APPENDIX F

Noise and Vibration Assessment

Rice Daubney

The Chris O'Brien Lifehouse at RPA

Acoustic Development Application Report and Director General's Requirements

Document ref
Issue/RO3

ARUP

Rice Daubney

The Chris O'Brien Lifehouse at RPA

Acoustic Development Application Report and Director General's Requirements

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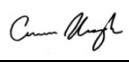
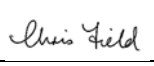
		Signature			
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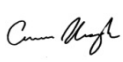
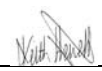
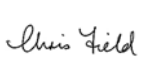
		Signature			
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Executive Summary

The Chris O'Brien Lifehouse at RPA (Lifehouse) will be constructed along Missenden Road, Camperdown. The proposed development has been evaluated against the acoustic assessment requirements set out in the Director-General's requirements, appropriate Department of Environment, Climate Change and Water (DECCW) policy, and relevant Australian Standards.

Design of the Lifehouse will be conducted in accordance with noise criteria and guidelines set from relevant Australian Standards, and the NSW DECCW's Industrial Noise Policy, Environmental Noise Criteria for Road Traffic Noise, Assessing Vibration Guideline, and Interim Construction Noise Guideline.

Operational noise levels from the Lifehouse development are expected to meet the criteria via the incorporation of appropriate noise mitigation into the design of the development.

Traffic noise impacts on surrounding residents are expected to be negligible.

Effective management of the construction process to minimise noise, including selection of equipment, work practices and work methods, will be necessary to minimise the noise impact of the construction works on surrounding areas. The guidance of the NSW DECCW Interim Construction Noise Guideline will be followed in assessing noise impacts and formulating noise mitigation measures to control construction noise impacts from Lifehouse.

A Construction Noise and Vibration Management Plan will be prepared for the Lifehouse development.

Providing that appropriate measures are adopted to manage construction and operational noise from the Lifehouse, the proposed development is considered to be suitable based on the relevant requirements given by Director-General of the Department of Planning.

A summary of the relevant sections of the Director-General's requirements addressed in this assessment is presented in Table 1.

Requirement	Section(s) of Report
3.0 Environmental Amenity and Public Domain	
Consideration of the impacts of the project on solar access, acoustic privacy, visual privacy, views and wind impacts	2.1, 5.4, 6.1
4.0 Environmental Assessment – Noise and vibration	
Quantitative assessment of potential construction, operational and traffic impacts required.	2.1, 2.4, 5.4, 5.5, 5.6, 6.1

Table 1: Summary of Requirements covered in this report

The following architectural drawings were used as a reference to provide input into this acoustic planning report:

- Rice Daubney Project No. 08500 – SK 104 to SK 114 inclusive.

1 Introduction

Arup Acoustics has been engaged by Rice Daubney and Capital Insight to undertake an Acoustic assessment and provide a report to accompany the Director General's Requirements (DGR) for the proposed project.

1.1 Description of Development

The Chris O'Brien Lifehouse at RPA (Lifehouse) development involves the construction of a new $300 million cancer treatment and research facility, located in the Royal Prince Alfred Hospital – Sydney University precinct at Camperdown, Sydney. The proposal involves the establishment of new facilities, linking to the existing radiotherapy bunkers for the treatment of cancer patients, a treatment area for patients undergoing chemotherapy and clinic facilities. In addition, staff offices and support facilities will be established as part of the new centre. The centre is scheduled to open in April 2013.

The proposed Lifehouse site is on the location of the existing Page and Brown Street Outpatient's Building on Missenden Road, which is currently being demolished

The second stage of the development (Stage B1) will involve the fit out of additional areas, including two ward floors, which will allow inpatient activity to occur within Lifehouse at RPA. It is proposed that there will be a total of 96 beds within the new inpatient wards, as well as 18 new critical care beds. It will also include additional theatres and support services.

The Lifehouse will consist of thirteen (13) levels incorporating three basement levels. Nominated spaces consist of:

- Basement car parking
- Patient services facilities
- Integrated medicine or "Wellness Centre"
- Day therapy, pathology, clinics, residential units,
- Theatres (3 off in Stage A; 7 off in Stage B1)
- ICU (Stage B1)
- Inpatient Units (Stage B1)
- Associated office and administrations areas
- Plant rooms

1.2 Scope of Assessment

Director General's Requirements (DGRs) have been issued by DoP for the Project Plan for the development.

There are two requirements given under the Project Plan for acoustics, as follows:

3.0 Environmental Amenity and Public Domain

- *Consideration of the impacts of the project on solar access, acoustic privacy, visual privacy, views and wind impacts*

4.0 Environmental Assessment – Noise and vibration

- *Quantitative assessment of potential construction, operational and traffic impacts required.*

This report presents acoustic issues and design criteria relevant to the Lifehouse project. The key elements of the development of acoustic significance are:

- Assessing compliance with the DGRs
- The impact of operational noise to the nearby residential community
- The impact of mechanical services noise to the nearby residential community (To be addressed by Sinclair Knight Mertz (SKM)).
- The noise impact from additional traffic generated by the Lifehouse project.

Acoustic terminology used throughout this report is presented in Appendix A.

1.3 Consultations

A consultation with the Responsible Authority (RA) was not required to complete this report.

2 Acoustic Considerations

2.1 Noise and Vibration Impact of the Development on the Environment

Noise impacts on the community from the development when operational are expected to be from the following sources:

- plant and services equipment associated with the new facilities
- operational noise from the site (e.g. deliveries, unloading)
- traffic noise from the site on public roads

Plant and services equipment noise from the Lifehouse development is assessed in a separate report by Sinclair Knight Merz (SKM).

Operational noise and traffic noise impacts from the Lifehouse development are assessed in this report.

2.2 External Noise and Vibration Affecting the Development

Environmental noise and vibration sources that may affect the development once operational are:

- Plant and services noise from adjacent properties
- Traffic and pedestrian noise, both on-site and from surrounding streets
- Helicopter noise from helicopters using the RPA helipad
- Aircraft noise from aircraft on approach/departure from Sydney Kingsford-Smith airport.

Control of these noise sources is particularly important for noise-sensitive areas of the Lifehouse development such as the inpatient units, accommodation areas, the Level 1 patient bridge, and operating theatres.

Many of these issues can be resolved with adequate façade glazing and building envelope construction in the detailed design stage.

Naturally-ventilated areas present additional acoustic design challenges. Natural ventilation in healthcare facilities has reported benefits to patient healing rates and general occupant comfort by connection to the external environment. If natural ventilation is considered during the design stages of the Lifehouse project, specialist acoustic advice will be provided to ensure that internal noise levels are controlled to a level satisfactory for occupant comfort.

