.
- 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.
- Notify the noise sensitive receivers and Hawkesbury City Council in a timely manner should there be any need for an extension to the proposed arrangements.
- Provide them with a copy of this report as approved by the Hawkesbury City Council.
- Hawkesbury 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.
- 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 Hawkesbury 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 Method

Noise and vibration levels should be monitored from time to time to ensure that noise generated because 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:

- Short-term monitoring
- Long-term monitoring

Both 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 to minimise noise and vibration impacts.

Long-term monitoring

Like 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 methods 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.

7.5 Noise & Vibration Monitoring Program

The following monitoring program is proposed for this project. Refer to Figure 6 for the approximate monitoring locations:

- Attended vibration monitoring at Position 1 at the start of the works
- Unattended noise monitor installed at Position 1 during all stages, at least for a period representing the average works
- Unattended vibration monitor installed at Position 1 during demolition

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

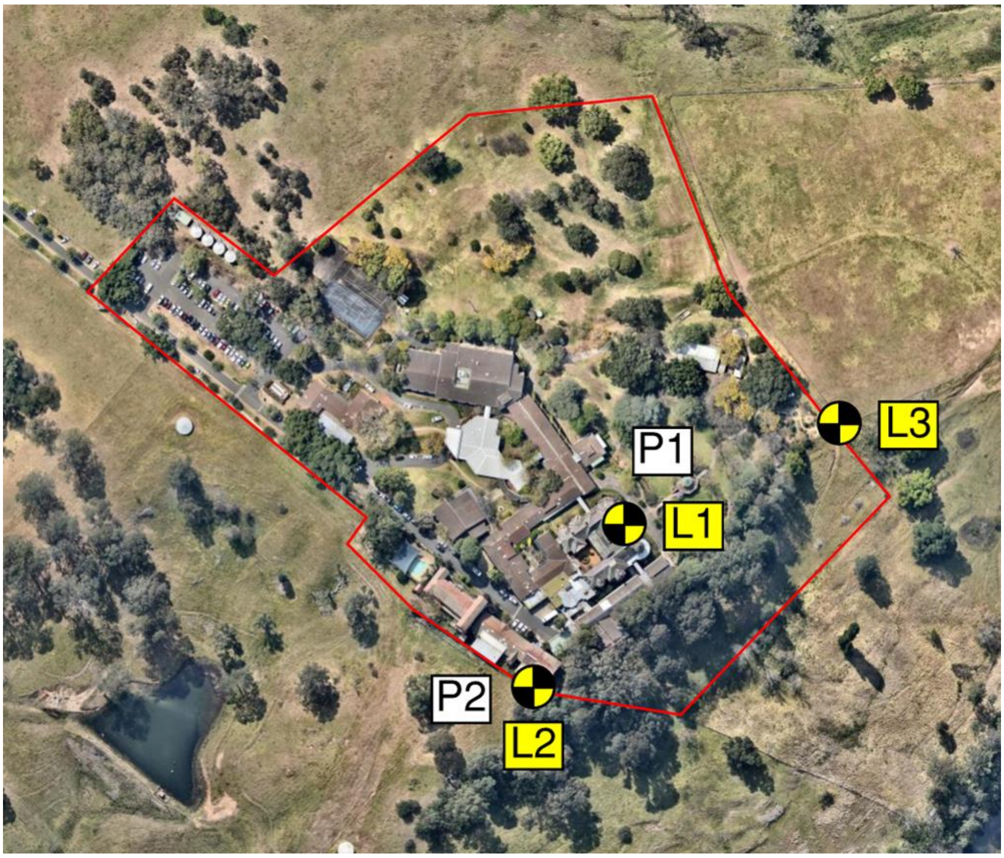


Figure 6: Attended Noise and Vibration Monitoring Location

8. Conclusion

A Construction Noise and Vibration Management Plan has been provided for the construction works to be conducted at St John of God Richmond Hospital, 177 Grose Vale Road North Richmond NSW 2753.

The details of the noise and vibration assessments undertaken to predict the impacts on sensitive receivers have been presented in Sections 5 and 6. As shown in Section 5.3, the noise levels not expected to exceed the noise management levels during the standard hours of construction at the nearby residential receivers. The vibration levels are predicted to comply with the cosmetic damage criteria and the human comfort levels during the standard hours of construction at the nearby residential receivers.

To reduce the potential of noise and vibration impacts on the sensitive receivers, noise and vibration management strategies have been proposed in Section 7.

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 early 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 2.1, 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 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

