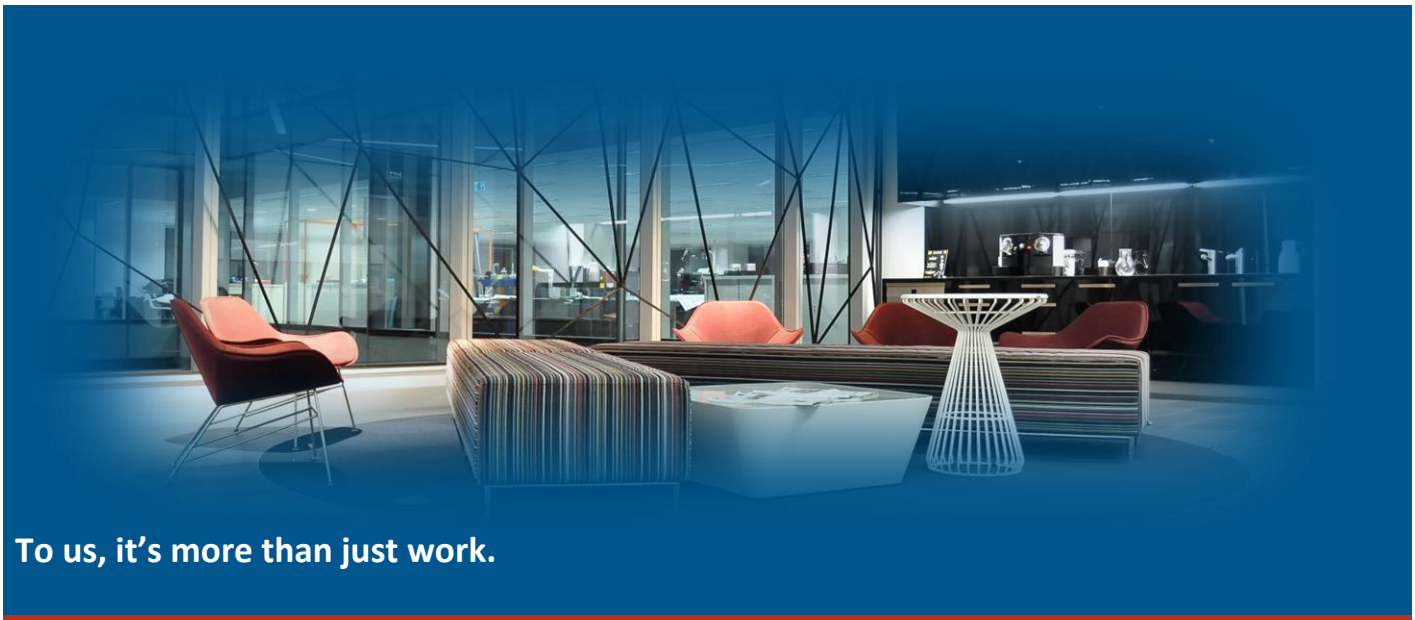

To us, it's more than just work.

Sutherland Hospital Planning

Environmental Acoustic Assessment
Acoustic Services Report

Prepared for:	Prepared by:
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WOOD & GRIEVE ENGINEERS

Revision

REVISION	DATE	COMMENT	APPROVED BY
3	25/02/2015	Comments added	**ORFG**
2	18/12/2014	Final	**ORFG**
1	11/12/2014	For comments	**ORFG**

Contents

1. Introduction

The purpose of this report is to provide an environmental noise impact assessment as part of the State Significant Development for the proposed Sutherland Hospital development, located on The Kingsway, Caringbah, NSW 2871. The proposed works will be located to the North Western side of the site.

The objectives of the NSW Health Infrastructure Project, which includes a new build of Sutherland Hospital, is to provide contemporary healthcare facilities suited to the current and future needs of the catchment population, and to provide capacity to support the agreed scope of clinical care in an environment that facilitates the delivery of contemporary health services.

Facility function should allow efficient bed utilisation and staffing to better meet the current and future needs of Caringbah and the surrounding community.

The scope of the Sutherland Hospital project is summarised as follows:

Level 1 (connection to existing level)

- New lift – to provide the new building with access to linen, kitchen, morgue etc…
- Plant areas
- Linen expansion – to cater for increased bed numbers

Level 2

- Emergency department (ED) with 41 treatment spaces and 4 resuscitation spaces
- Emergency Short Stay Unit (EDSSU), 8 beds
- Imaging Expansion (CT scanner plus new X-Ray room)

Level 3

- 32 Bed Impatient Unit (IPU)
- 16 Bed General Medical Unit (GMU)
- 6 Bed High Dependency Unit/Intensive Care Unit (HDU-ICU)

Level 4

- Plant

The operation of the services equipment associated with this project will occur equally inside and outside the buildings. The development will consist of the construction of one new building which will house several new departments. No helipad is expected in this development.

This assessment discusses the likely noise impact on the potentially nearest most-affected receivers (residential) of the proposed development.

This assessment has been prepared considering the documents listed in Section 2.2.

The report provides:

- A statement of compliance with the Sutherland Shire Council Development Control Plan (DCP) criteria for the proposed hospital re-development within the vicinity of the nearest potentially affected residential receivers.
- Recommendations for noise mitigation measures for the proposed development in order to meet the Sutherland Shire Council criteria when compliance is not achieved.
- Traffic noise impact assessment associated with the proposed Hospital re-development.
- Construction noise and vibration criteria.

This noise assessment is based on noise data collected by two noise loggers located at two representative locations close to the site over a period of 9 days in October 2014.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore this report shall not be relied upon as providing any warranties or guarantees.

2. Background

2.1 Information Sources

This assessment was based on the concept design architectural drawings provided by BVN (plan and elevations) and the following information:

- 141007 EAST ELEVATION.pdf
- 141007 EAST WEST SECTION.pdf
- 141007 LEVEL 2.pdf
- 141007 LEVEL 3.pdf
- 141007 LVL 1.pdf
- 141007 LVL 2.pdf
- 141007 LVL 3.pdf
- 141007 NORTH SOUTH SECTION.pdf
- 141007 NORTH WEST ELEVATION.pdf
- 141007_Section details of wall types.pdf
- 141007_Finishes mark up for QS.pdf

- Mail correspondence from Traffic Planning Consultant – Andrew Hulse from ARUP (Aconex General Correspondence: Arup NSW-GCOR-000067 15/11/2014)

- Noise data collected on site through the use of two noise loggers and a Type 1 hand held sound level meter.