Traffic vibration impacts on the development should be controlled by appropriate design of the building structure by the structural engineer. Specialist design advice should be sought for any medical equipment that requires a low-vibration environment to operate.

During detail design an assessment of intrusive traffic noise levels will be undertaken however, it is expected that internal traffic noise levels will comply with the appropriate Australian Standard or project specific noise level target.

2.3 Internal Noise and Vibration Impacts on the Development

Occupants of the proposed development may be affected by noise and vibration generated within the development itself. Potential noise and vibration impacts are expected to be from:

- Plant and services equipment associated with the development.
- Vertical inter-level noise via the lift shaft and risers.
- Lift vibration
- Noise transfer via the atrium

- Noise impacts on external leisure areas (e.g. sunken courtyard areas)
- Occupant-induced vibration (e.g. footfall vibration)

These considerations will be resolved during the detailed design stage of the building by the structural engineer, acoustic consultant and mechanical engineer.

2.4 Construction Noise and Vibration Impacts on the Surroundings

Construction noise and vibration impacts are expected to be associated with:

- Construction equipment used on site
- Construction-related traffic.

Where feasible, construction methods and equipment will be selected such that noise and vibration levels in surrounding areas meet the relevant criteria for human comfort and building damage. Hours of work will be restricted as appropriate.

Construction methodology and equipment will be selected considering the recommended work practices in the NSW Department of Environment, Climate Change and Water (DECCW)'s *Interim Construction Noise Guideline* (ICNG).

A *Construction Noise and Vibration Management Plan* will be prepared for the construction of the Lifehouse development, and will include a quantitative assessment of construction noise levels following the procedure of the ICNG.

2.5 Noise from the Community Affecting the Development

2.5.1 Aircraft/Helicopters

The proposed Lifehouse site lies just outside the ANEF 20 contour (based on the Sydney Airport 2023/24 ANEF contours published by Sydney Airport Corporation Limited). This means that a hospital development is considered acceptable on the site based on the guidance of AS 2021[1]. Therefore, noise impacts from commercial aircraft traffic from Sydney Airport are expected to be able to be satisfactorily controlled using standard façade constructions.

However, helicopters using the RPA helipad will fly close to the Lifehouse building (with the closest part of the flightpath to the RPA helipad being approximately 180 m^2, and therefore the building envelope of the Lifehouse development will be designed to control helicopter noise levels to meet the AS2021 criteria given in Section 5.3.2.

2.5.2 Road Traffic

Road traffic on Missenden Road is generally intermittent throughout the day, with heavier traffic during peak hour periods. There are several bus routes using Missenden Road to access RPA, with bus stops near to the Lifehouse site.

Attended surveys and the measured noise logger data indicate that most traffic along this section of Missenden Road is generally free-flowing, although the pedestrian crossing outside the Administration Building of RPA results in vehicles decelerating and accelerating in the vicinity of the proposed Lifehouse site.

Traffic noise impacts from vehicles within the RPA precinct, especially on Susan Street, may also cause noise impacts to sensitive areas of the development, particularly the Level 1 patient bridge, which spans over Susan Street.

The façade of the Lifehouse development will be designed to control break-in of general traffic noise to meet the intrusive noise criteria given in Section 5.3.1.

1 Australian Standard AS2021 (2000) *Acoustics – Aircraft noise intrusion – Building siting and constuction*

2 Heli-Consultants Pty Ltd (2010) *Lifehouse Construction and Royal Prince Alfred HLS Flight Paths*

2.5.3 Pedestrians

The acoustic design of the building façade to control the break-in of general road traffic noise and helicopter noise will be sufficient to control the break-in of noise caused by pedestrian activities outside the building.

3 Site Description

The proposed Lifehouse building is located on the west side of Missenden Road, Camperdown, within the Royal Prince Alfred Hospital (RPA) precinct.

The land usage of the surrounding area is a mixture of other buildings at RPA hospital, residential colleges of the University of Sydney, multi-level residential developments, and some light commercial properties.

The adjacent buildings to the Lifehouse site on the west side of Missenden Road are other hospital/healthcare buildings, including the King George V Memorial Hospital building, which is now used as an administration block, and is located immediately to the north of the Lifehouse site across the eastern end of Salisbury Road.

Across Missenden Road to the north-east is the Administration Building of RPA, including the Victoria Pavilion, while the nearest residential receiver is St Andrew's College, which is a residential college of the University of Sydney and is located across Missenden Road approximately 45 m to the south-east of the Lifehouse site.

St John's College, another residential college of the University of Sydney, is located to the north of the Administration Building of RPA, approximately 180 m to the north of the Lifehouse site.

To the south of the Lifehouse site across Carillon Avenue, the land usage is primarily residential, with several multi-level residential buildings. The nearest residential receivers across Carillon Avenue are located approximately 110 m to the south of the Lifehouse site.

A site plan of the Lifehouse site vicinity is provided in Figure 1:

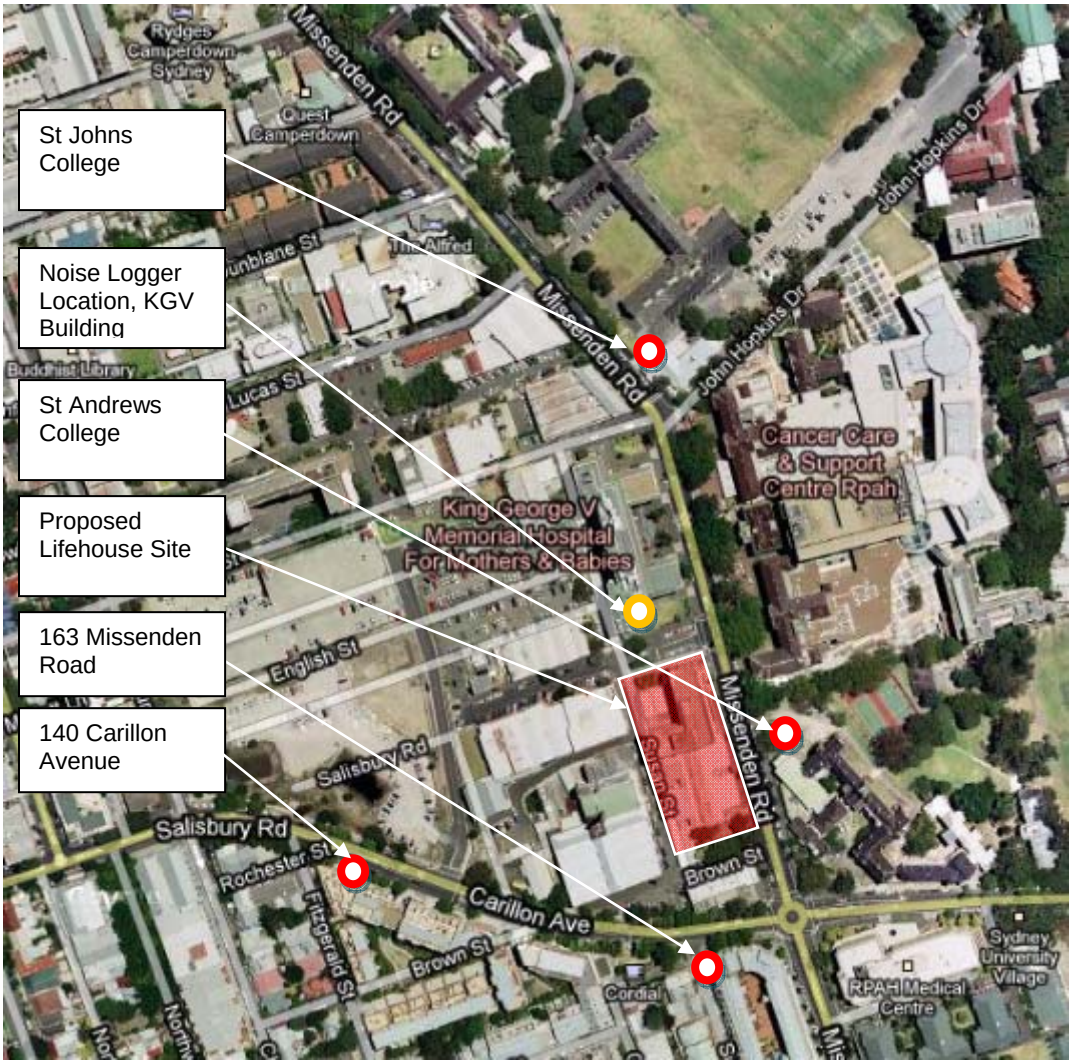

Figure 1: Site Plan, Lifehouse development and surrounding area.

4 Noise Survey

4.1 Purpose of the Noise Survey

An attended noise survey was carried out to assess the current ambient noise levels around the proposed development site and to identify noise sensitive receivers. Unattended monitoring was also undertaken for this stage of the development application.

The purpose of the noise survey was to:

- Identify sources of noise that are likely to affect the development, and their maximum expected levels
- Identify existing ambient noise levels, to assist in setting appropriate noise criteria to assess the impact of the development on the surroundings
- Identify potential noise-sensitive receivers in the vicinity.

4.2 Noise Sensitive Receivers

The main use of the surrounding area is mixed residential and healthcare, with some associated light commercial premises (e.g. cafes, restaurants). The area immediately surrounding the Lifehouse site is mostly healthcare (the surrounding RPA Hospital buildings) apart from St Andrews College, which is a residential college of University of Sydney and is located across Missenden Road from the Lifehouse site.

The ambient noise environment is generally characterised by road traffic noise, high pedestrian activity, and general urban “hum”, including plant noise from surrounding RPA buildings and distant traffic noise from Parramatta Road. These characteristics are consistent with an “urban” area as defined in the NSW Industrial Noise Policy (INP).

Some healthcare buildings (those with patient accommodation) and residential properties in the vicinity of the Lifehouse site will be sensitive to noise at all times.

Administrative areas of the surrounding healthcare buildings (e.g. the KGV building) and the commercial premises in surrounding area are less sensitive to noise from the Lifehouse building, and will only be sensitive when in use.

The most affected noise sensitive receivers are expected to be St Andrews College, and the residential receivers on Carillon Avenue, particularly receivers to the south-west of the Lifehouse building (e.g. 140 Carillon Avenue) that may have direct line-of-sight to plant areas at the Lifehouse development.

A summary of the closest noise-sensitive receivers to Lifehouse is presented in Table 2.

Receiver	Direction from Lifehouse Site	Approximate Distance from Site	Receiver Type
St Andrew's College	SE	45 m	Residential
KGV Building	N	25 m	Commercial
St John's College	N	180 m	Residential
140 Carillon Avenue	SW	150 m	Residential
163 Missenden Road	S	110 m	Residential

Table 2: Closest Noise-Sensitive Receiver Locations, Lifehouse development

4.3 Methodology

A noise survey was carried out to establish the current ambient noise levels around the proposed development site and to identify noise sensitive receivers. This included both attended and unattended monitoring.

A noise survey has been carried out and to establish the current ambient noise levels in the vicinity of the subject site.

A noise logger (RTA Technologies Type 02 noise logger #035) continuously measured the noise level on the southern balcony of Level 8 of the KGV building at RPA Hospital, which is immediately adjacent to the Lifehouse site from 23 March 2010 to 30 March 2010.

The logger recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15 minute intervals continuously for the measurement period. Weather observations were undertaken during this period and where noise levels were affected the data was not used. The logger was checked for calibration before and after the monitoring period and no deviation had occurred.

The noise levels measured are considered as representative for the current noise environment of the closest noise-sensitive receivers to the Lifehouse development.

The average hourly noise levels throughout the day have been determined from the total measurement period. Average noise levels from the logger are presented in Appendix B. The raw data from the loggers is available upon request.

Table 3 presents an overview of the measured ambient noise parameters from the unattended noise survey. The Rating Background Level (RBL) and average industrial L_{Aeq} are presented for the day, evening and night time periods, as defined in the NSW Industrial Noise Policy (INP).

The Rating Background Level was calculated using the 'tenth percentile' method given in Appendix B of the INP. The average industrial L_{Aeq} noise level (which is the noise level from all industrial noise sources, not necessarily the measured ambient L_{Aeq} noise level) was represented by the measured L_{A90} noise level.

The Industrial Noise Policy notes that when industrial noise levels are approximately constant (e.g. mechanical plant noise), the L_{A90} descriptor may be a more appropriate representation of the average industrial noise level than the measured L_{Aeq}, which may be affected by other noise sources such as traffic noise.

Time Period	Rating Background Level RBL L_{A90}	Average Industrial L_{Aeq}
Day (0700hrs -1800hrs)	52	56
Evening (1800hrs-2200hrs)	51	54
Night time (2200hrs-0700hrs)	45	48

Table 3: Noise survey results from logger on the southern Level 8 balcony of KGV Building, RPA Hospital, 23 March 2010 to 30 March 2010, dB re 20μPa

5 Acoustic Design Criteria

Acoustic design criteria are presented for:

- Noise breakout to the community, for mechanical services associated with the development
- Internal noise levels, including services noise and external noise break-in to the development

Design criteria are based on relevant Australian Standards, codes, policies and control plans, including:

- *NSW Industrial Noise Policy,* Environmental Protection Authority (INP), January 2000
- *NSW Environmental Criteria for Road Traffic Noise*, (ECRTN), May 1999
- AS/NZS 2107 (2000), *Acoustics- Recommended design sound levels and reverberation times for building interiors*
- AS 2021 (2000): *Acoustics – Aircraft noise intrusion – Building siting and construction*

5.1 Internal Noise Criteria

AS 2107 provides guidance for design background noise levels for various types of occupancy. The limits apply to steady-state or quasi steady-state sounds such as noise from air conditioning systems, and are given as overall dB(A) limits for many types of room.