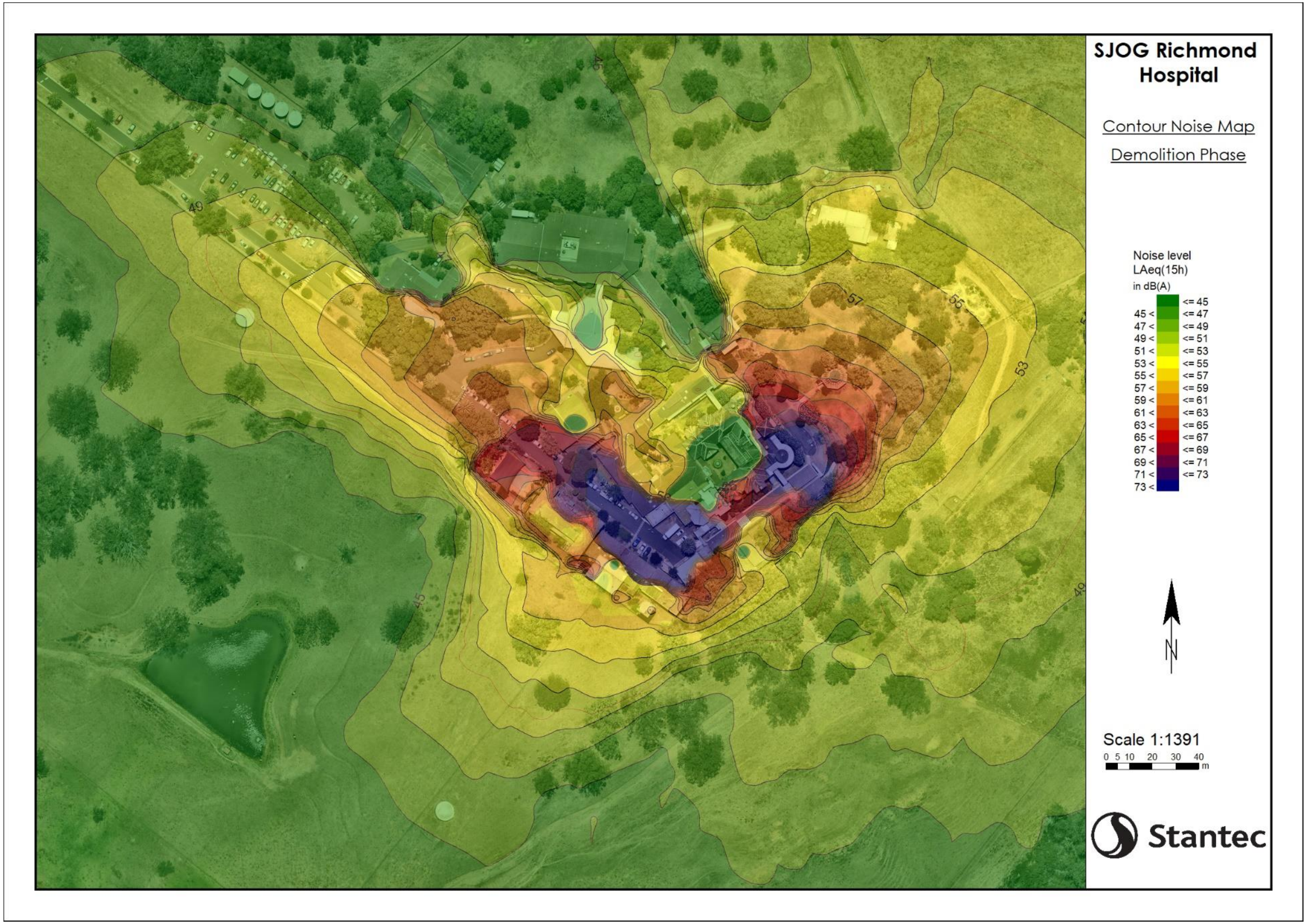


Figure 7: Noise Prediction Map

Figure 8: Noise Prediction Map

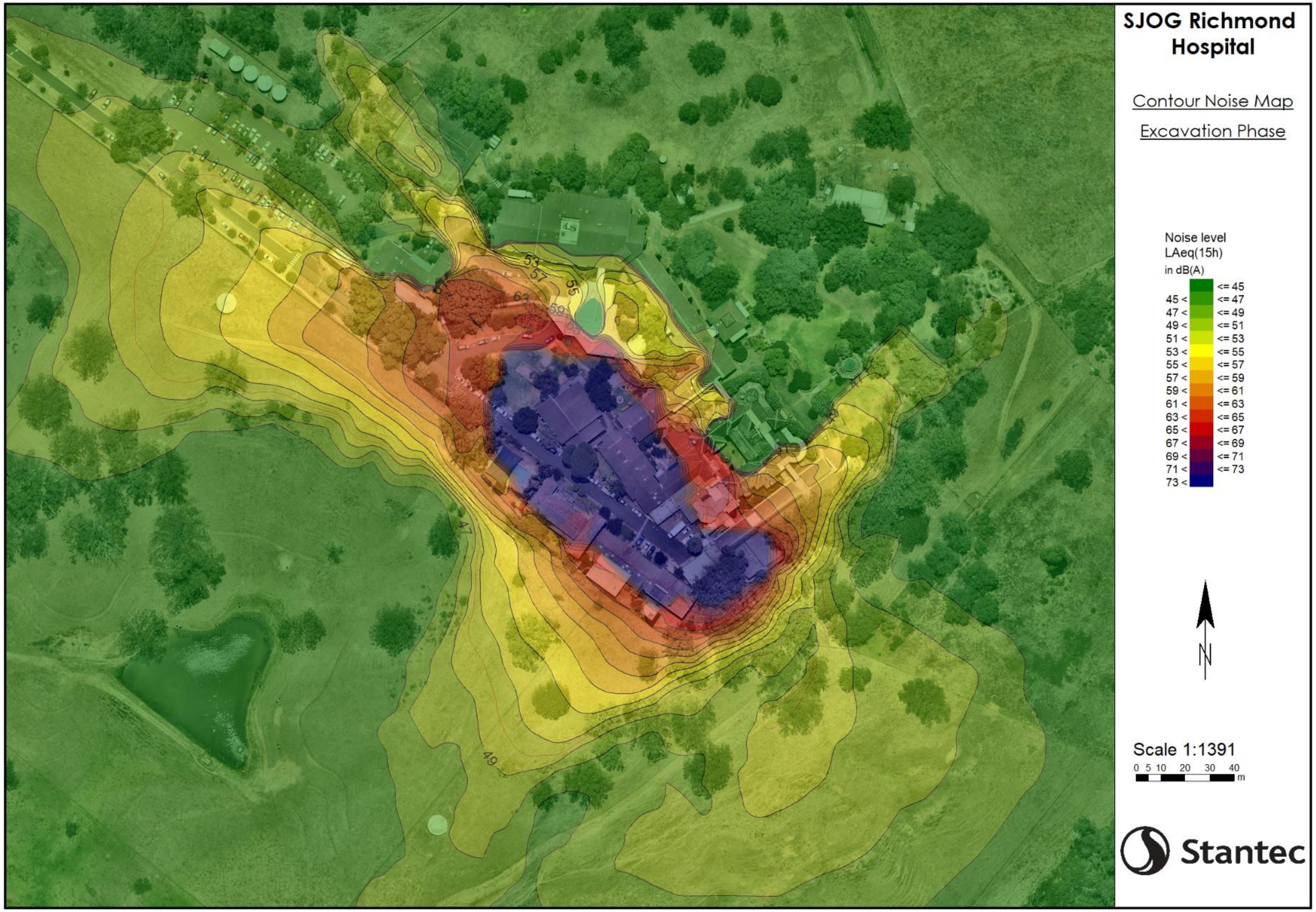