- Generic noise data of mechanical plant based on manufacturers catalogues.
  Acoustic - Mechanical – Structural Services Coordination Mail Correspondence:
  (Aconex Advice: TTWNSW-ADVICE-000029 12/12/2014)
  (Mail from Eleine Clarke - Senior Mechanical Engineer from STEENSEN VARMING 20/11/2014)

2.2 Reference documents

- Sutherland Shire Council Development Control Plan 2006
- Sutherland Shire Local Environmental Plan 2006
- New South Wales (NSW) Office of Environment and Heritage, Industrial Noise Policy (INP) January 2000.
- New South Wales (NSW) Environmental Protection Authority (EPA), Environmental Noise Control Manual (ENCM) 1994.
- New South Wales (NSW) Department of Environment Climate Change and Water (DECCW) Interim Construction Noise Guideline July 2009.
- Australian Standard, AS 2436-1981, “Guide to Noise Control on Construction, Maintenance and Demolition Sites”.

3. Project Overview

3.1 Proposed development

The objectives of the NSW Health Infrastructure, which includes the refurbishment and new build of Sutherland Hospital, is to provide contemporary healthcare facilities suited to the current and future needs of the catchment population, and to provide capacity to support the agreed scope of clinical care in an environment that facilitates the delivery of contemporary health services.

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- 16 Bed General Medical Unit (GMU)
- 6 Bed High Dependency Unit/Intensive Care Unit (HDU-ICU)

Level 4

- Plant

3.2 Site description

The site of the Suthertland Hospital is bounded by Kingsway Rd to the North, residential properties to the East, Kareena Rd. to the West and some buildings, car park space and railway line (further away) to the South. The nearest sensitive receivers have been identified as follows and are displayed in Figure 1:

- Location R1: Residential receivers across Kingsway Rd to the North approximately 110m form the site (displayed in Green)
- Location R2: Residential receivers across Kareena Rd to the West approximately 80m form the site (displayed in Green)
- Location H1: Kareena Private Hospital's wards receiver across Kingsway Rd to the North approximately 140m form the site (displayed in Blue)

3.3 Existing noise environment

The existing background noise is typical for an urban area that has local traffic with characteristically intermittent traffic flows with some limited commerce or industry. We can observe decreasing noise levels in the evening period and the evening ambient noise levels defined by the natural environment and infrequent human activity.

The lowest noise levels are generally recorded around 3 in the morning. With this scenario, the OEH Industrial Noise Policy (INP, Environment Protection Authority 2000) 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

The noise monitoring locations are illustrated in Figure 1.

The long term monitoring Locations L1 (Kareena Rd) and L2 (Kingsway Rd) were selected away from any mechanical plant located in the vicinity that was likely to affect the noise monitoring results. These locations were selected as representative of the ambient noise level of the areas surrounding the site.

In addition to the unattended noise monitoring, attended noise monitoring was conducted at locations P1 to P5, which are also shown in Figure 1.

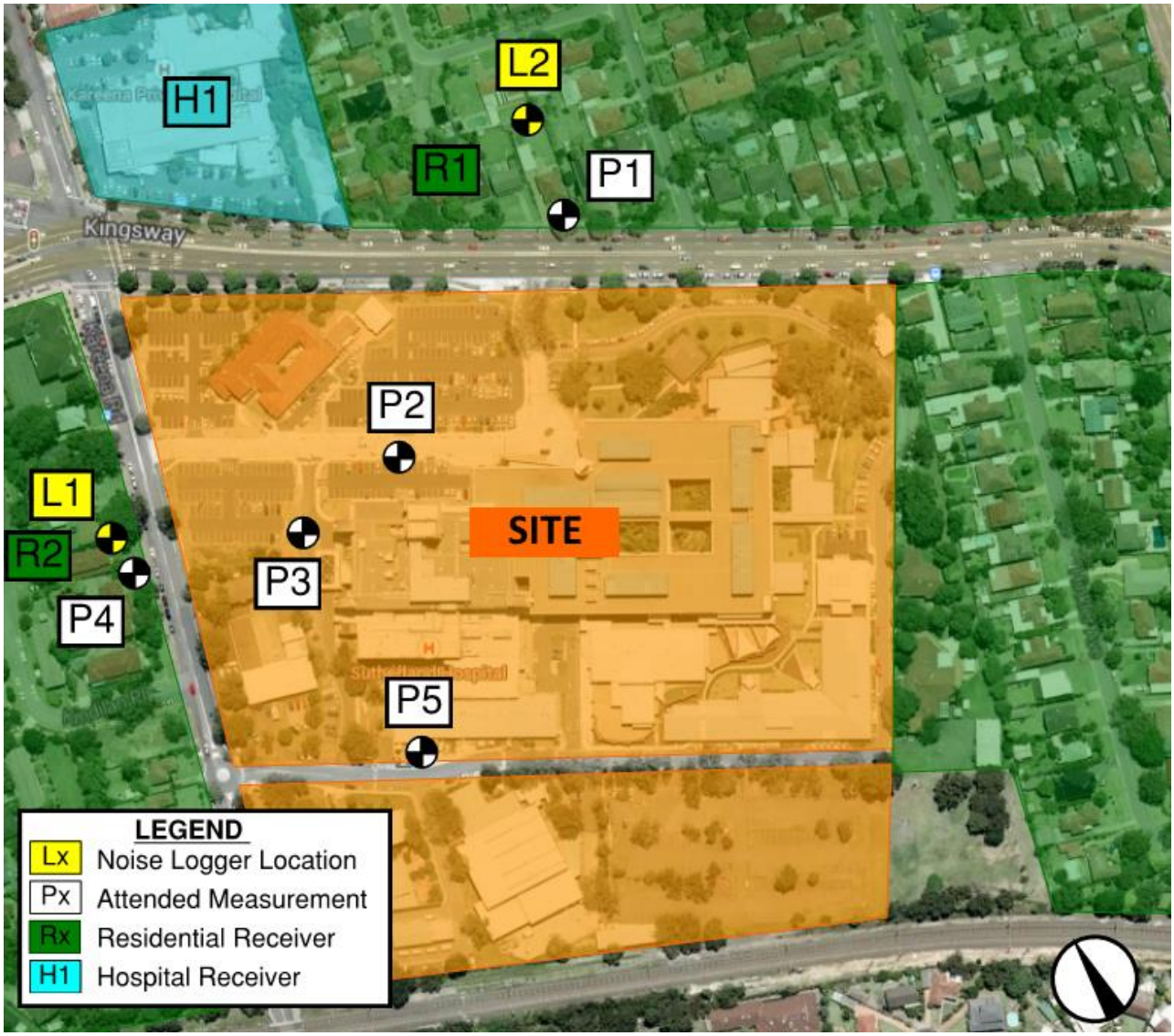
3.3.1 Instrumentation

The equipment used for the noise survey was the following:

- ARL Environmental Noise Logger EL-315 S/N 194574 used at L1 in Figure 1.
- ARL Environmental Noise Logger EL-315 S/N 194603 used at L2 in Figure 1.
- Hand-held sound spectrum analyzer Brüel & Kjær 2250 S/N 2709742 used at P1, P2, P3, P4 and P4 in Figure 1.
- Brüel & Kjær Calibrator, S/N: 2709826 used for hand-held sound spectrum analyzer.

