

MANILLA DISTRICT HOSPITAL REDEVELOPMENT NOISE AND VIBRATION ASSESSMENT

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1 INTRODUCTION

Renzo Tonin & Associates were engaged to conduct an environmental noise and vibration assessment for the redevelopment of Manilla District Hospital located at Court St, Manilla. More specifically, this report quantifies the impact from site operation and construction activities associated with the proposed development.

Noise impact is assessed according to the requirements of the Director General and the NSW Department of Environment and Climate Change (DECC). Noise emissions from the site are calculated at the potentially most affected neighbouring residences and in-principle noise mitigation measures are provided where required to reduce noise emissions to within the DECC requirements.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

2 PROJECT DESCRIPTION

2.1 Location

Manilla Hospital is located at the eastern end of Court Street, Manilla and is bound by residential properties to the north in Strafford Street, to the west along Court Street and to the east in Kanangra Road. Manilla water treatment plant and a Citizens Centre are located opposite the site, along the southern side of Court Street.

Inspection of the area surrounding the site identified the following residential locations as critical receivers potentially affected by noise emanating from the proposed site.

- **Receiver R1** – Residential properties located at 99-109 Strafford Street, adjoining the site to the north.
- **Receiver R2** – Double storey residential property located at 110 Court Street, adjoining the site to the west.
- **Receiver R3** – Residential property located at 135 Court Street, approximately 30 metres south of the site.
- **Receiver R4** – Residential properties located at the corner of Strafford Street and Kanangra Road including 115, 117 Strafford Street and 3 Kanangra Road, adjoining the site to the east.
- **Receiver R5** – Manellae Lodge located 30 metres south-east of the existing site.

The selected locations are shown in Figure 1 of Appendix B

We note that there is terrain height difference of approximately 15 metres between the hospital and residences located in Strafford Street and Kanangra Road. Currently, newly built residential dwellings as well as vacant land for sale within both Strafford Street and Kanangra Road exist. Therefore, further residential development is expected adjacent to Manilla hospital.

2.2 Project description

The proposed redevelopment of Manilla Hospital will include demolition of the existing hospital and construction of new single storey buildings. The proposed development will also include staff accommodation, on-site car parking and additional landscaping.

The proposed on-site car park will be located at the western end of the site and will contain provision for public car spaces, staff parking, bus, and motorcycle spaces. There will be access driveways to the site for both general entry and ambulance entry via Court Street.

A mechanical plant enclosure area will be situated on the roof containing 9 condenser units exhaust fans. The enclosure is to have no roof and the walls are to be fitted with standard louvers. Solar panels will also be installed on the roof. The staff accommodation building will include 1 condenser unit proposed to be located outdoors underneath the decking.

A fire booster pump and a back-up generator could be utilised in the event of emergency or during testing. The fire booster pump will be located in an enclosure which has 3 solid walls, 1 open wall and a roof within the services area, while the back-up generator will be fully enclosed in a room.

2.3 Noise Issues

The Director General requires the following noise and vibration issues to be addressed:

- Construction noise and vibration during the development of the site;
- Continuous noise from mechanical plant once site is in operation.

3 EXISTING ACOUSTIC ENVIRONMENT

3.1 Noise Monitoring Methodology

Noise monitoring was conducted to quantify the existing noise environment so that noise criteria for the development could be determined. Monitoring was conducted between Tuesday 20th January and Wednesday 21st January 2009 to establish existing ambient and background noise levels.

Appendix C details the noise monitoring methodology and the graphical recorded output from long term noise monitoring is included in **Appendix D**.

3.2 Noise Monitoring Locations

Noise measurements are to be taken at the nearest or potentially most affected residential locations. In this case a location representative of the potentially most affected receivers was selected, whilst also ensuring noise from the existing hospital was not audible.

- **Location L1** **121 Court Street, Manilla.**

Noise logger placed in the front yard in the 'free field' (at least 3.5m from any structures). Noise environment is dominated by natural sounds and intermittent traffic noise from Court Street.

The monitoring location is shown on Figure 1 in Appendix B.

3.3 Existing Background, Ambient & Traffic Noise Levels

Table 1 presents the measured L_{eq} and L_{90} noise levels for the day, evening and night periods as defined in the DECC's INP.

- **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.

Table 1 - Measured Existing Background (L_{90}) & Ambient (L_{eq}) Noise Levels, dB(A)

Noise Monitoring Location		L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
		Day	Evening	Night	Day	Evening	Night
L1	121 Court Street, Manilla	37	35	31	51	48	44

Notes: Day is defined as 7:00am to 6:00pm, Monday to Saturday; 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; 10:00pm to 8:00am Sundays & Public Holidays.

From the noise monitoring conducted over approximately 24 hours, the lowest background noise level has been determined to be 31dB(A) at night. According to p24 of the INP, even where background noise levels are measured to be below 30dB(A), they should be set to 30dB(A) for the purpose of setting noise criteria. Therefore, despite the limited duration of noise monitoring, the noise criteria will be close to the minimum allowable value, and therefore additional noise monitoring would not change the criteria significantly.

3.4 Short-Term Monitoring

To help establish and characterise existing background and ambient noise levels, short term noise measurements were conducted on Tuesday 20th January 2009 and Wednesday 21st January 2009.

The short term noise measurements were conducted using a B&K 2260 precision sound level meter. This instrument complies with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and is designated as Type 1 instrument having an accuracy suitable for field and laboratory use. The sound level analyser was calibrated prior and subsequent to the measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed.