Figure 9: Noise Prediction Map

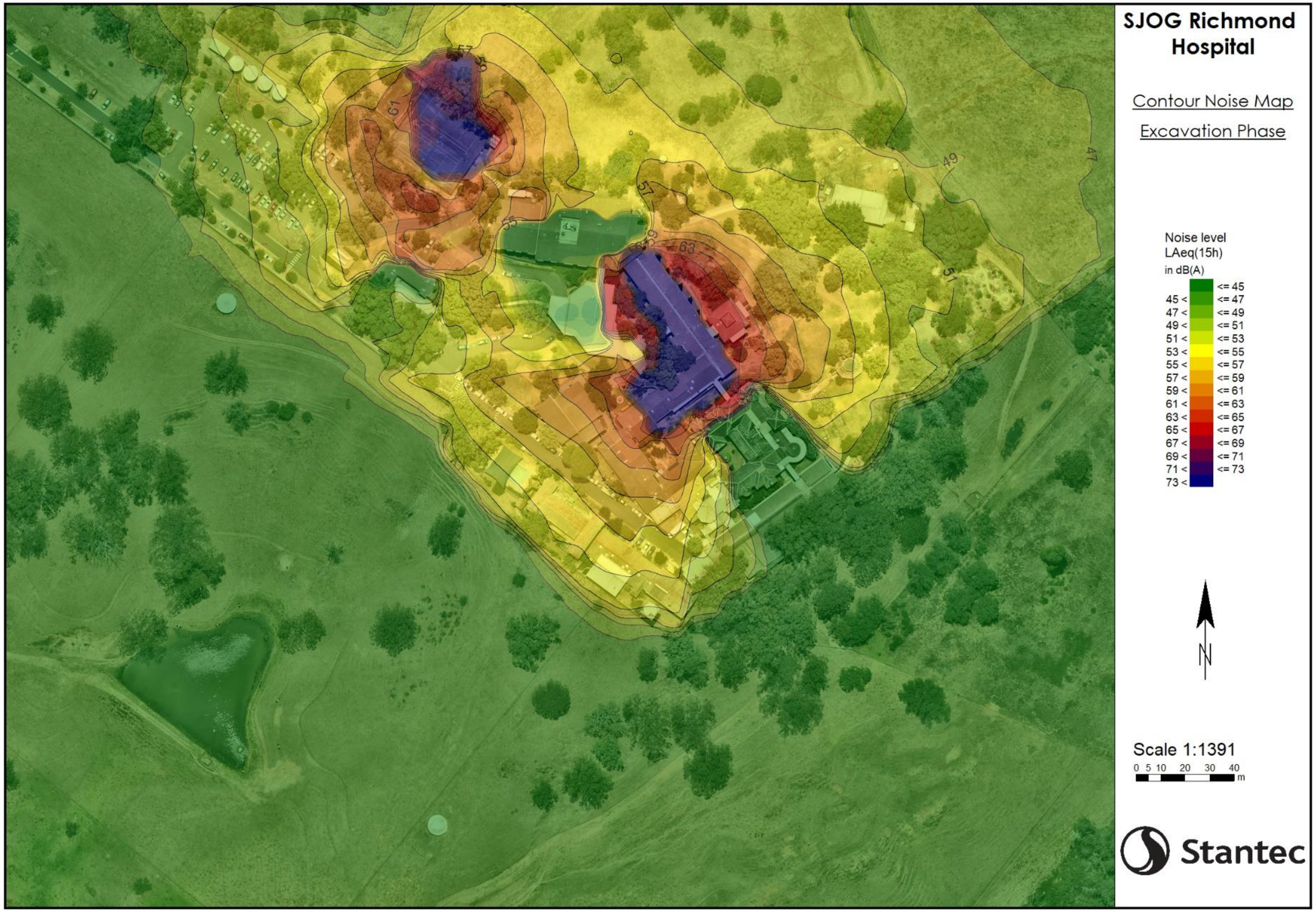


Figure 10: Noise Prediction Map

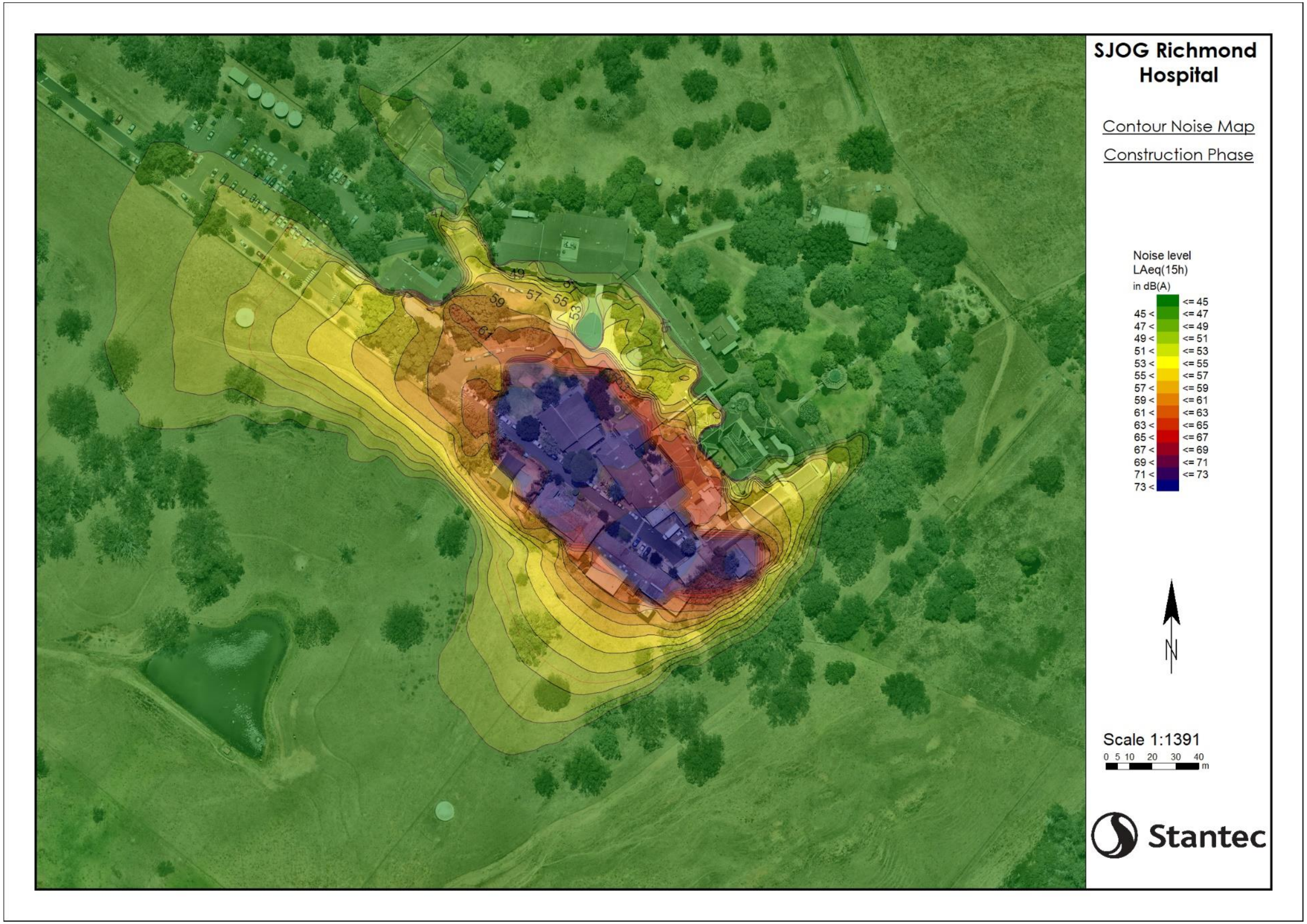