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.

Figure 1: Site map illustrating nearest sensitive receivers and noise measurement locations



Source: Nearmap.com

Figure 2: Site location overview with new Level 1 development layout overlaid

Source: Nearmap.com

3.3.2 Short-term measurements

Table 1 below shows a summary of the attended measurements results.

Table 1: Summary of short-term measurements

Measurement Location	Date/Start Time	$L_{Aeq,15min}$ dB(A)	$L_{A90,15min}$ dB(A)	Background Noise Description
P1	10/10/2014 10:47	68.4	56.5	Ambient noise dominated by traffic noise from Kingsway
	21/10/2014 15:24	72.0	62.0	
P2	10/10/2014 11:15	58.4	51.6	Ambient noise dominated by traffic noise from Kingsway, cars passing by towards nearby carpark
	21/10/2014 16:22	56.9	52.3	
P3	10/10/2014 11:32	57.0	50.6	Ambient noise dominated by traffic noise from Kingsway, cars passing by towards

Measurement Location	Date/Start Time	$L_{Aeq,15min}$ dB(A)	$L_{A90,15min}$ dB(A)	Background Noise Description
	21/10/2014 16:06	55.2	50.8	nearby carpark
P4	10/10/2014 12:07	59.5	49.9	Ambient noise dominated by traffic noise from Kareenda rd.
	21/10/2014 15:46	64.4	55.2	
P5	10/10/2014 12:27	62.1	48.5	Ambient noise dominated by traffic noise from cars passing by – no railway noise

3.3.3 Long-term measurements

The two noise loggers (L1 and L2) were set to record statistical noise levels and continuously logged from Friday 10th October until Tuesday 21st October 2014. The data collected by the two noise loggers is also shown graphically in Appendix 1.

The equipment recorded the noise levels over the 15-minute period and then determined the L_{A90} and L_{Aeq} levels of the noise environment.

Table 2 presents the results of the continuous averaged sound pressure levels (L_{Aeq}), and the rated background noise level (L_{A90}) see Appendix 2 for definitions.

Table 2: Summary of existing and background noise levels

Location	Rated background noise level RBL			$L_{Aeq,period}$		
	Day	Evening	Night	Day	Evening	Night
L1	45	41	37	60	60	55
L2	43	42	34	55	52	47

4. Noise and Vibration Criteria

4.1 Internal noise levels

4.1.1 Development near Rail Corridors and Busy Roads – Interim Guideline – NSW Government Department of Planning

As the site adjoins a classified road (Kingsway), internal noise level criteria according State Environmental Planning Policy is summarized on Table 3.

Table 3: Internal Noise Criteria – Recommended Max. Level dB(A) for Hospitals near Busy Roads

Hospitals	Recommended Max Level dB(A)
Wards	35
Other noise sensitive areas	45

4.1.2 AS/NZS 2107:2000

Background sound level design targets were obtained from standard AS/NZS 2107:2000. These criteria will affect the design of air conditioning plant and the design of sound isolation requirements between occupied areas. It should be noted that the base building noise levels associated with the operation of mechanical services may also influence internal noise levels in the proposed various hospital areas. The contribution of the base building design will require consideration for mechanical services noise controls thought the use of internal insulated ductwork but more likely through the use of in-duct silencer to prevent from bacterial transmission issue via reticulation of the mechanical system. These criteria will also affect the design of the building façade. Table 4 presents the background noise levels that are the basis of the acoustic design for each type of space.

Table 4: Recommended internal noise levels and reverberation times

Type of occupancy/activity	Recommended design sound level, Leq dB(A)	
	Satisfactory	Maximum
2 HEALTH BUILDINGS		
Casualty areas	40	50
Corridors and lobby spaces	40	50
Consulting rooms	40	45
Delivery suites	45	50
Intensive care wards	40	45
Kitchens, sterilizing and services	50	55
Laboratories	45	50
Nurses stations	40	45
Pharmacies	45	50

Sterilizing areas in operating	40	45
Surgeries	40	45
Wards	35	40
Waiting rooms, reception areas	40	50
General offices areas	40	45
Private offices	35	40

It should be noted that the recommended design sound levels given in the table above apply for the combined noise from building services (supply, breakout, return etc.) and intrusive noise (traffic noise etc.).

It is recommended that the "Satisfactory" levels provided above are aimed as they are also in accordance with Development near Rail Corridors and Busy Roads – Interim Guideline – NSW Government Department of Planning recommendations stated in the previous section.

4.2 Exterior Mechanical Plant and Equipment Noise Criteria

4.2.1 Sutherland Shire Council Development Control Plan (DCP) 2006

The Sutherland Shire Council Development Control Plan 2006 doesn't refer to any particular criteria for proposed new development in terms of noise impact to the surrounding environment. Nevertheless, the Sutherland Shire Council recognizes and accepts the NSW Office of Environment & Heritage (OEH) Industrial Noise Policy (INP) as the guideline to follow in order to assess impact noise of new development.

4.2.2 New South Wales (NSW) Office of Environment & Heritage (OEH) Industrial Noise Policy (INP)

Sutherland Shire Council recognizes and accepts the NSW OEH INP as a guideline, therefore the state policy will be used to assess noise associated with the operation of the new mechanical plant installed for the proposed Hospital redevelopment.

The environmental noise criteria or project-specific noise level is calculated following the NSW OEH INP guidelines.

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established the most stringent for each considered assessment period (day, evening, night) is adopted as the project-specific noise level (PSNL).

Intrusiveness Criteria

The NSW OEH INP states the following:

"The intrusiveness of an industrial 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 5 dB(A)."

The intrusiveness criterion can be summarised as follows:

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

The intrusiveness criteria for each assessment location are presented below in Table 5.

Table 5: Intrusiveness Criteria – dB(A)

Period (as defined in the INP)		Intrusiveness criteria at each assessment location	
		Location L1	Location L2
Day	$L_{Aeq,\ 15\ min}$	50	48
Evening	$L_{Aeq,\ 15\ min}$	46	47
Night	$L_{Aeq,\ 15\ min}$	42	39

As a worst case scenario the intrusiveness levels of L2 will be used in the assessment.

Amenity Criteria

The NSW DECCW INP states the following:

"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 INP. Meeting the acceptable noise levels in table 2.1 will protect against noise impacts such as speech interference, community annoyance and to some extent sleep disturbance. These levels represent best practice for assessing industrial noise sources, based on research and a review of assessment practices used overseas and within Australia."