The sound level meter was placed 1.5m above ground level in the 'free field' at the following locations:

- **Location S1 – 135 Court Street, Manilla**

Near front boundary and approximately 40 metres south-west of the site. Noise environment dominated by natural sounds and intermittent traffic noise from Court Street. Noise levels at this location were considered representative of Receiver R2, R3 and R5.

- **Location S2 – Vacant block west of 99 Strafford Street, Manilla**

Near front boundary fence and approximately 130m north-west of the site. Noise environment dominated by natural sounds and intermittent traffic noise from Strafford Street. Noise levels at this location were considered representative of Receivers R1 and R4.

Locations S1 and S2 are shown in Figure 1 of Appendix B.

Short-term noise measurements were carried out during separate periods of the day and the results are provided in the table below.

Table 2 – Measured Existing Short Term Noise Levels

Noise Monitoring		Time	Noise Source	L _{Aeq}	L _{A90}
S1	135 Court Street, Manilla	11:35 – 11:50	Insects, ducks and intermittent traffic noise from Court St	54	42
		15:30 - 15:45	Birds, insects and intermittent traffic noise from Court St	57	43
		21:15 – 21:30	Mechanical plant from hospital clearly audible and insect noise	42	40
S2	Vacant block west of 99 Strafford Street, Manilla	11:55 – 12:10	Insects, ducks and intermittent traffic noise from Strafford St	53	40
		15:55 – 16:10	Birds, insects and intermittent traffic noise from Strafford St	57	41
		21:35 – 21:50	Mechanical plant from hospital audible and insect noise	43	42

4 OPERATIONAL NOISE ASSESSMENT OF MECHANICAL PLANT

4.1 Noise Criteria

The Director General's requirements do not state specific noise criteria, therefore we refer to NSW DECC's INP for operational noise.

4.2 NSW DECC's INP

Operational noise from mechanical plant is assessed to NSW Industrial Noise Policy (INP, Department of Environment and Climate Change). The assessment procedure in terms of the NSW INP has two components:

- Controlling intrusive noise impacts in the short term for residences
- Maintaining noise level amenity for particular land uses for residences and other land uses.

4.2.1 Intrusive Noise Impacts

According to the INP, the intrusiveness of a mechanical noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5dB(A).

The intrusiveness criterion is summarised as follows:

$$L_{Aeq, 15 \text{ minute}} \leq L_{A90} \text{ background noise level plus } 5\text{dB(A)}$$

Therefore the strictest intrusiveness criteria using the lowest background measurements are presented below for each assessment location:

Table 3 – DECC $L_{Aeq,15\text{min}}$ Intrusiveness Criteria

Period	Intrusiveness Criteria, dB(A)
	Receiver R1, R2, R3 and R4
Daytime ¹	$\leq 37 + 5 = 42$
Evening ²	$\leq 35 + 5 = 40$
Night ³	$\leq 31 + 5 = 36$

Note:

1. Daytime refers to the period from 0700 to 1800 (Monday to Saturday) and 0800 to 1800 (Sundays and Public Holidays)

2. Evening refers to the period from 1800 to 2200

3. Night time refers to the period from 2200 to 0700h (Monday to Saturday) and 2200 to 0800 h (Sundays and Public Holidays)

4.2.2 Protecting Noise Amenity

The Amenity Criteria are determined in accordance with Chapter 2 of the NSW INP. The INP recommends base acceptable noise levels for various receivers, including residential, commercial, industrial receivers and sensitive receivers such as schools, hospitals, churches and parks. These base noise criteria are then lowered by up to 10dB depending on the extent of existing industrial noise impact upon the receiver. Higher levels of existing industrial noise therefore result in stricter Amenity Criteria applied to any new industrial development. In this way the cumulative impacts of existing and known future industrial noise sources are minimised.

To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1 of the policy, the applicable parts of which are reproduced below.

Table 4 - Amenity Criteria – Recommended L_{Aeq} Noise Levels from Industrial Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level	
			Acceptable	Recommended Maximum
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
Note:	1. Daytime refers to the period from 0700 to 1800 (Monday to Saturday) and 0800 to 1800 (Sundays and Public Holidays) 2. Evening refers to the period from 1800 to 2200 3. Night time refers to the period from 2200 to 0700h (Monday to Saturday) and 2200 to 0800 h (Sundays and Public Holidays)			

4.3 Noise Sources

4.3.1 Mechanical Plant

Mechanical plant is to be installed on the outside of the main hospital and staff accommodation buildings in order to cater for air conditioning, ventilation and air extraction. Solar panel are being utilised and therefore heat pumps are not required as part of the mechanical services. The make and model numbers for the condenser units were provided by Norman Disney and Young as follows:

Main Building

- 9 condenser units:
 - DAIKIN Model No. REYQ10PY1 x 3
 - DAIKIN Model No. REYQ12PY1 x 2
 - DAIKIN Model No. REYQ14PY1 x 4

Staff Accommodation Building

- 1 condenser unit - DAIKIN Model No. REYQ8PY1 x 1

The fire booster pump has an estimated exhaust noise of 92 dB(A) at 1m. However, it is proposed that a muffler will be utilised which reduces the exhaust noise emission to 60 dB(A) at 1m.

The locations of the proposed mechanical plant are indicated in the mechanical ventilation plans provided by Norman Disney and Young (Drawing Nos. M-OG-001, M-OG-002, M-OG-003, M-OG-004, M-OR-002 and M-OR-004, dated 11.11.08).