Figure 11 Noise Prediction Map

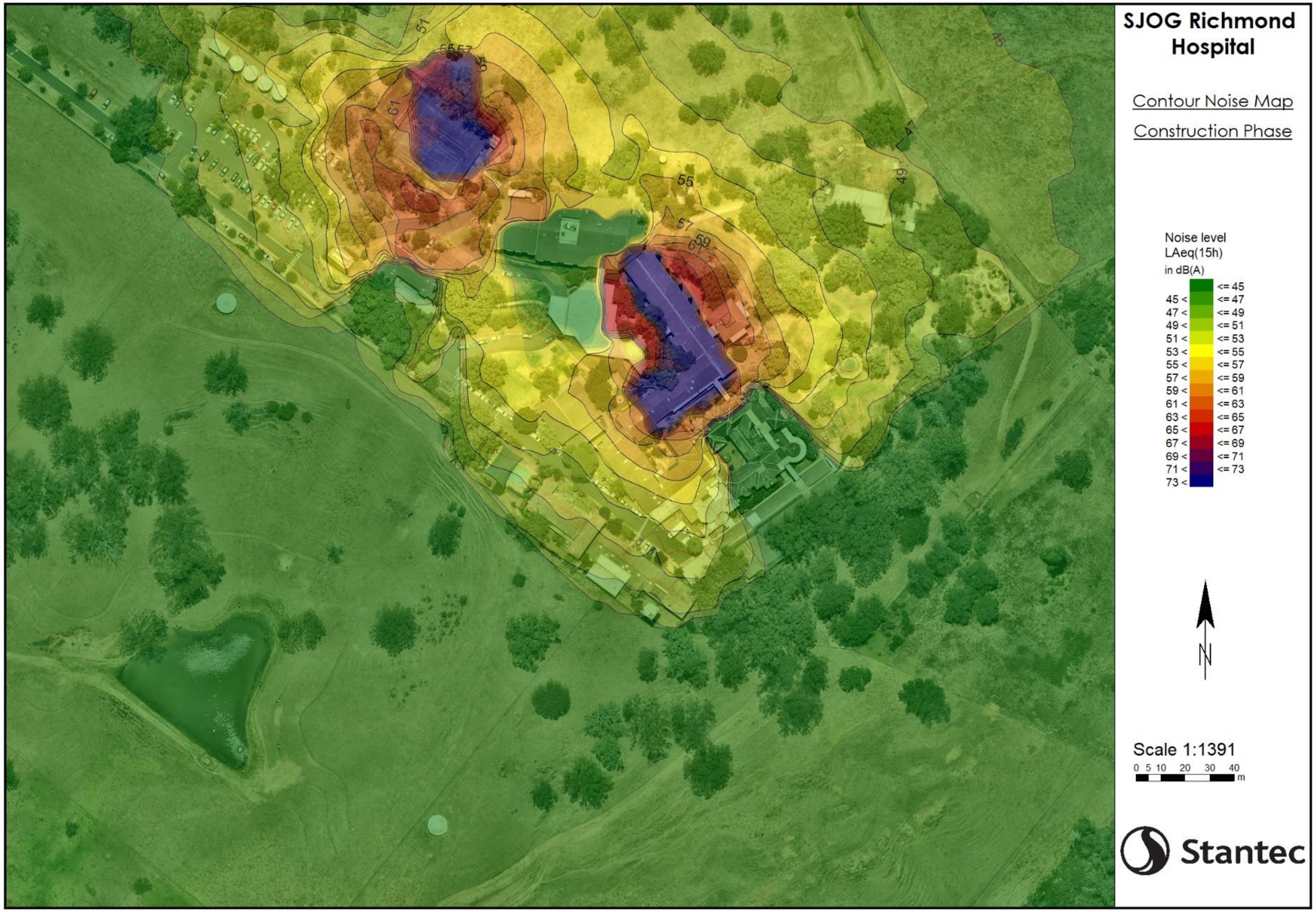
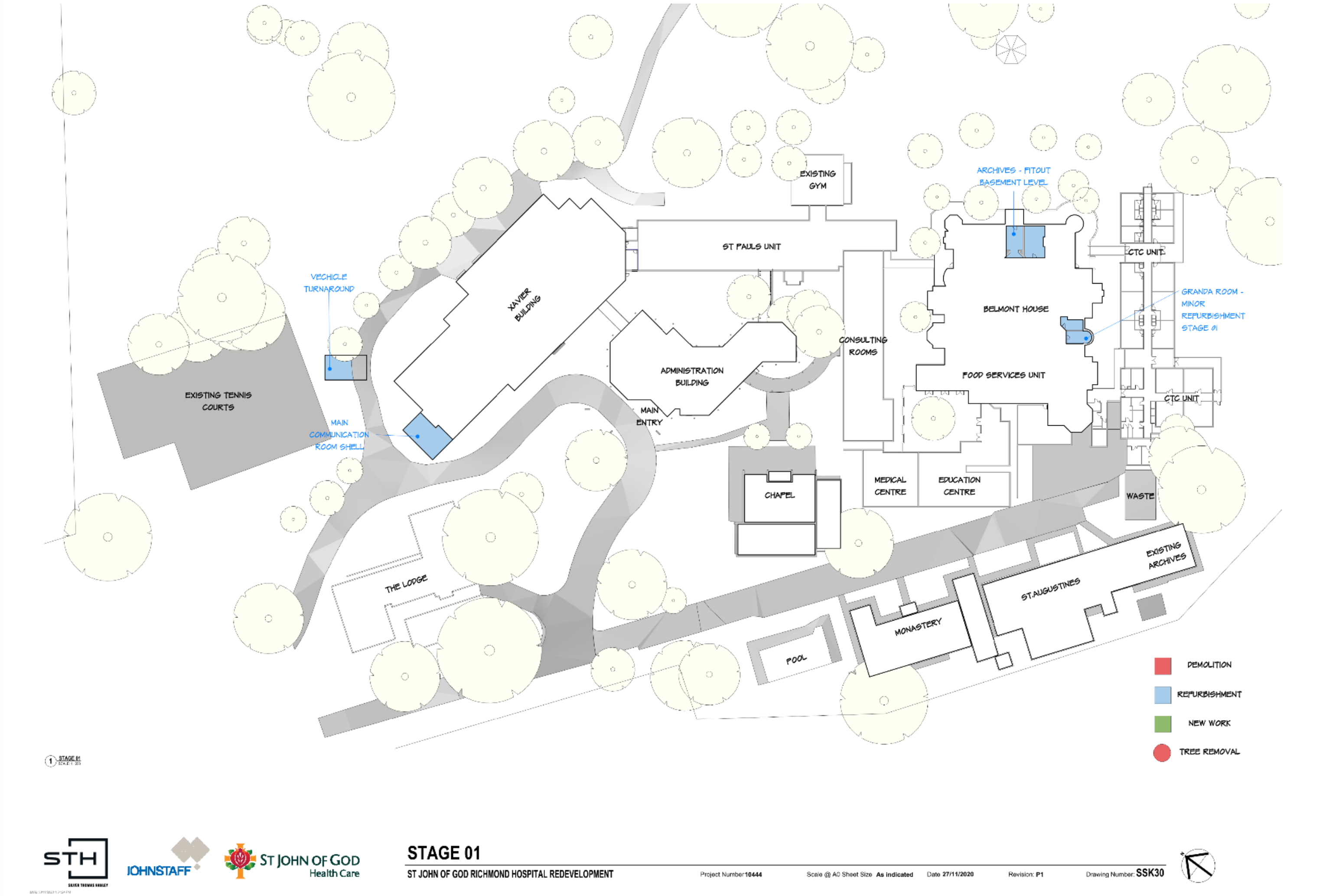
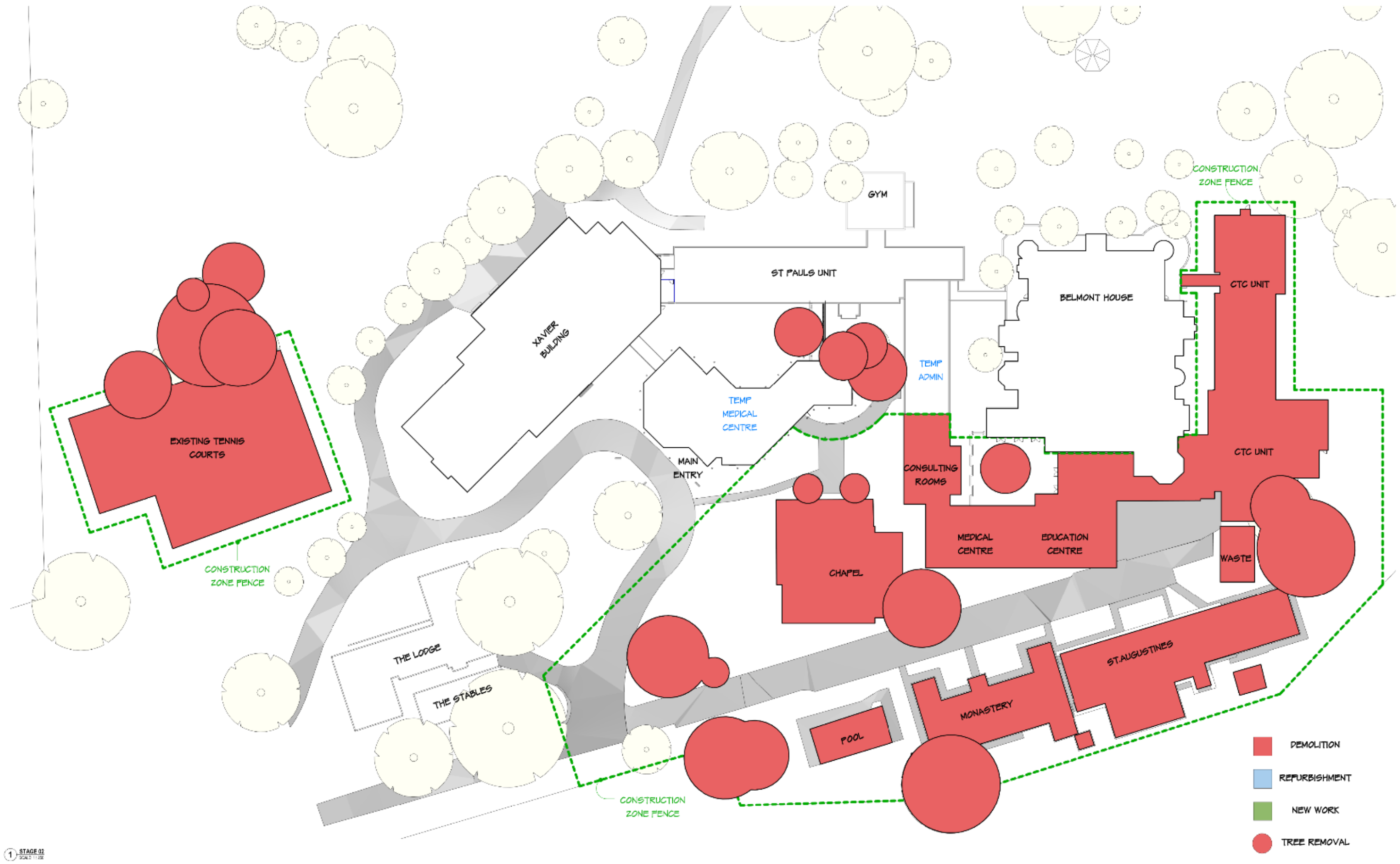