The applicable parts of Table 4: Recommended L_{Aeq} Noise Levels from Industrial Noise Sources - dB(A) which are relevant to the project are reproduced below:

Table 6: Recommended LAeq noise levels from industrial noise sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)	
			Acceptable	Maximum
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
Hospital ward - Internal - External	 All All	 Noisiest 1-hour period Noisiest 1-hour period	 35 50	 40 55

Table 7: Amenity Criteria

Period	Amenity Criteria for Residential Locations using L1	Amenity Criteria for Residential Locations using L2
Day	55	55
Evening	45	45
Night	40	40

Modifying Factor Adjustments

The NSW DECCW INP also states: "Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."

In order to take into account the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table 4.1 of Chapter 4 of the NSW DECCW INP (see Table 7 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 8: Table 4.1 NSW DECCW INP – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: - **5 dB** or more if the centre frequency of the band containing the tone is above 400 Hz - **8 dB** or more if the centre frequency band containing the tone is 160 to 400 Hz inclusive - **15 dB** or more if the centre frequency of the band containing the tone is below 160 Hz	5 dB[2]	Narrow-band frequency analysis may be required to precisely detect occurrence.
Low Frequency Noise	Measurement of C-weighted and A-weighted level	Measure / assesses C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more	5 dB[2]	C-weighting is designed to be more responsive to low-frequency noise, especially at higher overall levels

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Impulsive Noise	A-weighted fast response and impulsive response	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB	Apply difference in measured levels as the correction, up to a maximum of 5 dB.	Characterised by a short rise time of 35 milliseconds (ms) and decay time of 1.5 s.
Intermittent Noise	Subjectively assessed	Level varies by more than 5 dB	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	On event in any 24-hour period	0 to – 20 dB(A)	The acceptable noise level may be increased by an adjustment depending on duration of noise.
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

Notes:

1. Corrections to be added to the measured or predicted levels.
2. Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range.

Project-Specific Noise Levels (PSNL)

Table 9 displays the PSNL based on the worst case scenario.

Table 9: Project Specific Noise Levels – dB(A)

Period	Descriptor	PNSL
Residential Areas		
Day	$L_{Aeq,Day}$	**48**
Evening	$L_{Aeq,Evening}$	**45**
Night	$L_{Aeq,Night}$	**39**
Hospital ward (external)		
Noisiest 1-hour period	$L_{Aeq,}$ (Internal)	**35**
	$L_{Aeq,}$ (External)	**50**

Note: The PSNL for the project was established using the noise data collected at logger location L2 as it is the most representative location of ambient noise level for the surrounding potentially most affected receivers.

The most stringent noise criterion to meet at the boundary of the nearest potentially affected receiver is the residential night time criterion of 39 dB(A).

4.3 Sleep Disturbance Criteria

The NSW OEH's INP does not address the issue of sleep arousal. The NSW EPA's "Environmental Noise Control Manual" (ENCM) however, makes the general observation that a person's sleep can be significantly disrupted by noise. Scientific research has established that short duration or intermittent noise is more disturbing to sleep than continuous noise of similar acoustic energy.

Chapter 19 of the ENCM provides guidelines for assessing sleep disturbance resulting from short-duration high-level noises which occur at night (10:00pm to 7:00am according to the DECCW) as follows:

"Noise control should be applied with the general intent to protect people from sleep arousal. To achieve this, the L_1 level of any specific noise source should not exceed the background noise level (L_{90}) by more than 15 dB(A) when measured outside the bedroom window."

The following Table 10 summarises the sleep arousal criteria that are applied to the surrounding residential and hospital premises based on data from L2.

These noise levels can be assessed (outdoor) at the facade of the premises.

Table 10: Sleep Arousal Criteria

Location	Night-time L_{A90}	L_{A1} Criteria – dB(A)
All	34	49

The Application notes regarding the INP published by the OEH suggest that the OEH recognises that the current sleep disturbance criterion of an $L_{A1,1min}$ not exceeding the $L_{A90,15min}$ by more than 15 dB(A) is not ideal. Nevertheless as there is insufficient evidence to determine what should replace it, the OEH will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely to occur, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level $L_{A1, 1min}$ that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN, Environment Protection Authority 1999). Other factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise levels will occur.
- Time of day (normally between 10pm and 7am).
- Whether there are times of the day when there is a clear change in the noise environment (such as early morning shoulder periods).

The $L_{A1, 1min}$ descriptor represents a maximum noise level measured under fast time response. DECCW will accept analysis based on either $L_{A1, 1min}$ or L_{Amax}.

4.4 Traffic Noise Criteria

Road traffic noise impact in this report is assessed according to the NSW Road Noise Policy (2011) and the Transport Planning Consultants from Arup.

The traffic noise criteria for the proposed road (or residential land use developments) in NSW Road Noise Policy divides land use developments into different categories and lists the respective criteria for each case.

Table 3 and Table 4 Section 2.3.1 in the NSW Road Noise Policy sets out the assessment criteria for residences and hospital wards to be applied to particular types of projects, road category and land use. Relevant to this project is Category 6 plus Hospital wards under Local roads category, which is summarized in Table 11 below.

Table 11: NSW Road Noise Policy – Road Traffic Noise Assessment Criteria for Residential Land Uses

Road Category	Type of Project/Land Use	Day, dB(A) (7:00am to 10:00pm)	Night, dB(A) (10:00pm to 7:00am)
Local roads	6. Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq\ (1\ hr)}$ 55 (external)	$L_{Aeq\ (1\ hr)}$ 50 (external)
	2. Hospital wards	$L_{Aeq\ (1\ hr)}$ 35 (internal)	$L_{Aeq\ (1\ hr)}$ 35 (internal)

In the process for applying the criteria, for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2dB above that of the corresponding 'no build option'.

4.5 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the NSW Office of Environment and Heritage. It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW OEH ICNG (July 2009) were specifically referenced. The limits presented in Table 12 apply.

Table 12: NSW OEH ICNG Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (8am – 1pm) No work on Sunday & Public Holidays	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.

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 30 m 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.

Source: Chapter 4 (Table 2 Sec 4.1.1) of NSW DECCW ICNG.

Other sensitive land uses, such as schools or hospitals, typically consider noise from construction to be disruptive when the properties are being used. Presents management levels for noise at other sensitive land uses based on the principle that the characteristic activities for each of these land uses should not be disturbed.

Table 13: NSW OEH ICNG Construction Noise Criteria (other sensitive land uses)

Land use	Management Level $L_{Aeq,15min}$
Hospital wards and operating theatres	Noise Internal noise level 45dB(A)

Source: Chapter 4 (Table 3 Sec 4.1.1) of NSW OEH ICNG.

4.5.1 Construction Vibration Criteria

The OEH has developed a document, "Assessing vibration: A technical Guideline" in February 2006 to assist in preventing people from excessive vibration levels within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects.