Target noise limits for steady-state noise generated by building services and noise break-in from external sources have been determined by a combination of guidance from AS 2107 and experience from similar projects.

In addition to the overall dB(A) limits, Arup also recommends designing to a rating curve such as the Noise Rating (NR) curves. This will assist in achieving a balanced background noise spectrum, avoiding annoying characteristics such as low-frequency “rumble” or high-frequency “hiss”, while still achieving the overall AS 2107 dB(A) noise levels.

For a typical building services spectrum, the NR rating of the spectrum is approximately 5 units below the dB(A) rating – e.g. an overall level of 45 dB(A) typically would be rated at approximately NR 40.

Table 4 outlines noise level targets for the various spaces to be achieved by all services running normally and together plus quasi-steady external noise break-in.

Type of occupancy	Recommended design sound level (From Table 1, AS2107)	
	Satisfactory	Maximum
Laboratories	45 dB(A) / NR40	50 dB(A) / NR45
Wards, Level 1 Patient Bridge	35 dB(A) / NR30	40 dB(A) / NR35
Waiting rooms, reception areas, lobbies	40 dB(A) / NR35	50 dB(A) / NR45
Operating theatres	40 dB(A) / NR35	45 dB(A) / NR40
Consulting rooms; sterilising areas in operating theatres	40 dB(A) / NR35	45 dB(A) / NR40
Inpatient accommodation – living areas	35 dB(A) / NR30	45 dB(A) / NR40
Inpatient accommodation – sleeping areas	30 dB(A) / NR25	40 dB(A) / NR35
Offices – board and conference rooms, private offices	35 dB(A) / NR30	40 dB(A) / NR35
General office areas – call centres, open offices	40 dB(A) / NR35	45 dB(A) / NR40
Common office areas – cafeterias , public spaces, tea rooms	45 dB(A) / NR40	50 dB(A) / NR45
Atrium	45 dB(A) / NR40	50 dB(A) / NR45
Common areas – Lift lobbies, foyers, coffee bars and restaurants, cafeterias, retail, supermarket and food courts	45 dB(A) / NR40	55 dB(A) / NR50

Table 4: Design Internal Sound Levels, dB re 20μPa

Note: The recommended design sound levels given in this table are used 'traditionally' for sealed, air-conditioned buildings, and apply only to "quasi steady-state" noise – typically building services noise.

These noise levels correspond to the combined measured level of external sources of noise break-in and the ventilation/air-conditioning systems operating normally.

If natural ventilation is proposed for some spaces in the Lifehouse development, specific acoustic design targets will be established to maintain acoustic comfort in these spaces while facilitating natural air flow.

Arup Acoustics generally recommends that the 'maximum' levels be used for design in order to provide a degree of noise masking and speech privacy in internal areas.

5.2 Reverberation Times

AS 2107 also provides recommended mid-frequency design reverberation times for building interiors. The recommended reverberation times represent appropriate room acoustic conditions for different building areas.

Type of occupancy	Recommended reverberation times (From Table 1, AS2107)
Laboratories	0.6 s – 0.8 s
Wards, Level 1 Patient Bridge	0.4 s – 0.7 s
Waiting rooms, reception areas, lobbies	0.4 s – 0.6 s
Operating theatres	0.6 s – 0.8 s
Consulting rooms; sterilising areas in operating theatres	0.4 s – 0.6 s
Offices – board and conference rooms, private offices	0.6 s – 0.8 s
General office areas – call centres, open offices	0.4 s – 0.6 s
Common office areas – cafeterias and tea rooms	Minimised as far as practicable
Common areas – Lift lobbies, foyers, coffee bars and restaurants, cafeterias, retail, supermarket and food courts	Minimised as far as practicable

Table 5: Design Reverberation Times,

5.2.1 Atrium

AS 2107 does not provide design recommendations for atrium areas, and therefore design criteria for the atrium have been derived from Arup's previous experience. Typically, an atrium will be designed to have a relatively reverberant acoustic to provide a sense of space and grandeur.

However, for healthcare buildings such as Lifehouse, a less reverberant room acoustic is considered appropriate. This will assist in noise control within the atrium and result in a more subdued and discreet acoustic environment, reducing the disturbance to occupants of the building due to noise transfer from other areas.

Therefore, it is recommended that the reverberance of the atrium is minimised as far as practicable.

5.3 Design Criteria for Control of External Noise

5.3.1 Traffic Noise

Internal noise criteria for traffic noise intrusion to "sensitive land uses" such as healthcare buildings are given in Table 2 of the ECRTN. Criteria are provided for hospital wards, but the ECRTN also states that appropriate criteria for other noise-sensitive spaces within healthcare buildings may be obtained by interpolation within the "maximum" noise levels recommended in AS 2107, as summarised in Table 6.

Type of occupancy	Internal Traffic Noise Level, $L_{Aeq(1hr)}$ (From ECRTN and Table 1, AS2107)	
	Day (7 am to 10 pm)	**Night (10 pm to 7 am)**
Wards, Level 1 Patient Bridge	35 dB(A)	35 dB(A)
Operating theatre	40 dB(A)	40 dB(A)
Consulting rooms; sterilising areas in operating theatres	40 dB(A)	40 dB(A)
Inpatient accommodation – living areas	40 dB(A)	40 dB(A)
Inpatient accommodation – sleeping areas	35 dB(A)	35 dB(A)
Offices – board and conference rooms, private offices	35 dB(A)	35 dB(A)
General office areas – call centres, design offices, open offices, reception areas, rest rooms and tea rooms	40 dB(A)	40 dB(A)

Table 6: Traffic Noise Intrusion Criteria for Lifehouse development, ECRTN/AS 2107

The $L_{Aeq(1hr)}$ descriptor used in the ECRTN has a special meaning, and refers to the highest tenth-percentile of each hourly L_{Aeq} noise level over the day (7 am to 10 pm) or night (10 pm to 7 am) time periods, as defined in Appendix C of the ECRTN, and therefore does not necessarily represent the “worst” hour during the day.

The façade of the Lifehouse development should be designed to meet the internal traffic noise levels given in Table 6.

For particularly sensitive spaces, such as operating theatres, wards, and the Level 1 Patient Bridge, maximum noise levels from external traffic (represented by the $L_{A1,15minute}$ noise parameter), should be controlled to meet the maximum internal noise levels for aircraft noise given in Table 7.