Figure 12 Noise Prediction Map

Appendix C Project Stage Drawings





STAGE 02

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT

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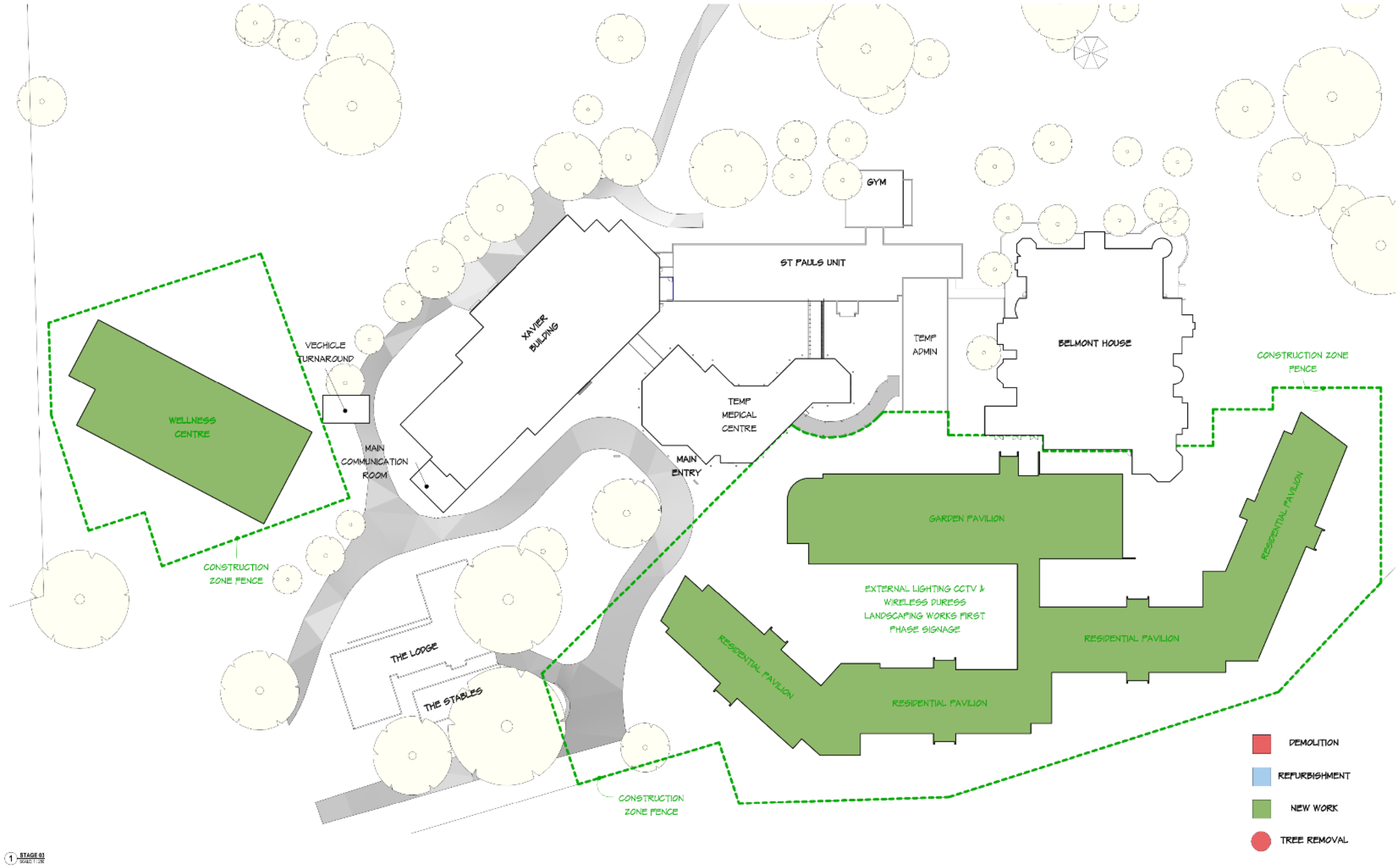