Noise data used in the noise prediction model, as provided by Norman Disney and Young, are shown in the table below:

Table 5 - Sound Pressure Levels of Proposed Condensers and Heat Pump

Mechanical Plant Description	Sound Pressure Level @ 1m, dB(A)
DAIKIN Model No. REYQ8PY1	58
DAIKIN Model No. REYQ10PY1	58
DAIKIN Model No. REYQ12PY1	60
DAIKIN Model No. REYQ14PY1	62
Fire Booster Pump	60

4.4 Predicted Noise Levels

Operational noise predictions have been based on the architectural drawings provided by Rice Daubney (drawing no. SK1200, dated August 2008) and mechanical plant data provided by Norman Disney and Young.

For noise prediction purposes the following worst-case scenario for both the intrusiveness and amenity assessments during the continuous operation of the facility (24 hours a day) was assumed:

- All compressors and heat pumps in operation simultaneously
- The back-up generator is shielded from residences
- A conservative reduction of 5 dB(A) to noise emitting from outdoor mechanical plant situated at the staff accommodation building to account for shielding to residential receivers R2, R3 and R5.

Based on the above information and assumptions, the predicted noise levels at residential receivers are as follows:

Table 6 - Predicted Noise Levels from Mechanical Plant

Receiver	Period	INP Criteria		Predicted Noise Levels, L_{Aeq}
		Intrusive	Amenity	
R1 - Strafford Street residences	Day	42	55	33
	Evening	40	50	33
	Night	36	45	33
R2 – 110 Court Street	Day	42	55	32
	Evening	40	50	32
	Night	36	45	32
R3 – 135 Court Street	Day	42	55	31
	Evening	40	50	31
	Night	36	45	31
R4 - corner of Strafford Street and Kanangra Road	Day	42	55	30
	Evening	40	50	30
	Night	36	45	30
R5 – Manellae Lodge	Day	42	55	35
	Evening	40	50	35
	Night	36	45	35

Noise levels from mechanical plant are predicted to comply with both the intrusiveness and amenity criteria at all times and therefore no additional noise mitigation is required.

5 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

5.1 Construction Noise Criteria

Chapter 171 of the NSW *Environmental Noise Control Manual* (ENCM, Environment Protection Authority 1994) provides guidelines for assessing noise generated during the construction phase. However, the Department of Environment and Climate Change (DECC) has recently released its draft *NSW Construction Noise Guideline* (CNG). This document is currently only issued for consultation and comment, although it will become DECC's standard policy for assessing construction noise. It is intended that this new guideline will supersede Chapter 171 of the ENCM.

The key components of the policy that could be incorporated into this assessment include:

1. Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.

In recent years NSW noise policies including DECC's NSW Industrial Noise Policy (INP) and the NSW Environmental Criteria for Road Traffic Noise (ECRTN) have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

Consistent with the latest guideline (CNG) we recommend the use of L_{Aeq} as the key descriptor for measuring and assessing construction noise.

2. Application of reasonable and feasible noise mitigation measures

As stated in the CNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints

Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

3. Quantitative and qualitative assessment

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

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

A qualitative assessment is recommended for small projects with a duration of less than one week and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the significant scale of the construction works proposed for this project, a quantitative assessment is carried out herein, consistent with the CNG's requirements.

Management Levels

The table below (reproduced from Table 4.1 of the CNG) sets out the noise management levels and how they are to be applied. The guidelines intend to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

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

Table 7 – Noise at Residences Using Quantitative Assessment

Time of Day	Management Level $L_{Aeq} (15 \text{ min})^*$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected $RBL + 10dB(A)$	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq} (15 \text{ min})$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected $RBL + 5dB(A)$	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(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 <i>NSW Construction Noise Guideline</i> .

** 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 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence*

Based on the background noise levels measured for this project, the construction noise criteria are summarised below.

Table 8 – Summary of Construction Noise Management Levels

Time of Day	Management Level L_{Aeq} (15 min)	Construction Noise Management Level, dB(A)
During recommended standard hours (Day)	RBL + 10dB(A)	47
Outside recommended standard hours (Evening)	RBL + 5dB(A)	40
Outside recommended standard hours (Night)		36

5.2 Proposed Construction Hours

The proposed hours for construction works at Manilla Hospital are:

- Monday to Friday 7.00am – 6.00pm
- Saturday 7:00am – 1:00pm
- No work will be undertaken on Sundays or Public Holidays unless emergency works are required.

There may be some work conducted outside of these times, however it will be restricted to internal fit-out and hospital recant/decant. There will be no use of plant outside of the proposed hours. The duration of the construction for the proposed project is expected to be up to 26 months.

5.3 Construction Vibration Criteria

5.3.1 Disturbance to Buildings Occupants

For disturbance to human occupants of buildings, we refer to DECC's '*Assessing Vibration; a technical guideline*', published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'.

Vibration sources are defined as *Continuous*, *Impulsive* or *Intermittent*. Section 2 of the technical guideline defines each type of vibration as follows:

Continuous vibration continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).

Impulsive vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.

Intermittent vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude'.

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

‘Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).’

Preferred and maximum values for continuous and impulsive vibration are defined in table 2.2 of the guideline and are reproduced below.

Table 9 - Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2) 1-80Hz

Location	Assessment period ¹	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Critical areas ²	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, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration					
Critical areas ²	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, schools, educational institutions and places of worship	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

1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

Notes: 2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 2.4 of the guideline and are reproduced below.