5.3.2 Helicopter/Aircraft Noise

AS2021 contains criteria for recommended maximum internal noise levels from aircraft noise for various building usages.

Type of occupancy	Maximum Internal Design Level, L_{Amax}
Laboratories	65 dB
Wards	50 dB
Waiting rooms, reception areas	65 dB
Operating theatres	50 dB
Consulting rooms; sterilising areas in operating theatres	50 dB
Inpatient accommodation – living areas	50 dB
Inpatient accommodation – sleeping areas	55 dB
Offices – board and conference rooms, private offices	55 dB
General office areas – call centres, design offices, open offices, reception areas, rest rooms and tea rooms	65 dB
Common office areas – cafeterias, lobbies, public spaces	70 dB
Common areas – Lift lobbies, foyers, coffee bars and restaurants, cafeterias, retail, supermarket and food courts	75 dB

Table 7: Aircraft Noise Intrusion Criteria for Lifehouse development, AS 2021

5.4 Operational Noise Criteria

The New South Wales environmental noise policy relating to industrial noise is the *New South Wales Environment Protection Authority Industrial Noise Policy* (INP) dated January 2000, which covers noise emission from operation of a facility and from plant and equipment on the proposed facility. Noise from traffic movements on a site (i.e. not on public roads) is assessed as being operational noise under the INP.

The objective of the INP is to protect residential areas from noise generated by commercial, industrial or trade premises. Noise limits are set based on land use in the area and existing background noise levels. Compliance is achieved if the adjusted L_{Aeq} noise level at any residence affected by noise from the facility is below the noise limit. The adjusted L_{Aeq} is determined by applying corrections for such noise characteristics as duration, intermittency, tonality, and impulsiveness.

The assessment of noise emission under INP is based on the calculation of a noise limit at a receiver position, taking into account the land-use in the surrounding area and the background noise level.

The INP separates the day into three different time periods – day, evening and night. These time periods are detailed in Table 8.

Period	Day of Week	Time period
Day	Monday-Saturday	7:00 am-6:00 pm
	Sunday, Public Holidays	8:00 am-6:00 pm
Evening	Monday-Sunday	6:00 pm -10:00 pm
Night	Monday-Saturday	10:00 pm -7:00 am
	Sunday, Public Holidays	10:00 pm -8:00 am

Table 8 : Standard INP Time Periods

The INP states that background noise levels should be determined over the “days and times of operation of the development”. When setting criteria, only the measured data from the hours of operation of the development should be included.

The proposed plant at the Lifehouse development will potentially operate continuously, and therefore noise levels across the entire Night time period have been used to determine background noise levels for this assessment.

The INP provides guidance on acceptable noise levels from the introduction of new industrial noise sources to an area. The assessment procedure for industrial noise sources has two components:

- Controlling intrusive noise impacts in the short term for residences.
- Protecting noise level amenity for particular land uses such as residences and commercial offices etc.

Both of these components result in noise criteria that should not be exceeded in order to avoid any adverse noise impacts on the affected areas. Both criteria should be taken into account when assessing the noise impact of industrial source(s) associated with the proposed development, and where the intrusiveness and the amenity criterion differ, the most stringent of the noise criteria should be adopted as the project-specific noise criterion.

5.4.1 Intrusiveness Criterion

A 15-minute sampling period is typically used when measuring the level of intrusive noise. This is taken to be a reasonable estimate of the period over which annoyance may occur. Therefore the intrusiveness criterion is summarised as follows:

$L_{Aeq\ (15\ min)} \leq L_{A90\ (15\ min)}$ Background Level + 5 dB

Because of the variable nature of background noise levels, the INP specifies single number background noise levels for use in setting the intrusiveness noise criterion. The Assessment Background Level (ABL) for each time period of a day is the level exceeded by 90 % of the $L_{A90,15min}$ measurements. The Rating Background Level (RBL) for a particular time period is the median of the ABL values for that time period for each day of the measurement period.

Industrial noise from the subject development should be controlled to not exceed the Rating Background Level (RBL) + 5 dB at the boundary of any noise sensitive receiver, as summarised in Table 9:

Noise Sensitive Receivers	Time Period	RBL	Intrusiveness Criterion
		dB(A)	RBL + 5 dB(A)
Residential Receivers	Day	52	**57**
	Evening	51	**56**
	Night*	45	**50**

Table 9: Intrusiveness Criteria for Residential Receivers

The intrusiveness criterion only applies at residential receivers, unlike the amenity criterion, which applies at both residential and commercial receivers.

5.4.2 Amenity Criterion

Criteria for the protection of amenity are given for various types of receiver and different times of the day. The amenity criterion is set so that the noise levels from the industrial noise source do not increase the total industrial noise levels at the receiver above the acceptable noise level (ANL) for that receiver.

The amenity criterion applies to the L_{Aeq} noise level from all industrial noise sources over the time period T, (i.e. $L_{Aeq,T}$) which is the time period over which the criterion applies – e.g. for the Day time period, T is 11 hours, and the amenity criterion is a $L_{Aeq,11hr}$ noise level.

The amenity criterion is set based on how close the existing average industrial noise levels ($L_{Aeq,average}$) are to the ANL, using adjustment factors given in Table 2.2 of the INP.

In cases where the existing $L_{Aeq,average}$ noise levels exceed the ANL by more than 2 dB(A), and the existing noise levels are unlikely to decrease in future, then the amenity criterion is set to be 10 dB(A) lower than the existing noise levels at the receiver. This is to prevent a creeping background noise environment.

Note that the L_{Aeq} industrial noise level is not necessarily the measured L_{Aeq} noise level from a noise logger or attended measurements; in cases where the existing industrial noise sources are steady-state the measured L_{A90} noise level may be a better representation of the existing industrial noise levels.

The amenity criterion applies to other land uses (including commercial premises and hospital buildings), unlike the intrusiveness criterion, which only applies for residential receivers.

A summary of the amenity criteria is presented in Table 10:

Noise Sensitive Receiver	Time period	Existing L_{Aeq}, dB(A)*	ANL** L_{Aeq}, dB(A)	Modification to acceptable noise limit***	Amenity Criterion Existing $L_{Aeq,T}$ + modification of ANL (L_{eq}, dB(A))
Residential Receivers	Day	56	60	ANL-2 dB	**58 dB**
	Evening	54	50	L_{Aeq}-10 dB	**44 dB**
	Night	48	45	L_{Aeq}-10 dB	**38 dB**
Hospital Wards	Noisiest 1 Hour*	48	50	ANL-4 dB	**46 dB**
Commercial Receivers	Day	56	65	ANL-0 dB	**65 dB**
	Evening	54	65	ANL-0 dB	**65 dB**
	Night	48	65	ANL-0 dB	**65 dB**

* Assumed to occur during the Night time period, where receivers are most sensitive to noise

** Acceptable Noise Level, according to Table 2.1 (NSW Industrial Noise Policy, 2000)

***According to Table 2.2 (NSW Industrial Noise Policy, 2000)

Table 10: Derivation of Amenity Criteria

5.4.3 Industrial Noise Policy Limiting Criteria

The most stringent of the intrusiveness and the amenity criteria is the limiting criterion according to the INP, and sets the project specific noise level to be met by the development. Table 11 compares the intrusiveness and the amenity criteria at the Noise Sensitive Receivers, and identifies the limiting criterion for each time period.