STAGE 03

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT

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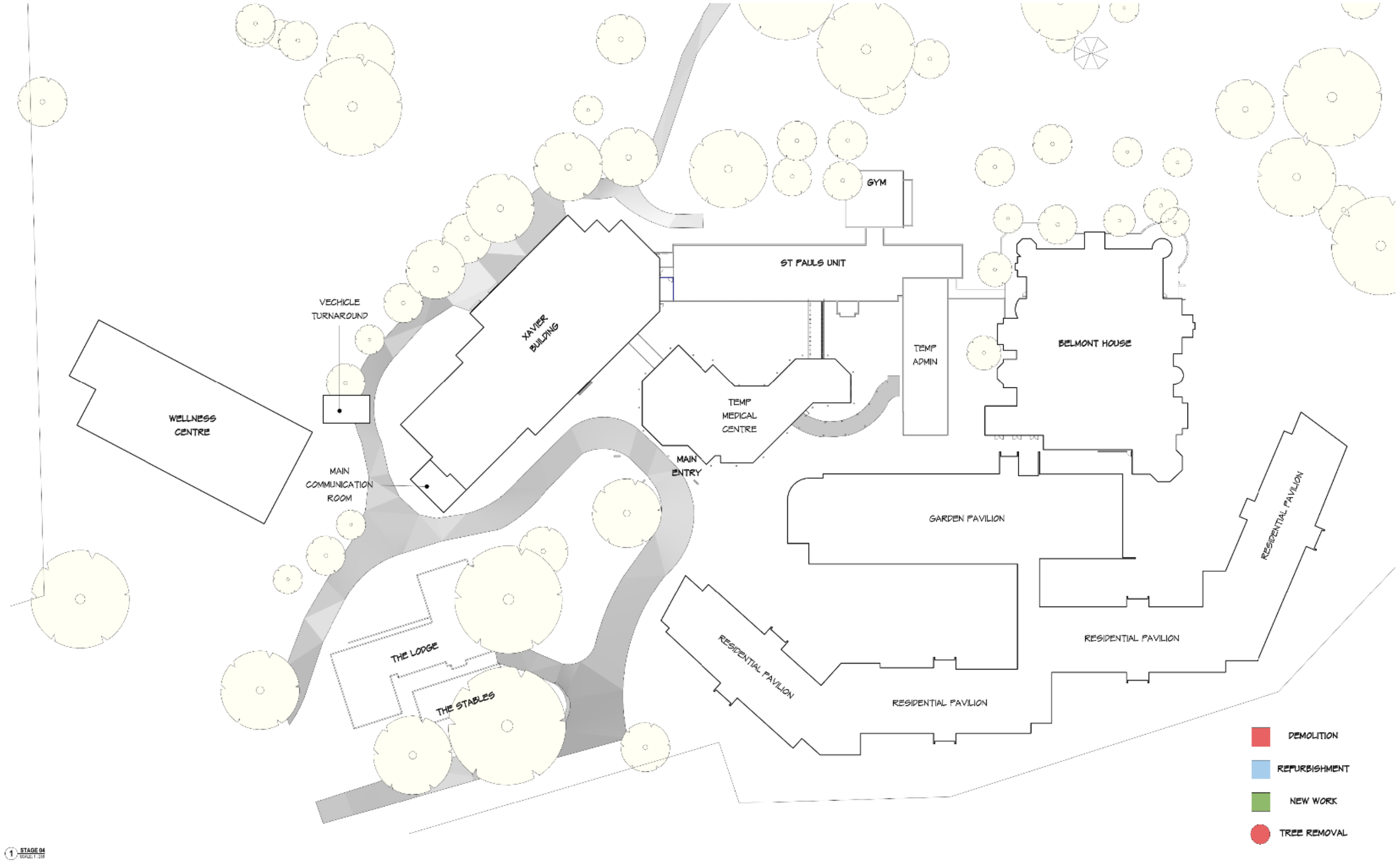
STH | JOHNSTAFF | ST JOHN OF GOD Health Care



STAGE 04

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT

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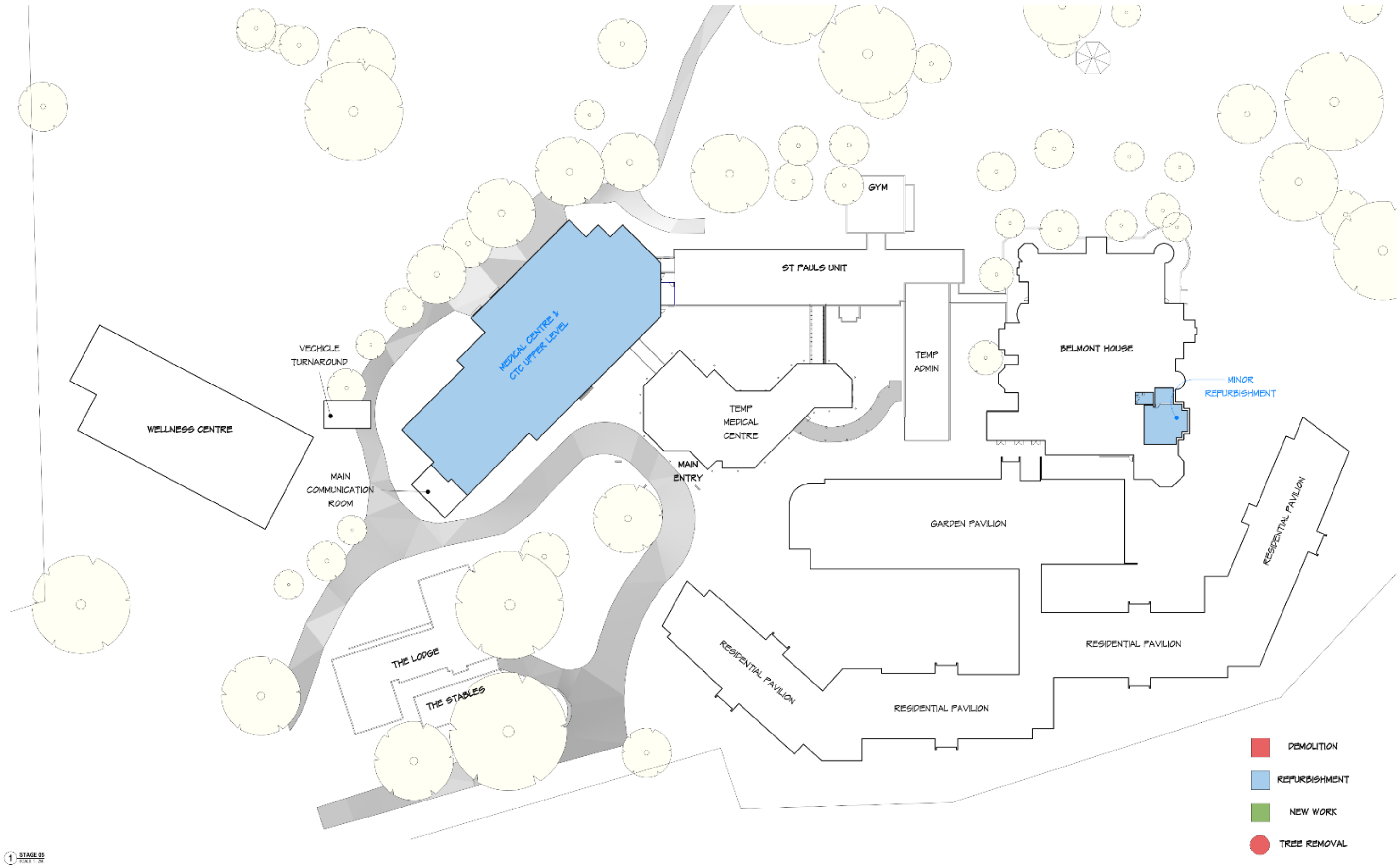