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

4.5.2 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 also 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.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 14. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 14: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and place of worship	Day or night time	0.020	0.014	0.040	0.028
Critical areas	Day or night time	0.0050	0.0036	0.010	0.0072
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.014
Critical areas	Day or night time	0.0050	0.0036	0.010	0.0072

4.5.3 Human Comfort – Intermittent Vibration Criteria

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. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 15: Acceptable Vibration Dose Values for Intermittent Vibration (m/s1.75)

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

4.5.4 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from the construction activities which will avoid the risk of damaging 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.

Most commonly specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure.

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

Table 16 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn’t occur.

Table 16: Guideline value of vibration velocity, vi for evaluating the effects of short term vibration

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

Table 17 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Table 17: Transient vibration guide values for cosmetic damage

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

4.6 Construction Vibration Project Specific Levels

Table 18 indicates the construction vibration criteria applicable to residential properties and schools located adjacent to the development site.

Table 18: Construction vibration criteria summary

Location	Period	Human Comfort Vibration Objectives					Building damage Objectives – Velocity (mm/s)
		Continuous mm/s^2 (RMS)		Intermittent $m/s^{1.75}$ (VDV)	Impulsive vibration m/s^2 (RMS)		
		z-axis	x- and y-axis		z-axis	x- and y-axis	
Residential	Daytime	10-20	7.1-14	0.2-0.4	0.3-0.6	0.21-0.42	5
	Night time	7-14	5-10	0.13-0.26	0.1-0.2	0.071-0.14	5
Critical areas	Daytime or Night time	5-10	3.6-7.2	0.1-0.2	5-10 mm/s	3.6-7.2 mm/s	3

5. Noise Impact Assessment

5.1 Noise Considerations

The following activities have been identified as being likely to generate noise with the potential to impact the surrounding environment.

These noise sources include:

- Continuous noise from mechanical plant such as cooling towers, air handler units (AHU), chillers, condenser units and fans.
- Noise associated with back-up electrical system such as emergency diesel generators (300 kVA Cummings)
- Intermittent noise from typical site operation, such as maintenance activities and patron noise
- Intermittent traffic noise from light weight trucks entering the loading dock delivering various type of goods
- Intermittent traffic noise from car movement entering and exiting the carparks located on site
- Intermittent noise from ambulances accessing the emergency department unit (EDU)

Equipment selections are yet to be finalised, therefore an indicative assessment has been conducted.

5.2 Mechanical Plant

5.2.1 Noise Sources

The proposed hospital redevelopment will include typical building services equipment, which will generate noise. Most of the spaces will be air-conditioned which will require mechanical system with items such as chillers, compressors, cooling towers to be located within plantrooms.

The main sources of building services noise are being located within plantrooms. Typically the noise of these plants will be controlled through the building fabric and the control of noise breakout through airways required for ventilation purposes with the use of attenuators or acoustic louvres.

As the site is an operational hospital with critical activities and equipment it will be supported by a redundancy system for power supply in order to avoid any issue in case of power outage. These redundancy systems when operating whether in case of main power failure or for maintenance purposes will generate a substantial amount of noise which is required to be assessed in detail.

Hydraulic systems also require to be considered in this assessment such as pumps, booster pumps for fire system etc.

The building services including mechanical, electrical and hydraulics noise sources associated with the development that has been assessed includes:

Level 1 plant room (located to the North East of the site):

- 3 x Water Cooled Chiller units in Plant room
- 5 x Fan units

Level 4 AHUs plant room (located to the centre of the site):

- 11 x Air Handling Units in Plant room and associated Relief Air Fans (RAF)
- 1 x Fan units

Level 4 CTs plant room (located to the centre of the site):

- 3 x Cooling Tower (CT) (two different options as per Table 21 equipment have been assessed within sections 5.5.1 and 5.5.2)

Level 5 existing roof AHUs plant room (located to the centre of the site):

- 3 x Air Handling Units in Plant room
- 1 x RAF

Level 5 new roof AHUs plant room (located to the centre of the site):

- 4 x Air Handling Units in Plant room and associated Relief Air Fans (RAF)
- 1 x RAF

A detailed assessment will be conducted when further information becomes available.

The typical noise data (Sound Power Levels) of the proposed mechanical units are presented from Table 19 to Table 23.

Table 19: Sound Power Data of Level 1 Mechanical Plant dB(A) re 1 pW

# Units	Item	SWL dB re 1pW								Overall dB(A) re 1pW
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
1	Chiller CH-1 Climavenetta	-	-	-	-	-	-	-	-	95
1	Chiller CH-2 Climavenetta	-	-	-	-	-	-	-	-	98
1	Chiller CH-3 Climavenetta	-	-	-	-	-	-	-	-	100
1	EXF 1.1	78	80	86	85	84	82	77	69	89
1	OAF 1.1	78	80	86	85	84	82	77	69	89
1	OAF 1.2	78	80	86	85	84	82	77	69	89
1	EXF 1.2	78	80	86	85	84	82	77	69	89
1	EXF 1.3	-	56	64	65	62	61	53	46	67

Table 20: Sound Power Data of Level 4 Mechanical Plant dB(A) re 1 pW

# Units	Item	SWL dB re 1pW (inlet)								Overall dB(A) re 1pW
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
1	EXF 2.2	-	62	69	73	75	74	68	59	79
1	AHU 2.1	82	82	85	80	76	72	66	59	82
1	AHU 2.2	78	80	85	78	76	72	65	60	82
1	AHU 2.3	74	78	80	74	70	67	61	55	77
1	AHU 2.4	86	90	87	81	75	71	64	57	84
1	AHU 2.5	81	83	84	77	73	71	66	61	80
1	AHU 3.1	78	80	85	78	76	72	65	60	82
1	AHU 3.2	81	82	82	77	71	67	63	58	78
1	AHU 3.3	81	82	84	80	75	69	65	60	81
1	AHU 3.4	81	83	84	77	73	71	66	61	80
1	AHU 3.5	82	82	85	80	76	72	66	59	82
1	AHU 3.6	74	79	82	75	71	67	62	56	78
1	RAF 2.1	95	85	90	88	91	87	85	80	95
1	RAF 2.2	86	83	83	87	85	84	79	70	90
1	RAF 2.3	78	80	86	85	84	82	77	69	89
1	RAF 2.4	96	92	94	92	90	88	85	81	95
1	RAF 2.5	85	79	85	83	83	81	78	69	88
1	RAF 3.1	93	96	93	92	91	84	85	82	95
1	RAF 3.2	96	94	101	101	101	100	94	79	106
1	RAF 3.3	96	94	101	101	101	100	94	79	106
1	RAF 3.4	85	79	85	83	83	81	78	69	88
1	RAF 3.5	95	85	90	88	91	87	85	80	95
1	RAF 3.6	85	79	85	83	83	81	78	69	88