Noise Sensitive Receiver	Time Period	Intrusiveness Criterion	Amenity Criterion	Limiting Criterion
Residential Receivers	Day	57	58	**57**
	Evening	56	44	**44**
	Night	50	38	**38**
Hospital Wards	Noisiest 1 Hour	N/A	48	**48**
Commercial Receivers	Day	N/A	65	**65**
	Evening	N/A	65	**65**
	Night	N/A	65	**65**

Table 11: Project Specific Noise Level, dB L_{Aeq}

Mechanical plant noise levels from are typically steady during the hours of operation of the building. Therefore, the most stringent noise criterion over all time periods has been adopted as the project-specific noise criteria:

- Residential receivers: 38 dB(A)
- Hospital wards: 48 dB(A)
- Commercial receivers 65 dB(A)

5.5 Criteria for Construction Noise

The DECCW *Interim Construction Noise Guideline* provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels, and specifies that "all feasible and reasonable" work practices should be applied to manage construction noise impacts in the event that predicted construction management noise levels are exceeded.

The DECCW interim guideline sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 12. Noise levels apply at the worst affected property boundary of the residence, at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residences, the noise levels apply at the most noise-affected point within 30 m of the residence.

Time of day	Management level, $L_{Aeq\ (15min)}$	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 + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ 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 residents 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 noise activities can occur, 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 + 5 dB	• 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.

Table 12: DECCW management levels for airborne construction noise at residences

The DECCW interim guideline provides recommended noise levels for sensitive land uses other than residential receivers. The recommended limit for school buildings is reproduced below in Table 13:

Land Use	Management level, $L_{Aeq,15min}$ (applies when properties are being used)
Hospital wards and operating theatres (internal)	45 dB

Table 13: Recommended construction noise limits for non-residential receivers

The noise logger data from the KGV building has been used to determine the project specific construction airborne noise goals for surrounding receivers.

A summary of the project specific construction noise targets for residential noise-sensitive receivers is included below in Table 14.

Time period	Noise affected level, $dBL_{Aeq\ (15min)}$	Highly noise affected level, $dBL_{Aeq\ (15min)}$
Recommended standard hours:		
Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm	62 dB	75 dB
Outside recommended standard hours*		
Daytime Saturday 1 pm to 6 pm Sunday, Public Holidays 8 am to 6 pm	57 dB	53 dB
Evening Monday to Sunday 6 pm to 10 pm	56 dB	51 dB
Night-time Monday to Saturday 10 pm to 7 am Sunday, Public Holidays 10 pm to 8 am	45 dB	43 dB

* Time periods outside recommended work hours are as defined in NSW Industrial Noise Policy, 2000

Table 14: Project specific airborne construction noise targets

5.6 Criteria for Traffic Noise on Public Roads

Noise criteria for traffic movements on public roads resulting from the Lifehouse development were developed from the Environmental Criteria for Road Traffic Noise (ECRTN).

In accordance with the INP, road traffic noise from vehicles while on site is characterised as industrial noise, and therefore vehicle movements on site are subject to the noise criteria discussed in Section 5.4.

Road traffic noise from vehicles from Lifehouse operating on public roads is subject to the ECRTN noise criteria. The ECRTN provides several categories for type of development and appropriate noise planning targets are given for each type of development.

The ECRTN noise criteria are planning goals for new development and as such are not legislative requirements that must be met by new developments. Rather, these criteria should be used as design goals for the development; however the ECRTN recognises that ”the criteria are applied as targets, but recognise that there will be situations where planning strategies are not feasible”.

Lifehouse is best characterised as a development of either Type 8 – *Land use developments with potential to create additional traffic on collector roads* (for traffic on Missenden Road) or Type 13 – *Land use developments with potential to create additional traffic on local roads* (for traffic on eastern Salisbury Road). Table 15 presents an extract from Table 1 of the ECRTN outlining the appropriate noise criteria. If existing traffic noise levels already exceed the criteria, then the new development should not increase existing noise levels by more than 2 dB(A).

Type of Development	Noise Criterion Day (7 am – 10 pm)	Noise Criterion Night (10 pm – 7 am)
8. Land use developments with potential to create additional traffic on collector road	60 dB $L_{Aeq(1hr)}$	55 dB $L_{Aeq(1hr)}$
13. Land use developments with potential to create additional traffic on local road	55 dB $L_{Aeq(1hr)}$	50 dB $L_{Aeq(1hr)}$

Table 15: ECRTN Criteria for Lifehouse.

5.7 Vibration Design Criteria

5.7.1 General Building Areas

Vibration levels caused by activities on the site (including plant) should not exceed the levels specified in the DECCW *Assessing Vibration* guideline at any place of different occupancy at and around the site. The *Assessing Vibration* guideline provides operational vibration criteria for maintaining human comfort within different space uses.

Both “preferred” and “maximum” vibration criteria are given. Due to the increased sensitivity of some occupants of the Lifehouse development to noise and vibration, design to the “preferred” criteria is recommended.

The *Assessing Vibration* guideline recommends maximum weighted vibration levels for continuous vibration sources, such as mechanical services plant, and for impulsive vibration sources. The weighting curves are obtained from BS 6472: *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*.

For intermittent sources (e.g. trains, heavy vehicles, intermittent construction), the *Assessing Vibration* guideline uses the Vibration Dose Value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event.

Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as “impulsive” sources for the purposes of the *Assessing Vibration* guideline.

The vibration limits recommended for maintaining human comfort in residences and offices are shown in Table 16 below.

Location	Maximum z-axis weighted rms vibration acceleration (m/s^2)		Vibration Dose Value ($m/s^{1.75}$)
	Continuous	Impulsive	Intermittent
Residential areas (night)	0.007	0.10	0.13
Residential areas (day)	0.010	0.30	0.20
Office areas	0.020	0.64	0.40
Workshops	0.040	0.64	0.80

Table 16: Vibration limits in the AS 2670.2 for different types of occupancy

Vibration criteria for critical areas that are more vibration-sensitive than residential areas are not specifically given in the *Assessing Vibration Guideline*, and more specialist advice is recommended.