Table 10 – Acceptable vibration dose values for intermittent vibration ($\text{m/s}^{1.75}$)

Location	Daytime ¹		Night-time ¹	
	Preferred values	Maximum values	Preferred values	Maximum values
Critical areas ²	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992

5.3.2 Structural Damage to Buildings

Currently there exists no Australian Standard for assessment of structural building damage caused by vibrational energy. Therefore, reference is made to both the British and German standards below which are relevant to the assessment of structural damage.

British Standard

British Standard 7385: Part 2 “Evaluation and measurement of vibration in buildings”, can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which ‘cosmetic’, ‘minor’ and ‘major’ categories of damage might occur.

BS7385 recommends that the peak particle velocity is used to quantify vibration and specifies damage criteria for frequencies within the range 4Hz to 250Hz, which is the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The levels from the standard are given below.

Table 11 – BS 7385 Structural Damage Criteria

Group	Type of Structure	Peak component particle velocity, mm / s		
		4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings		50	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 to 20	20 to 50	50

The peak vibration limits set for minimal risk of ‘cosmetic’ damage are: 15mm/s for un-reinforced or light framed structures, for example residential or light commercial buildings (Group 2; increasing as the frequency content of the vibration increases) and 50mm/s for reinforced or framed structures, for example industrial and heavy commercial buildings (Group 1; constant across all frequencies). ‘Minor’ damage is considered possible at vibration

magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

These values relate to transient vibrations and to low rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%.

The levels set by this standard are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular types of buildings. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls.

This standard states that it considers sources of vibration including blasting, demolition, piling, ground treatments, compaction, construction equipment, tunnelling, road and rail traffic and industrial machinery.

As stated in the standard, it sets guide values for building vibration based on the lowest levels above which damage has been credibly demonstrated. That is, it gives guidance on the levels of vibration above which building structures could be damaged.

German Standard

The German standard DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures", also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum 'safe limit' of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (eg historical with preservation orders etc), it is 3mm/s. These limits increase as the frequency content of the vibration increases. These values are presented in the table below and are generally recognised to be conservative.

Table 12 – DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm / s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz 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

Group	Type of Structure	Vibration Velocity, mm / s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

5.4 Proposed Construction Activities

Construction works will take place on the existing hospital site. During construction, there will be use of council land for the site compound. The construction schedule is to be completed in 2 stages. The locations of these stages are shown on the architectural drawings provided by Rice Daubney (drawing no. SK 1200, dated November 08).

The proposed construction activities are summarised in the table below.

Table 13 - Proposed Construction Activities

Activity	Description of Activity	Duration	Works zone
Decant	No use of plant equipment	10 days	Stage 1
Site establishment	Use of manatou and HIAB to locate site sheds	5 days	Stage 1
Demolish existing northern end of the hospital	Use of excavator, truck and dog, backhoe and skid steer	2 months	Stage 1
Construction	First 4 months civil and structural works will incorporate the majority of heavy machinery, following 6 months will be internals and fit out which will incorporate Manatou, scissor lift, general construction hand power/air tools	10 months	Stage 1
Commission and Handover	Use of scissor lift, general construction hand power/air tools	10 days	Stage 1
Stage Transition – HNEAHS Recant stage 1 and decant stage 2	Hard landscaping on roadways and paths, soft landscaping in external areas	20 days	Stage 1 and Stage 2
Site Establishment	Use of manatou	5 days	Stage 2
Demolish existing southern end of the hospital	Use of excavator, truck and dog, backhoe and skid steer	2 months	Stage 2

Construction	First 4 months civil and structural works will incorporate the majority of heavy machinery, following 6 months will be internals and fit out which will incorporate Manatou, scissor lift, general construction hand power/air tools	10 months	Stage 2
Commission and hand-over	Use of scissor lift, general construction hand power/air tools	10 days	Stage 2

5.5 Construction Noise Sources

The following table lists construction plant and equipment likely to be used by the contractor to carry out the necessary construction work for this project.

Table 14 - Typical Construction Equipment & Sound Power Levels, dB(A)

Plant Item	Plant Description	Sound Power Levels		
		Range	Typical L _{A10} (Mid Point)	Typical L _{Aeq} (Mid Point)
1	Pneumatic Hand Tools (general)	110 – 115	113	110
2	Mobile Crane/HIAB/Manatou	110 – 115	113	110
3	Compactor	110 – 115	113	110
4	Pavement Laying Machine	110 – 114	112	109
5	Drum Roller/Sheep's Foot Roller/Trench Roller	108 - 111	110	107
6	Tracked Excavator	107 - 115	110	107
7	Grader	107 – 115	110	107
8	Water Cart	106 – 108	107	104
9	Rollers	100 – 113	107	104
10	Truck (>20tonne)	103 – 108	106	103
11	Asphalt Truck	106 – 106	106	103
12	Scissor Lift	105 – 105	105	102
13	Backhoe	101 – 108	104	101
14	Power Generator	100 – 106	103	100

Notes: 1. The sound power data within the column marked "Typical (Mid-Point)" has been used in this study to calculate typical noise levels at the nominated assessment locations.

The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table D2 of Australian Standard 2436 - 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", DECC's Draft 'NSW Construction Noise Guideline', information from past projects and information held in our library files.

5.6 Construction Vibration Sources

Typical vibration levels from construction equipment most likely to cause significant vibration are summarised below. The information was sourced from a variety of reference materials available in the Renzo Tonin & Associates library.