STH | JOHNSTAFF | ST JOHN OF GOD Health Care

STAGE 05

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT

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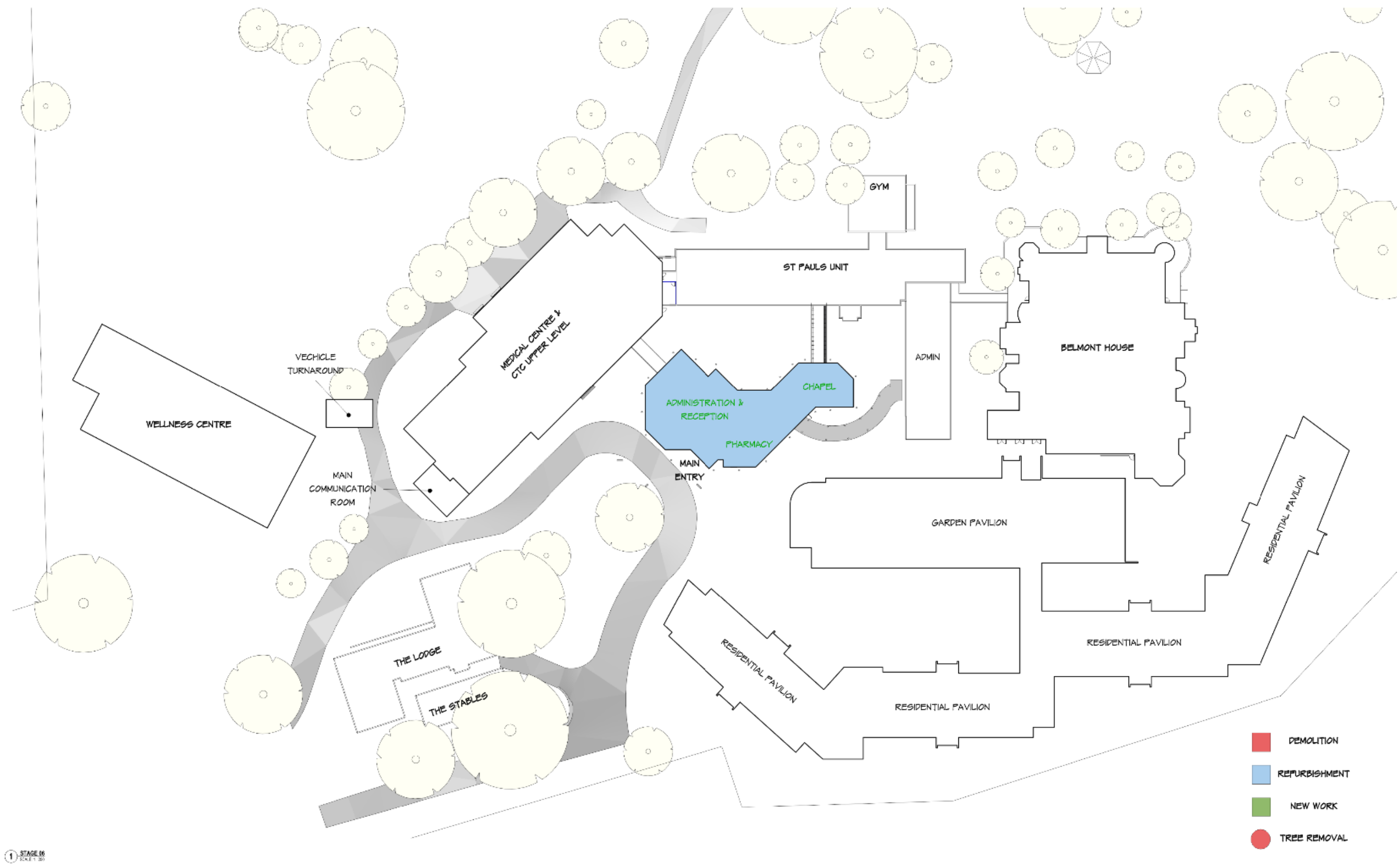