5.7.2 Critical Areas

For critical areas, such as operating theatres, imaging suites or vibration-sensitive equipment, the guidance of the *Assessing Vibration* guideline is not appropriate.

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) summarises appropriate design guidance for vibration-sensitive spaces in its *Sound and Vibration Control* guideline[3]. Design curves of vibration velocity against frequency are given in Figure 2, with guidance for appropriate design curves for particular space usages given in Table 17.

[3] ASHRAE (2007) ASHRAE Handbook – HVAC Applications, *Chapter 47: Sound and Vibration Control*

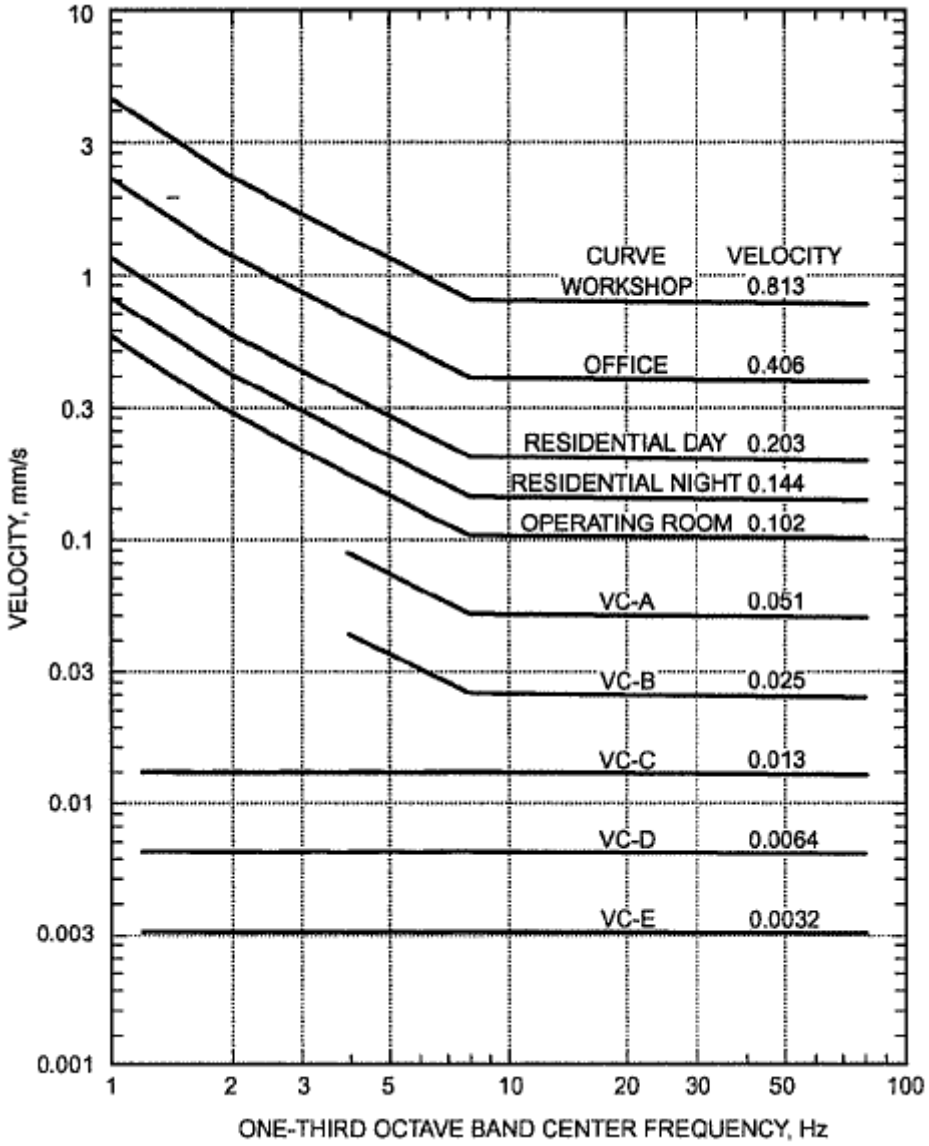

Figure 2: Recommended vibration design curves for sensitive areas (adapted from Table 37, Chapter 47 ASHRAE 2007 Handbook)

Space usage	Recommended design curve	Minimum velocity level (mm/s)
Operating theatres	OPERATING ROOM	0.102
Bench microscopes (up to 100 x magnification)		
Bench microscopes (up to 400 x magnification)	VC-A	0.051
Microsurgery, eye surgery, neurosurgery	VC-B	0.025
Bench microscopes (greater than 400 x magnification); optical equipment on isolation tables		
Electron microscopes (up to 30,000 x magnification); MRI machines	VC-C	0.013
Electron microscopes (greater than 30,000 x magnification)	VC-D	0.0054

Table 17: Recommended design targets for vibration-sensitive areas

6 Guidelines for Meeting Noise and Vibration Criteria

The following methods will be adopted to ensure that the acoustic design targets presented in Section 5 will be achieved.

6.1 Noise Impacts from Development on the Community

6.1.1 General

The following areas of the development are expected to generate operational environmental noise:

- Plant and services equipment in plant areas
- Operational traffic areas (e.g. loading docks, carparks)

Noise control strategies for these areas are discussed in the sections below.

6.1.2 Mechanical Services Plant

Noise control for mechanical plant at the Lifehouse development is discussed in the SKM report.

6.1.3 Operational Noise

Noise levels from vehicle movements on site, including carparks and loading docks may be mitigated by space planning of the development to minimise the need for heavy vehicles to reverse (including reversing beeper noise), and by locating loading docks and carpark entrances/exits away from noise-sensitive areas of the Lifehouse development and away from external noise-sensitive receivers.

Other noise mitigation measures include providing screening of loading docks/entrances by the building envelope of the Lifehouse buildings, acoustically treating the loading dock with absorptive material, and enclosing loading docks with shutters so that potentially-noisy unloading activities are conducted with shutters closed.

Noise control for on-site operational noise sources will be incorporated into the detailed design of the Lifehouse development.

6.1.4 Traffic Noise on Public Roads

The development of the Lifehouse building will create the need for additional staff for the RPAH precinct. This increase in staff will result in a marginal increase in traffic movements on Missenden Road and eastern Salisbury Road. These roads pass adjacent to the east and northern facades of the Lifehouse respectively.

Missenden Road is a through collector road, whilst Salisbury Road is a local road that provides access to an existing car park and the proposed future underground car park and loading docks for the Lifehouse development.

Table 18 below shows approximate existing traffic numbers on these roads in absence of the Lifehouse development and future predicted traffic numbers when Stage A and Stage B1 are complete.