Table 15 - Typical Ground Vibration Generated by Construction Plant

Activity	Typical Ground Vibration
Excavators	Typical ground vibration from bulldozers range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s.
Vibratory rollers	Ground vibration caused by vibratory rollers can range up to 1.5mm/s at distances of 25m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground/structure. Machinery should therefore not be brought to rest when in the vicinity of susceptible buildings, especially dwellings. Higher levels could occur at closer distances, however, no damage would be expected for any building at distances greater than approximately 12m (for a medium to heavy roller).
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels in the range of 0.01 - 0.2mm/s at the footings of buildings located 10 - 20m from a roadway. Very large surface irregularities can cause levels up to five to ten times higher. In general, ground vibration from trucks is usually imperceptible in nearby buildings. The rattling of windows and other loose fittings that is sometimes reported is more likely to be caused by airborne acoustic excitation from very low frequency (infrasonic) noise radiated by truck exhausts and truck bodies. While this may cause concern to the occupants, the phenomenon is no different from the rattling caused by wind or people walking or jumping on the floor and fears of structural damage or even accelerated ageing are usually unfounded.

5.7 Construction Noise and Vibration Predictions

5.7.1 Construction Noise

Noise levels at any receptors resulting from construction would depend on the location of the receptor with respect to the area of construction, shielding from intervening topography and structures and the type and duration of operation being undertaken. Furthermore, noise levels at receivers will vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Based on the typical construction activities presented in Table 13, the range of noise levels likely to be experienced by residents at Receivers R1, R2, R3, R4 and R5 are presented in Table 16 below.

Table 16 – L_{Aeq} Noise Level Ranges for Construction Activities

Work Area	Activity	Receiver R1	Receiver R2	Receiver R3	Receiver R4	Receiver R5
Stage 1	Demolition	59 - 67	55 - 64	55 - 63	58 - 67	61 - 69
	Construction	56 - 74	53 - 71	52 - 70	56 - 73	56 - 74
Stage Transition – Stage 1 and 2	Landscaping	58 - 63	68 - 74	66 - 71	56 - 62	62 - 68
Stage 2	Demolition	58 - 67	59 - 67	59 - 67	55 - 63	57 - 65
	Construction	56 - 73	56 - 74	56 - 74	52 - 70	55 - 72

The predicted construction noise levels are below 75dB(A) at all residences and therefore neighbours are not expected to be 'highly' affected. However, the levels are in exceedance of the set management levels and therefore all reasonable and feasible work practices should be applied to minimise noise. Recommendations for noise mitigation are made in Section 5.8 below.

5.7.2 Construction vibration

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of a vibration, are all important aspects in both the annoyances caused and the strains induced in structures.

The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific. Accordingly, indicative minimum 'buffer' distances have been developed for various plant types (based on recent projects undertaken by Renzo Tonin & Associates) to avoid human discomfort during daytime hours for residential type buildings as shown in Table 17 below. It is noted that since the human comfort criteria is more stringent than the structural damage criteria, if compliance is achieved for the assessment of human comfort, then compliance will also be achieved for the assessment of structural damage to buildings.

Table 17 - Recommended Minimum Buffer Distances for Construction Plant

Plant Item	Recommended Minimum Buffer Distance (m)
Vibratory rollers - light	5
Vibratory rollers - medium	12
Vibratory rollers - heavy	25
Truck movements	10

Based on the above table and the closest residences being a minimum distance of approximately 20m away, vibration levels from construction plant and equipment are anticipated to generally comply with the set limits for human comfort. However, should heavy vibratory rollers be used, then exceedance of the set limits may be experienced. Therefore, it is recommended that no heavy rollers be used within 25m of residential properties.

5.8 Construction Noise and Vibration Mitigation

5.8.1 Construction Noise Mitigation

The following recommendations provide in-principle noise control solutions to reduce noise impacts to residential receivers. Where actual construction activities differ from those assessed in this report, more detailed design of noise control measures may be required once specific items of plant and construction methods have been chosen and assessed on site.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table 18 below outlines a number of techniques and options for controlling construction noise and vibration, where considered reasonable and feasible.

Table 18 – Construction Noise and Vibration Management Options

Construction Noise and Vibration Management Options	
Source controls	
Time constraints	Heavy machinery should not be started and noisy activities should not commence prior to 7am. The 6.30am to 7am work period should be used only for staff arrivals and equipment preparation. Consider implementing respite periods with low noise/vibration-producing construction activities.
Scheduling	Perform noisy work during less sensitive time periods. Provide respite periods for residences Organise deliveries and access – Amalgamated loads can lead to less noise and congestion in nearby streets and optimise the number of vehicle trips to and from the site.
On Site	Note large reflecting surfaces on and off site that might increase noise levels, and avoid placing noise-producing equipment in locations where reflected noise will increase noise exposure or reduce the effectiveness of mitigation measures. Ensure site managers periodically check the site and nearby residences and other sensitive land uses for noise problems so that solutions can be quickly applied.
Equipment restrictions	Select low-noise plant and equipment. Pneumatic equipment is traditionally a problem – select supersilenced compressors and damped bits where possible. Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended Ensure equipment has the most effective mufflers, enclosures and low-noise tool bits and blades where reasonable and feasible. Always seek the manufacturer's advice before making modifications to plant to reduce noise. Use alternatives to diesel and petrol engines and pneumatic units, such as hydraulic or electric-controlled units where feasible and reasonable. Where there is no electricity supply, use an electrical generator located away from residences. Operate plant in a quiet and efficient manner - Reduce throttle setting and turn off equipment when not being used.
Emission restrictions	Establish stringent noise emission limits for specified plant and equipment. Implement noise monitoring audit program to ensure equipment remains within specified limits.
Substitute methods	Use quieter and less vibration emitting construction methods where possible.
Limit equipment on site	Only have necessary equipment on site.
Limit activity duration	Where possible, concentrate noisy activities at one location and move to another as quickly as possible. Any equipment not in use for extended periods during construction work should be switched off.
Equipment Location	Noisy plant and equipment should be located as far as possible from noise sensitive areas, optimising attenuation effects from topography, natural and purpose built barriers and materials stockpiles.
Site access	Vehicle movements outside construction hours, including loading and unloading operations, should be minimised and avoided where possible.