Table 21: Sound Power Data of Level 4 Cooling Tower Mechanical Plant dB(A) re 1 pW

# Units	Item	SWL dB re 1pW								Overall dB(A) re 1pW
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
3	CT-01, 02 and 03 (Option 1)	104	104	101	98	92	88	84	77	99
3	CT-01, 02 and 03 (Option 2)	96	96	95	93	89	83	77	69	94

Table 22: Sound Power Data of Level 5 Existing Mechanical Plant dB(A) re 1 pW

# Units	Item	SWL dB re 1pW								Overall dB(A) re 1pW
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
2	AHU 4.5	81	83	85	77	74	71	66	62	81
1	AHU 4.6	77	78	78	79	74	69	64	58	80
1	AHU 4.7	69	75	70	77	71	68	64	59	77
1	RAF 4.1	101	99	98	101	99	97	93	90	104

Table 23: Sound Power Data of Level 5 New Mechanical Plant dB(A) re 1 pW

# Units	Item	SWL dB re 1pW								Overall dB(A) re 1pW
		63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
1	AHU 4.1	83	82	87	82	78	73	68	60	84
1	AHU 4.2	82	84	86	79	76	73	68	64	83
1	AHU 4.3	75	79	83	75	71	68	62	56	78
1	AHU 4.4	74	79	82	75	71	67	62	56	78

5.3 Road Traffic Noise

Road traffic noise impact in this report is based on the consultation provided by Andrew Hulse (Associate Principal – Transport Planning at Arup) through Aconex General Correspondence (Arup NSW-GCOR-000067 15/11/2014). In summary we understand that the impact of the increase in traffic volume due to the development will be minimal as the existing traffic volume on site is already quite significant. The following paragraph is an excerpt from the Arup correspondence:

> *[…] 8 – 9am existing traffic= 444 vehicles per hour and 477 vehicles per hour is expected (34 vehicles per hour increase).*

1 – 2pm existing traffic= 683 vehicles per hour and 723 vehicles per hour is expected (40 vehicles per hour increase).

5 – 6pm existing traffic= 431 vehicles per hour and 470 vehicles per hour is expected meaning (39 vehicles per hour increase).

According to paragraph above as a worst case scenario it is noted that transportation consultant concluded that the number of vehicle movements will increase by up to 40 vehicles per hour.

This increase represents a likely increase of traffic noise by <0.25dB. The noise within the wards is also expected to be under 35dB(A). Therefore, NSW Road Noise Policy criteria will be met as the increase in road traffic noise doesn't exceed 2dB and the traffic noise within the wards is below the maximum allowed of 35 dB(A).

5.4 Ambulance Noise

The Ambulance Services of NSW has informed Wood and Grieve Engineers that sirens are not used within hospital sites, the only exception being a "short burst" alerting potential motorists of the ambulance's presence when absolutely necessary.

Whilst driving in response to an emergency call out ambulance drivers may use the siren continuously or use it periodically to alert motorists as deem necessary. Whilst returning to the hospital after attending an emergency the siren will only be used in an extreme emergency such as occurs when attempts are being made to resuscitate a "clinically dead" patient. No operational changes are proposed for the Sutherland Hospital project with the exception of the relocation of the ambulance bays. Noise levels generated by ambulance activities will be similar to those currently experienced in the area; with residential properties located along Kingsway and Kareena Rd likely to remain exposed to similar noise levels.

5.5 Assessment to the NSW OEH Industrial Noise Policy (INP)

Noise emissions from the proposed operations of the site were predicted. Noise emissions from the proposed development associated with noise sources identified in Table 19, 19, 20, 21 and 22 were calculated for the two nearest potentially most affected residential receiver locations (R1 and R2 shown in Figure 1) and for the nearby Hospital (H1).

Noise levels were calculated at the nearest affected residential locations considering the worst case scenario of all plant and equipment operating simultaneously.

Table 24 presents calculated noise levels at each receiver location. The predicted noise levels were simulated assuming no noise control treatment. In undertaking the predictive noise modelling, single-point calculations were undertaken for the three (3) nearest potentially affected receiver locations.

Calculation of noise from the site operations was based on the typical worst case scenario during the assessment periods including day, evening and night time. The location of noise sources and description are presented in Appendix 2.

5.5.1 Predicted noise levels (Option 1)

Table 24 presents the predicted noise levels associated with the Sutherland Hospital redevelopment at the boundary of the most sensitive receivers as identified in Figure 1.

Option 1 is based using the original proposed Cooling Towers.

Table 24: Predicted noise levels for mechanical plant (Option 1)

Location (See Figure 1)	INP Night time Criteria dB(A)	Predicted Noise Levels dB(A)	Compliance (Y/N)
R1	39	43.0	No
R2	39	40.7	No
H1	50	39.2	Yes

5.5.2 Predicted noise levels (Option 2)

Table 25 presents the predicted noise levels associated with the Sutherland Hospital redevelopment at the boundary of the most sensitive receivers as identified in Figure 1.

Option 2 is based using the quieter proposed Cooling Towers.

Table 25: Predicted noise levels for mechanical plant (Option 2)

Location (See Figure 1)	INP Night time Criteria dB(A)	Predicted Noise Levels dB(A)	Compliance (Y/N)
R1	39	38.4	Yes*
R2	39	36.4	Yes
H1	50	34.7	Yes

*Note that the noise level at R1 is just compliant and any additional noise contribution will result in non-compliance with the criteria

5.5.3 Comments

The results as shown in Table 24 and Table 25 indicate that the noise resulting from the mechanical plant is not complying at two of the receiver locations for Option 1 (with original cooling towers). This conclusion includes the noise mitigation measures presented in section 6.

On the other hand when Option 2 (with quieter cooling towers) is assessed all the noise criteria are met at all receiver locations, with the implementation of the noise mitigation measures presented in section 6.

Both options have the same acoustic mitigation measures implemented; the only difference is that in Option 2 relies on quieter cooling towers to be used.

According to the mechanical engineer option 2 using quieter cooling towers will add a weight of 0.5Tones for each unit (three cooling towers in total). This extra weight will need to be assessed by the structural engineer during the design development stage.

6. Recommendations

6.1 Mechanical Plant

Details of the proposed noise mitigation measures for mechanical services plant for environmental noise will be provided during the detailed design stage of the project.

Nevertheless, for planning purposes, it should be noted that 50mm thick internally lined ductwork after Level 1 plant room fans, acoustic louvres for the new plant room located within level 4 and a 4m high noise barrier are recommended and shown in Figure 3 and Figure 4 respectively. The acoustic louvres will provide the following noise reduction (dB) as shown in Table 26 and the noise barrier the following transmission loss (dB) shown in Table 27.