Location	Scenario	Time Period	
		AM Peak (8am - 9am)	PM Peak (5pm - 6pm)
Missenden Rd (South of Salisbury Rd)	Existing	1,252	1,524
	Stage A	1,272	1,541
	Stage B1	1,299	1,560
Salisbury Rd	Existing	235	207
	Stage A	278	255
	Stage B1	301	274

Table 18: Existing versus predicted future traffic numbers for Lifehouse development

The predicted increase in traffic numbers on Missenden and Salisbury Roads during morning and evening peak periods is predicted to result in an approximate increase in noise levels of less than 1 dB(A) for Missenden Road, and an increase of 1 dB(A) for eastern Salisbury Road.

The ECRTN allows an increase of up to 2 dB(A) in traffic noise levels from a project of this type. Therefore, the noise impact to noise sensitive receivers associated with additional traffic movements associated with the Lifehouse development is considered negligible.

6.1.5 Construction Noise

A construction noise assessment will be undertaken as part of preparation of a Construction Noise and Vibration Management Plan for the Lifehouse development, once more details of the expected construction process for Lifehouse are available.

6.2 External Noise Impacts on the Development

The following noise sources are considered to be the primary noise sources affecting the Lifehouse development:

- General road traffic noise from Missenden Road
- Bus traffic on Missenden Road, particularly buses accelerating and decelerating
- Vehicle traffic on service roads of RPA, particularly truck movements on Susan Street.
- Helicopter traffic from the helipad at RPA.

To control these noise sources, the following façade constructions are expected to be required, as discussed in the following sections.

6.2.1 Inpatient Accommodation Units

The façade performance for the inpatient areas should achieve approximately R_w+C_{tr} 35 dB.

To meet the acoustic requirements, a bespoke double glazed unit with integrated venetian blind in the air cavity will be used. The air gap should be at least 35 mm wide, with different glazing thicknesses on either side of the DGU (e.g. 6 mm and 10 mm glazing).

6.2.2 Level 1 Pedestrian Bridge

The façade performance for the pedestrian bridge should achieve approximately R_w+C_{tr} 35 dB.

This will be achieved by a high-performance double glazing system (e.g. 9.38 mm laminate | 19 mm air gap | 13.38 mm laminated glass).

6.2.3 Wards

The façade performance for wards should achieve approximately R_w+C_{tr} 35 dB.

This will be achieved by the bespoke double glazed unit system as for inpatient accommodation areas, or by a high-performance double glazing system (e.g. 9.38 mm laminate | 19 mm air gap | 13.38 mm laminated glass).

6.2.4 Operating Theatres, Consulting/Treatment Rooms

The façade performance for operating theatres and consulting/treatment rooms should achieve approximately R_w+C_{tr} 30 dB.

This could be achieved with a 6|12|8 double-glazing unit or by 10.38 mm laminated glass.

Appendix A

Acoustic Terminology

A1 Glossary of Acoustic Terminology

DECIBEL

The ratio of sound pressures that can be heard is a ratio of 10^6 (one million:one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound pressure level' (L_p) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. It is worth noting that an increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise, and a change of 2 to 3 dB is subjectively barely perceptible.

EQUIVALENT CONTINUOUS SOUND LEVEL

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

STATISTICAL NOISE LEVELS

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index which allows for this variation. The L_{10}, the level exceeded for ten per cent of the time period under consideration, has been adopted in this country for the assessment of road traffic noise. The L_{90}, the level exceeded for ninety per cent of the time, has been adopted to represent the background noise level. The L_1, the level exceeded for one per cent of the time, is representative of the maximum levels recorded during the sample period. A weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, eg $dBL_{A10,\ 5min}$ or $dBL_{A90,\ 8hr}$.

RATING BACKGROUND LEVEL (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

ASSESSMENT BACKGROUND LEVEL (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Appendix B

Noise Survey Data

B1 Noise Survey Data

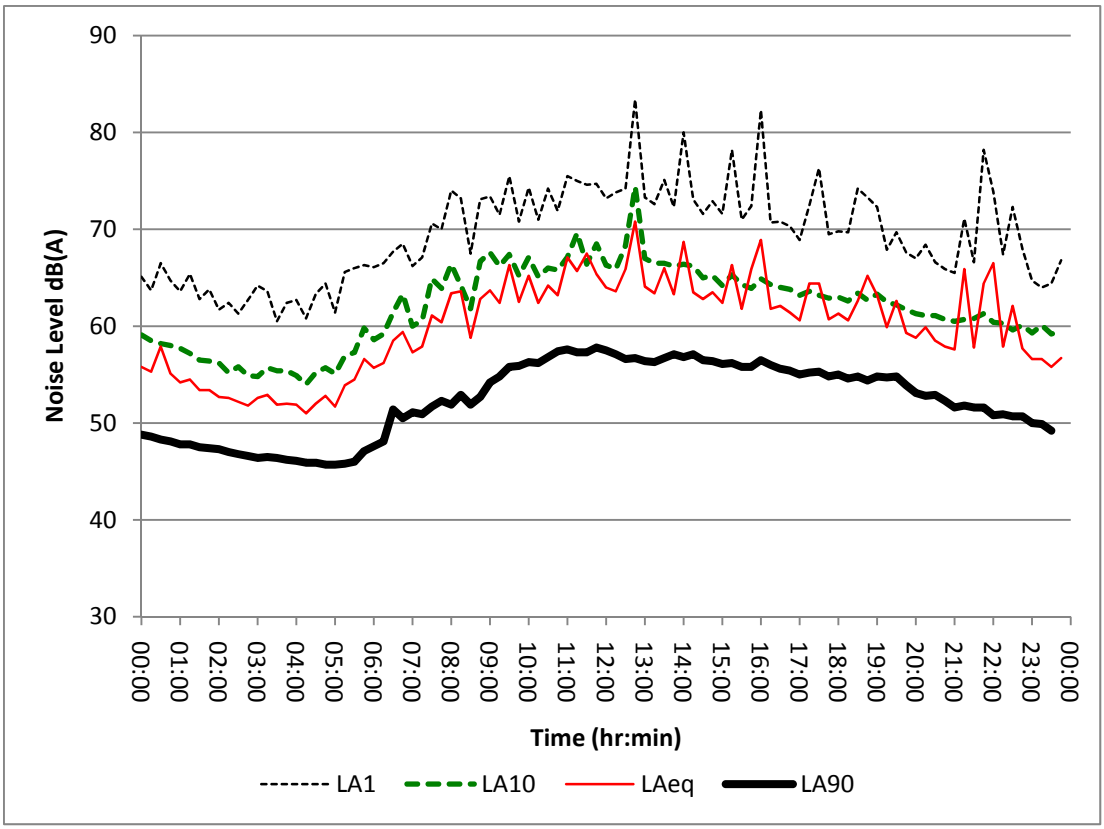

Figure 3: Average Noise Levels, 23 March 2010 to 30 March 2010, dB re 20μPa