Equipment maintenance	Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the design specifications. For machines with enclosures, check that doors and door seals are in good working order and that the doors close properly against the seals. Return any hired equipment that is causing noise that is not typical for the equipment – the increased noise may indicate the need for repair Ensure air lines on pneumatic equipment do not leak.
Reduced equipment power	Use only necessary size and power.
Quieter work practices	For example, implement worksite induction training, educating staff on noise sensitive issues and the need to make as little noise as possible.
Reversing alarms	Consider alternatives, such as manually adjustable or ambient noise sensitive types ("smart" reversing alarms) and closed circuit TV systems. Alternative site management strategies can be developed, in accordance with the Occupational Health and Safety Plan, with the concurrence of the Occupational Health and Safety Officer.
Path controls	
Noise barriers	Consider installing temporary construction noise barriers. Maximise shielding - Locate equipment to take advantage of the noise barriers provided by existing site features and structures, such as the existing southern end of the hospital will still be standing during Stage 1 construction which can be used to provide some shielding between plant and residents. Reduce the line-of-sight noise transmission to residences by using temporary barriers. Temporary noise barriers can be constructed from hoarding (plywood boards, panels of steel sheeting or compressed fibre cement board) with no gaps between the panels at the site boundary. Site buildings and material stockpiles can be effective temporary barriers.
Project Planning	Construction should be programmed so that noise barriers or mounding required to control noise are built as soon as possible.
Enclosures	Install noise-control kits for noisy mobile equipment and shrouds around stationary plant, as necessary.
Increased distance	Locate noisy plant as far away from noise-sensitive receptors as possible.
Site access	Select and locate site access roads as far away as possible from noise-sensitive areas.
Receptor controls	
Structural surveys and vibration monitoring	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.
Consultation	Community consultation, information, participation and complaint responses are essential aspects of all construction noise management programs. They typically involve: A community information program before construction and/or high risk activities are commenced. This usually involves a leaflet distribution and direct discussions and negotiations with affected residents, explaining the type, time and duration of expected noise emissions. The involvement of affected residents in the development of acceptable noise management strategies. A nominated community liaison officer with a contact telephone number. A complaints hotline. Timely responses to complaints, providing information on planned actions and progress towards the resolution of concerns.
Noise / Vibration Monitoring	Noise and vibration monitoring should be conducted during the Stage 1 demolition to determine noise impact and to assist with implementation of noise mitigation.

Where noise mitigation is found to be reasonable and feasible it should be implemented. Table 19 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 19 - Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	7 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 30	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	15 to 25	15 to 25	60	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436, for this assessment.

Table 20 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 20 - Noise Control Measures for Likely Construction Plant

Plant Description	Screening	Acoustic Enclosures	Silencing	Alternative Process
Backhoe	✓	✗	✓	✗
Pneumatic Hand Tools (general)	✓	✓	✓	✓
Excavator/Compactor/Rollers	✓	✗	✓	✗
Pavement Laying Machine	✓	✗	✓	✗
Mobile Crane/HIAB/Manatou	✓	✓	✓	✗
Trucks (>20 tone)	✓	✗	✓	✗
Water Cart	✓	✗	✓	✗

5.8.2 Construction Vibration Mitigation

The following in-principle vibration control measures are provided to minimise vibration impact from construction activities to the nominated occupancies and to meet DECC's human comfort vibration limits:

- The proper implementation of a construction noise and vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with stakeholders is recommended and should be aimed at providing a communication path directly to the contractor.
- All residential and commercial stakeholders within the vicinity of the proposed depot should be notified prior to the commencement of substantial construction that vibration may be perceptible during construction activities.
- A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences.
- Carry out vibration testing of actual equipment on site to determine acceptable site-specific buffer distances to sensitive occupancies.
- Carry out additional vibration monitoring when construction activities are at the nearest point to the nominated occupancies. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach / exceed the recommended limits in nearby occupancies.
- Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller rock breakers, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.
- Before, during and after the construction work we recommend preparation of a dilapidation report on the state of any existing buildings within 20m of the construction zone.

6 CONCLUSION

Renzo Tonin & Associates have completed an assessment of both operational noise impact and construction noise and vibration impact from the proposed redevelopment of Manilla District Hospital located at Court Street, Manilla.

The assessment for operational noise impact of mechanical plant upon potentially affected residential receivers has been quantified and compared to the noise guidelines set by the NSW DECC. Operational noise from the site was found to comply with the set criteria at all critical receivers, therefore no additional noise mitigation measures are required.

Noise emission from demolition, excavation and construction equipment upon the nearest affect residential receivers has been quantified. Residents are likely to be noise affected during the construction phase and therefore all reasonable and feasible noise and vibration mitigation should be implemented.