Table 26: Noise reduction for proposed acoustic louvres

	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Noise Reduction (dB)	9	13	15	17	20	19	21	21

Note: Recommendation is based on current situation and may differ if there are any changes on plant or layout.

Table 27: Minimum transmission loss reduction for proposed noise barrier material

	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Transmission Loss (dB)	15	18	23	28	33	36	32	32

Figure 3: Minimum length of 50mm internally lined ductwork within Level 1 plantroom (in blue)

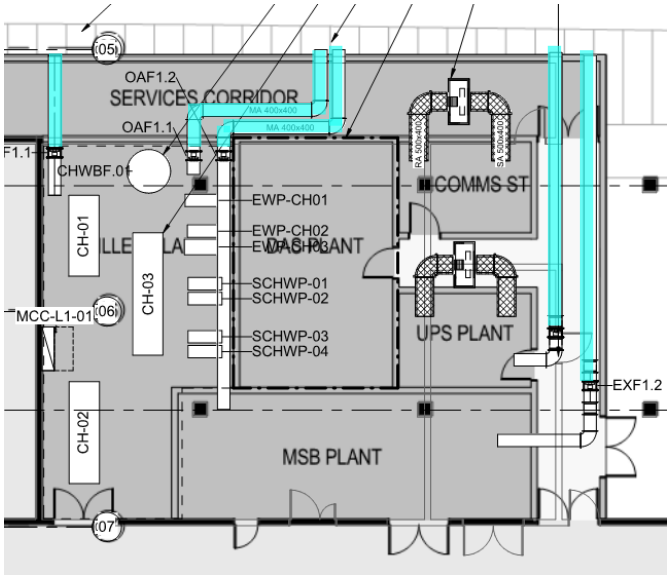
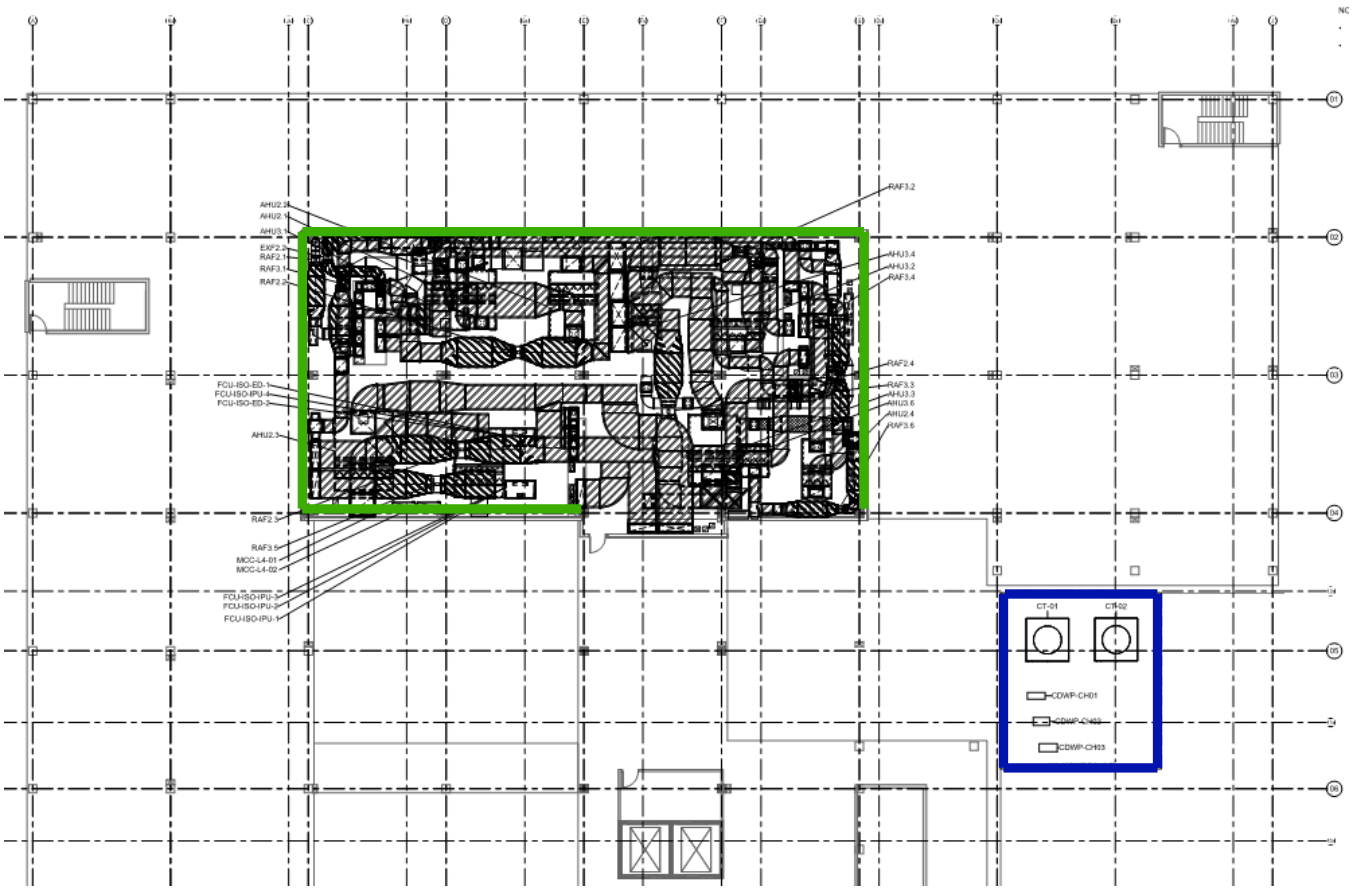


Figure 4: Acoustic louvres for Level 4 plantroom (in green) and 4m High noise barrier (in blue)



6.2 Construction Noise and Vibration

As the Sutherland hospital redevelopment will include for construction work to be undertaken while the Hospital is still operating it is recommended that a detailed Construction Noise and Vibration Management Plan (CNVMP) be developed prior to commencement of construction to ensure the noise and vibration criteria outlined in section Construction Noise Criteria 4.5 of this report are complied with.

The CNVMP should assess the likely noise and vibration emissions from construction activities occurring on site and recommend reasonable and feasible mitigation measures in order to comply with construction noise and vibration criteria and in doing so, minimizing the impact of construction activities on nearby residents but also on the hospital itself.

The CNVMP will include strategy to manage noise and vibration impact depending on the programmed construction activities such as noise and vibration monitoring and programming of activities generating high noise levels during particular non-sensitive period of the day.

7. Conclusion

This report presents the results of a study of operational noise emission from the proposed redevelopment of the Sutherland Hospital located on Kingsway, Sutherland NSW. This report forms a part of the documentation package to be submitted to the public authority as part of the State Significant Development for the proposed Sutherland Hospital redevelopment.