STAGE 06

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT

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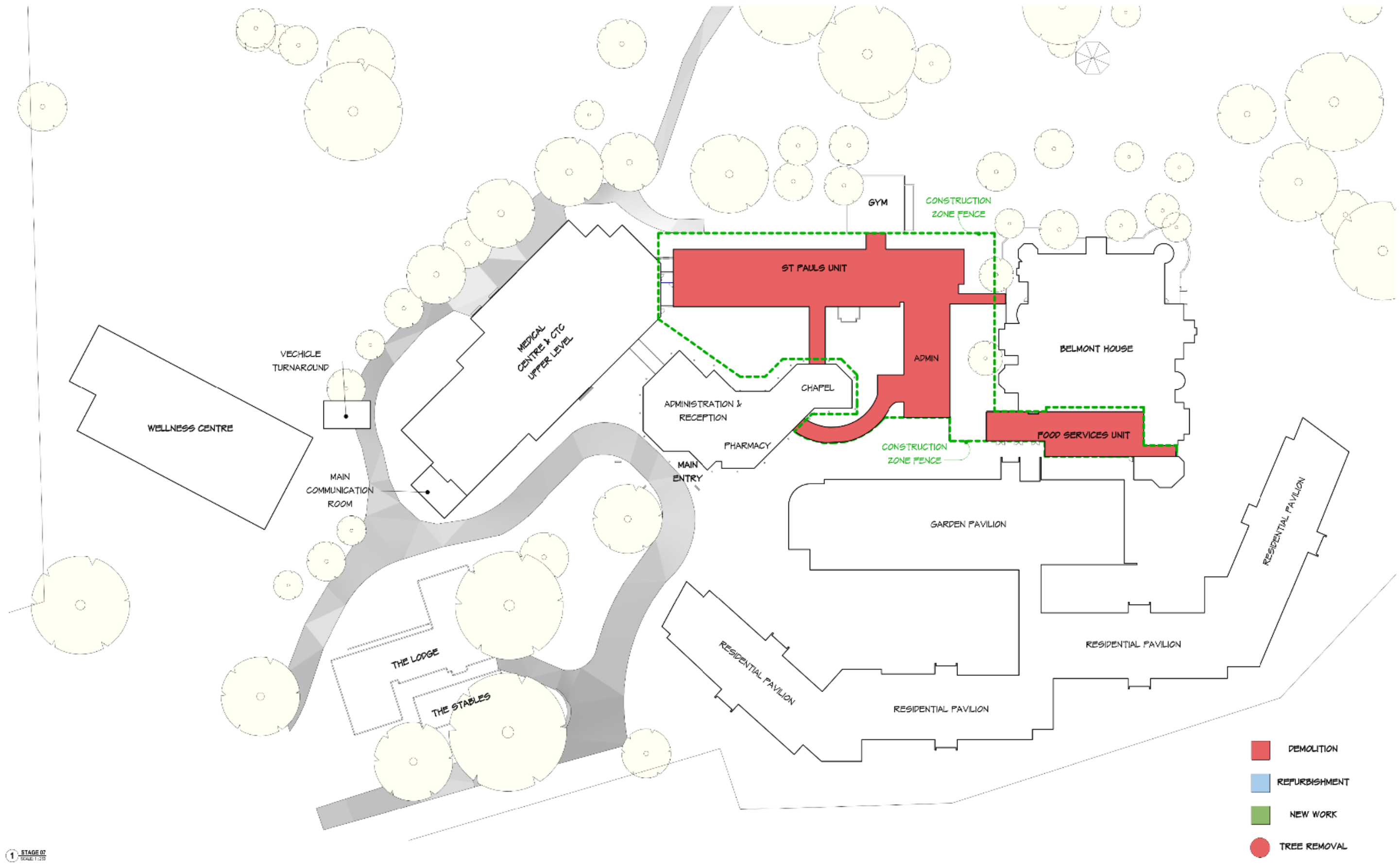
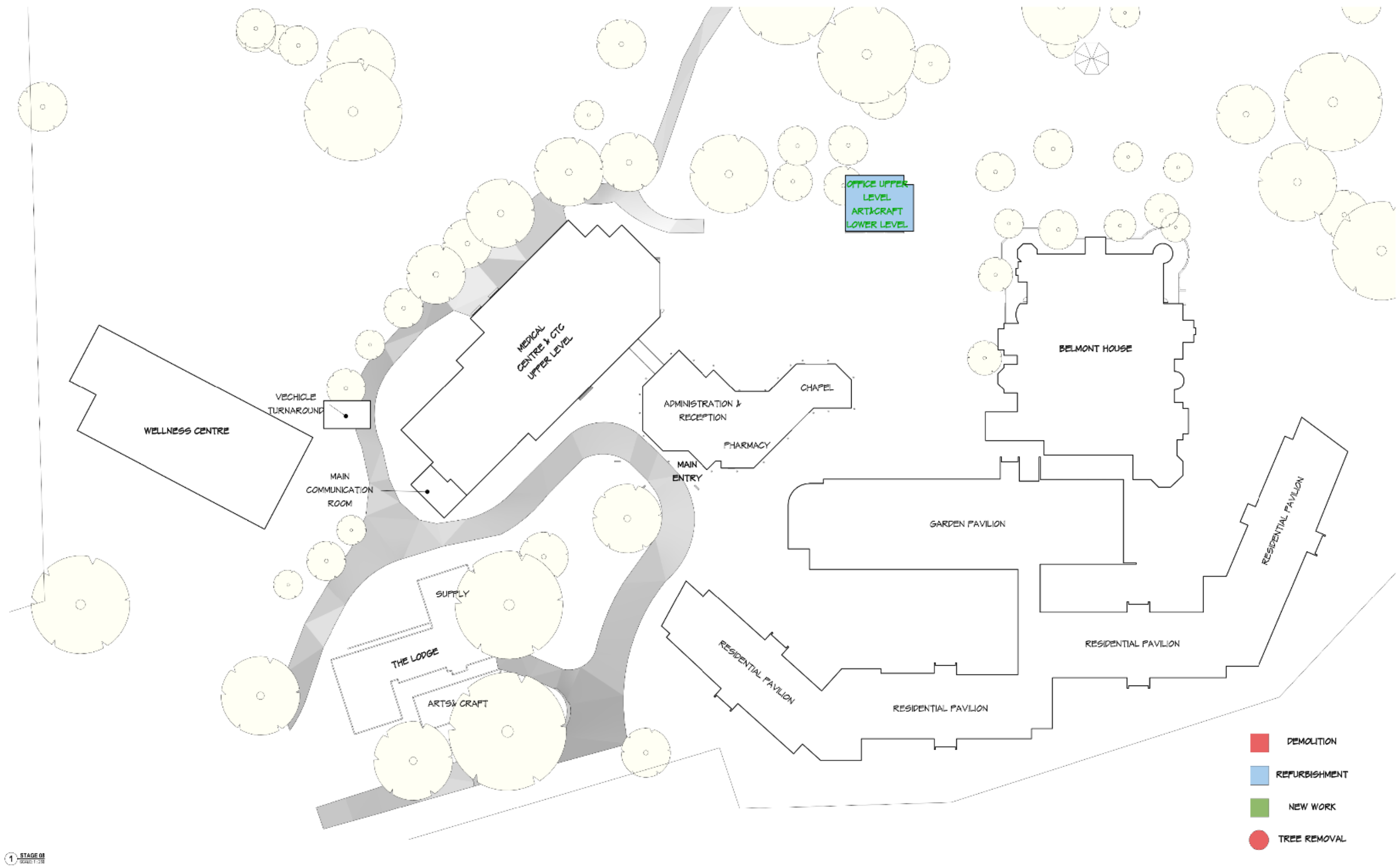


STAGE 07

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT | Project Number 10444 | Scale @ A0 Sheet Size As indicated | Date 27/11/20 | Revision: P1 | Drawing Number: SSK36



STH

JOHNSTAFF

ST JOHN OF GOD Health Care

STAGE 08

ST JOHN OF GOD RICHMOND HOSPITAL REDEVELOPMENT

Project Number 10444 | Scale @ A0 Sheet Size As indicated | Date 27/11/20 | Revision: P1 | Drawing Number: SSK37

Design with
community in mind

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