APPENDIX A - GLOSSARY OF ACOUSTIC TERMS

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

<i>Adverse Weather</i>	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
<i>Ambient Noise</i>	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
<i>Assessment Period</i>	The period in a day over which assessments are made.
<i>Assessment Point</i>	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
<i>Background Noise</i>	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L₉₀ noise level (see below).
<i>Decibel [dB]</i>	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street

100dB The sound of a rock band

115dB Limit of sound permitted in industry

120dB Deafening

dB(A): A-weighted decibels The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.

Frequency Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.

Impulsive 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 The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.

L_{max} The maximum sound pressure level measured over a given period.

L_{min} The minimum sound pressure level measured over a given period.

L_1 The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.

L_{10} The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

L_{90} The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).

L_{eq} The “equivalent noise level” is the summation of noise events and

integrated over a selected period of time.

<i>Reflection</i>	Sound wave changed in direction of propagation due to a solid object obscuring its path.
<i>SEL</i>	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
<i>Sound</i>	A fluctuation of air pressure which is propagated as a wave through air.
<i>Sound Absorption</i>	The ability of a material to absorb sound energy through its conversion into thermal energy.
<i>Sound Level Meter</i>	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
<i>Sound Pressure Level</i>	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
<i>Sound Power Level</i>	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
<i>Tonal noise</i>	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B - MAPS

B.1 Figure 1 - Monitoring locations and residential receivers



APPENDIX C - LONG TERM NOISE MONITORING METHODOLOGY

Noise Monitoring Equipment

All long term noise monitoring was conducted using RTA Technology noise loggers. The noise monitoring equipment used here complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as a Type 2 instrument suitable for field use.

A noise monitor consists of a sound level meter and a computer housed in a weather resistant enclosure. Ambient noise levels were recorded at a rate of 10 samples per second. Every 15 minutes, the data is processed statistically and stored in memory. The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 calibrator. No significant drift in calibration was observed.

Meteorology during Monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the INP. The Bureau of Meteorology (BOM) provided meteorological data, which is considered representative of the site, for the duration of the noise monitoring period. The data was modified to allow for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10m above ground level, and the microphone location, which is at 1.5m above ground level. The correction factor applied to the data was taken from *Australian Standard AS1170.2 1989 Section 4.2.5.1*.

Noise vs Time Graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10} , L_{90} , and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually ten to fifteen minutes. The Noise -vs- Time graphs in Appendix D illustrate these concepts.

Noise levels are commonly measured in units of A-weighted decibels or dB(A). The "A-weighting" refers to a standardised amplitude versus frequency curve used to "weight" sound measurements to represent the response of the human ear. The human ear is less sensitive to low pitch sound than it is to high pitch sound. Overall A-weighted measurements quantify sound with a single number to represent how people subjectively hear different frequencies at different levels.

Background noise is the term used to describe the noise measured in the absence of the noise under investigation. 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 time period. This is represented as the L_{90} noise level.

APPENDIX D - NOISE MONITORING RESULTS

121 Court St, Manilla - Front Yard

BACKGROUND & AMBIENT NOISE MONITORING RESULTS

NSW DEC's 'INDUSTRIAL NOISE POLICY', 2000

[illegible]

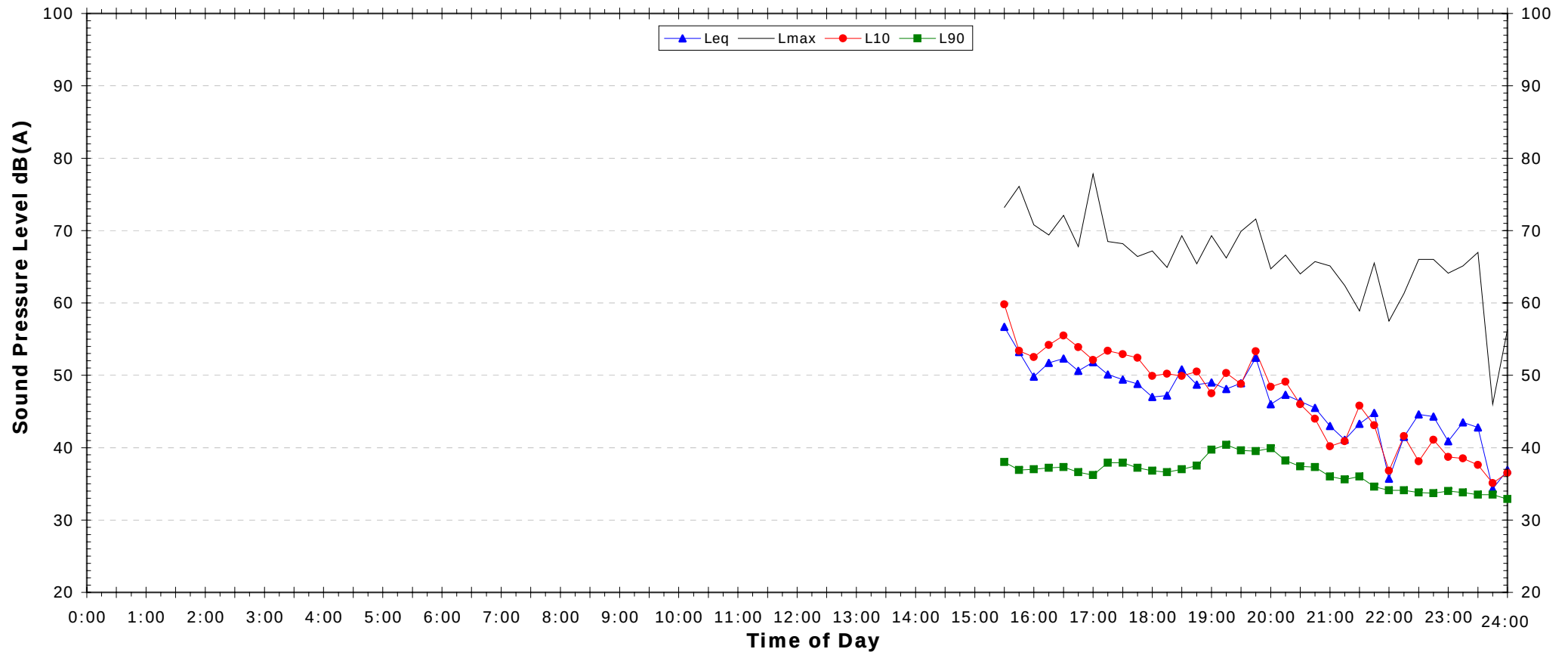
Notes:

1. Day is taken to be 7:00am to 6:00pm
2. Evening is taken to be 6:00pm to 10:00pm.
3. Night is taken to be the remaining periods.
4. Partial day's monitoring
5. Assessment Background Level (ABL)
6. Rating Background Level (RBL) for L90 and logarithmic average for Leq

EXISTING AMBIENT NOISE LEVELS

121 Court St, Manilla - Front Yard

Tuesday, 20 January 2009



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day	Evening	Night ²
	7am-6pm	6pm-10pm	10pm-7am
L ₉₀	36.6	34.6	31.4
Leq (see note 3)	51.8	47.5	43.5

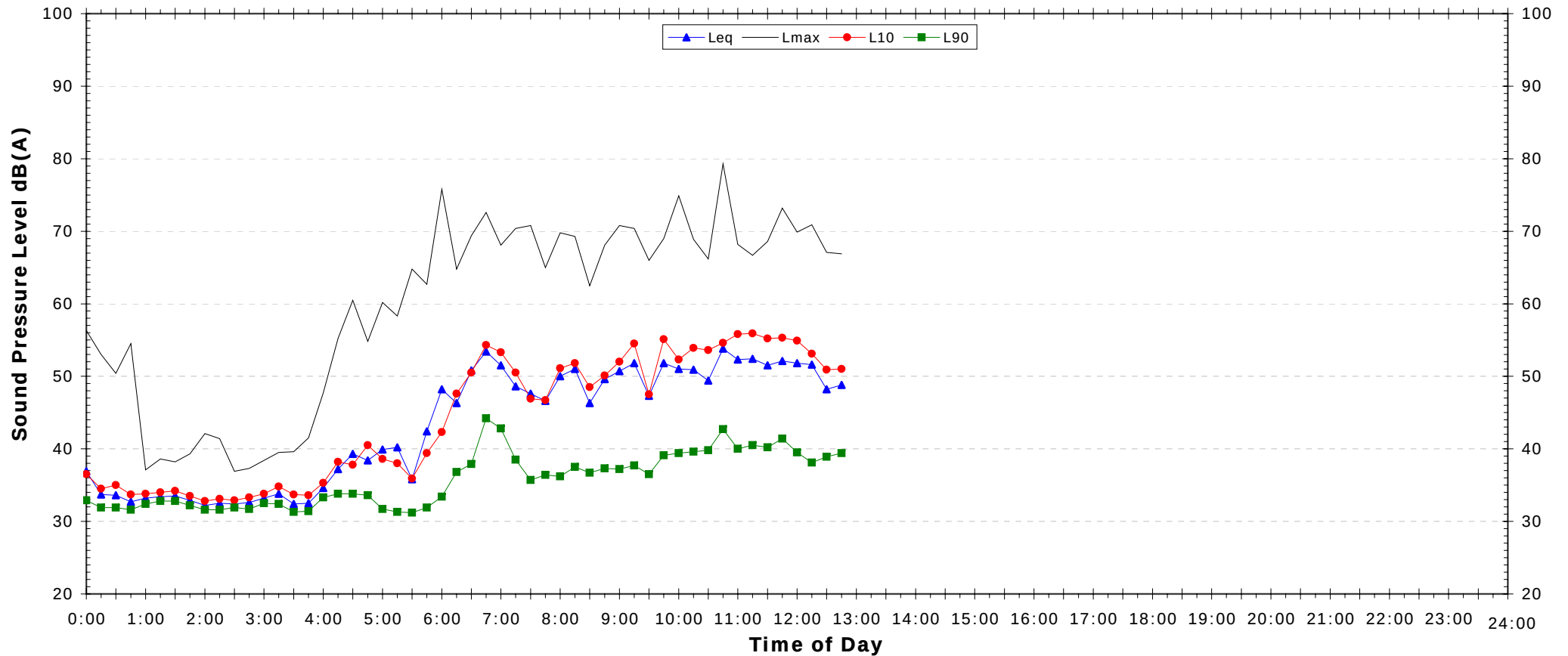
NOTES:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured in free-field; tabulated results facade corrected
4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)

EXISTING AMBIENT NOISE LEVELS

121 Court St, Manilla - Front Yard

Wednesday, 21 January 2009



NSW Industrial Noise Policy (Free Field)			
Descriptor	Day	Evening	Night ²
	7am-6pm	6pm-10pm	10pm-7am
L ₉₀	36.4	-	-
Leq (see note 3)	50.6	-	-

NOTES:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured in free-field; tabulated results facade corrected
4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)