The environmental noise and vibration intrusion criteria for the operation and construction of the proposed development have been established based on Sutherland Shire Council requirements and state policy guidelines.

The establishment of the noise criteria was based on our noise survey which monitored ambient and background noise levels using both hand held sound level meters and long-term noise loggers at the boundary of the potentially most-affected receivers.

Road traffic noise criteria intrusion was also established based on the requirements of state policy guidelines.

The predicted noise levels presented in this report show that the most stringent noise criterion (night time criterion) will be met with the implementation of the proposed mitigation measures for external Option 2 mechanical plant and units (with quieter cooling towers). The report also discussed potential noise impact associated with additional traffic generated by the new development and construction noise. No noise impact associated with additional traffic is expected.

We can confirm that upon implementation of the recommendation, there will not be any adverse operational acoustic environmental impact, it is the finding of this assessment that the proposed development should not be refused on the grounds of excessive noise generation.

Appendix 1: Long Term Noise Logger Data

Figure 5: Long term measurement location L1

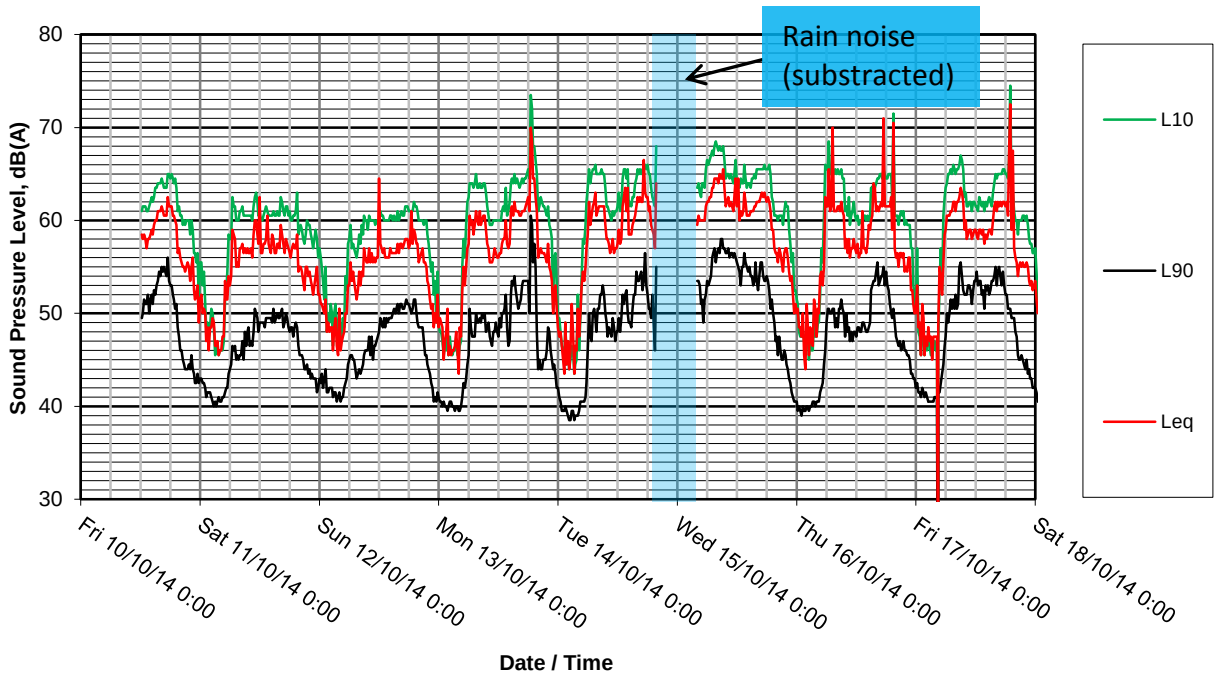
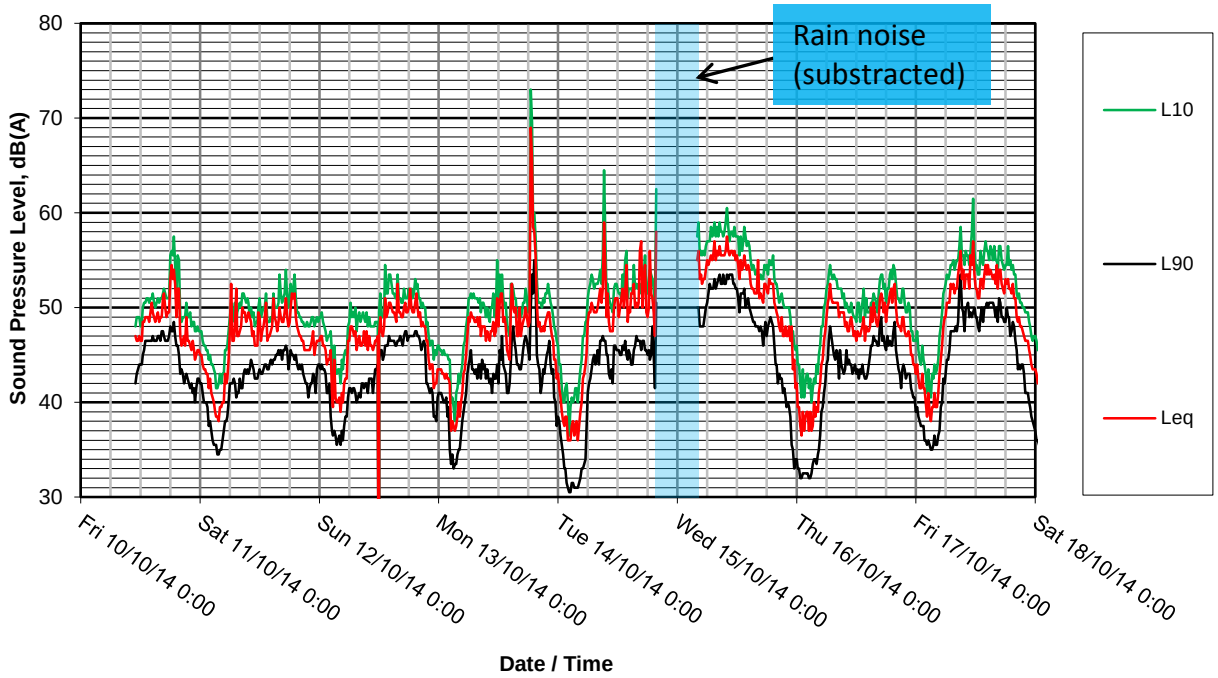


Figure 6: Long term measurement location L2



Appendix 2: Glossary of Acoustic Terms

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

Appendix 2: Glossary of Acoustic Terms

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