Brookvale Oval Redevelopment – Noise Impact Assessment

Manly Warringah Sea Eagles

c/o Hassell

Level 2, Pier 8/9, 23 Hickson Road, Sydney

Brookvale Oval Redevelopment Noise Impact Assessment

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Brookvale Oval Redevelopment – Noise Impact Assessment

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1 INTRODUCTION

Pulse Acoustic Consultancy Pty Ltd (Pulse Acoustics) has been engaged by Manly Warringah Sea Eagles (MWSE) c/o Hassell (the client) to undertake a Noise Impact Assessment for the proposed Brookvale Oval Redevelopment. The proposal includes a new state of the art Centre of Excellence and 3000 seat covered Grandstand at the Northern end of the subject site.

This document assesses the potential operational noise impacts of the Centre of Excellence and Northern Grandstand. In particular, operational impacts of the mechanical equipment, gymnasium and vehicle movements from the centre of excellence are analysed.

In this assessment, the nearest receivers are identified, and project criteria are derived. Operational noise criteria is taken from the *Noise Policy for Industry*, road noise criteria is derived from the *Road Noise Policy*, construction noise criteria is taken from the *Interim Construction Noise Guideline* and vibration criteria are derived from *Assessing Vibration: A Technical Guideline*, *BS 7385-2* and *BS 6472*. Noise modelling of the potential operational impacts is conducted in iNoise 2019.1.

Relevant noise recommendations for the operational and construction stages are given. A list of acoustic terminology used in this report is included in Appendix A.

1.1 Site Location

Brookvale Oval is located 13km north-east of the Sydney CBD, in the suburb of Brookvale. The south side of the oval fronts onto Pittwater Road, the east side of the oval is bounded by Pine Avenue and the west side of the oval is bordered by Alfred Road. Directly to the north of the oval is Brookvale Park and Federal Parade. The site location is shown in Figure 1.

Figure 1 Site location

1.2 Project Description

The proposed Brookvale Oval redevelopment comprises of a new state of the art Centre of Excellence and 3000 seat covered Grandstand at the Northern end of the subject site, as shown in Figure 2 to Figure 6. The facility will provide a state of the art training environment for players, events and sports administrators. Proposed facilities include

- A new 3000 seat grandstand with 100% roof coverage;
- Increased seating including greater levels of undercover spectator seating and people with a disability (PWD) seating;
- Dedicated lift access to each level for better team access, admin workplace, spectator comfort and corporate experience;

- Designated areas for admin and team training facilities;
- Public amenities including PWD amenities and parent's room;
- Player change rooms and amenities;
- Dedicated broadcast positions;
- Ramps for accessibility to building and adjacent west concourse; and
- Space and provisions for recovery pools;

The Centre of Excellence will feature a number of rooms that will contribute to the working operation of the facility, the physical preparation of the Sea Eagles and the administration of the club. As shown in Figure 3, the proposed lower ground level rooms include

- Plant rooms;
- Tanks; and
- Player access tunnel;

The proposed concourse level rooms in Figure 4 include

- Rehabilitation area;
- Male and female change rooms;
- Medical and rehabilitation room;
- Flexible education space;
- Lobby;
- Change room;
- Gymnasium;
- Property; and
- Plant.

As shown in Figure 5, the proposed upper level spaces include

- Comms;
- Male and female bathrooms;
- Boardroom;
- Meeting Rooms;
- Theatrette;
- Players lounge;
- Archive and store;
- Breakout;
- Offices;
- Performance analysis;
- Women's Academy;
- Plant rooms;
- Study; and
- Sleep rooms.

The centre of excellence is proposed to be operational 24 hours a day, seven days a week.

Figure 2 Proposed Site Plan

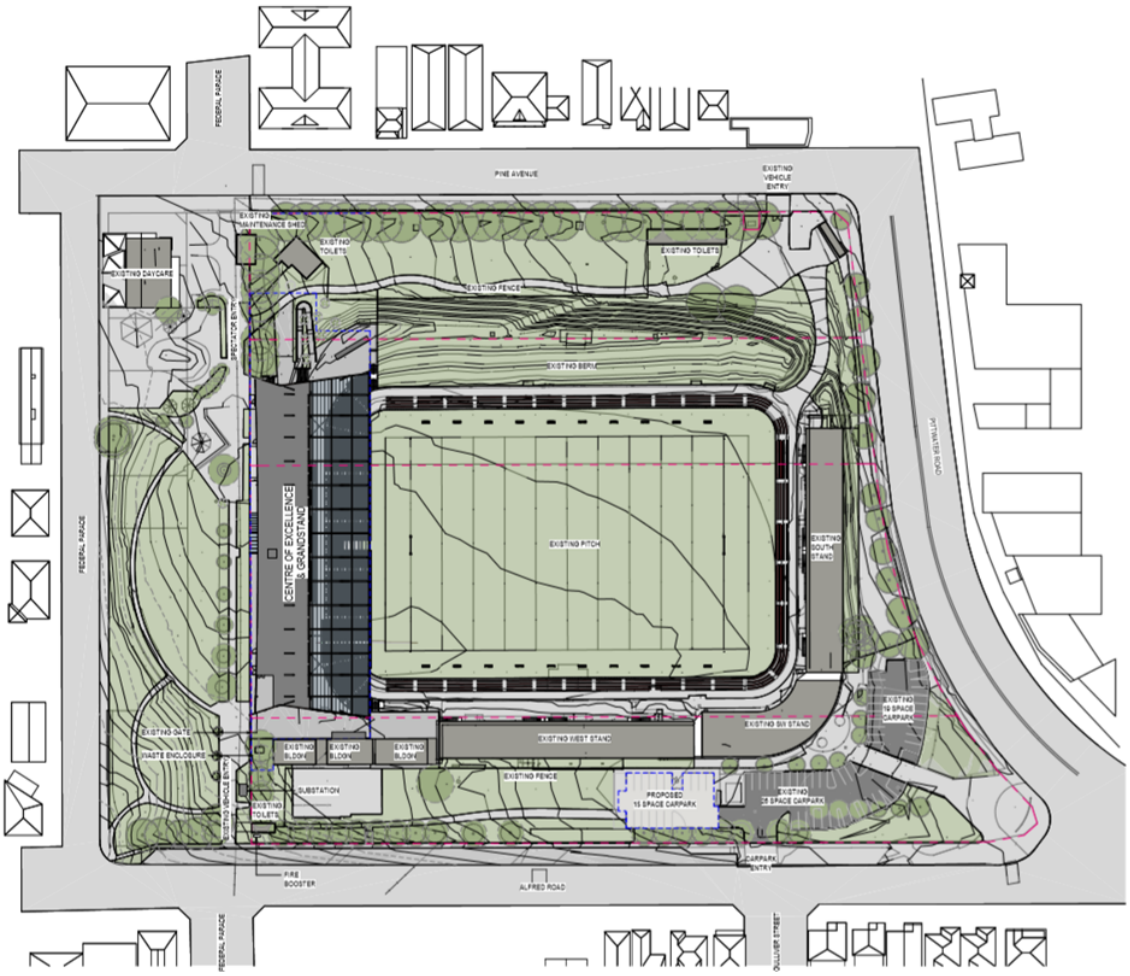


Figure 3 Proposed Lower Ground Level Plan

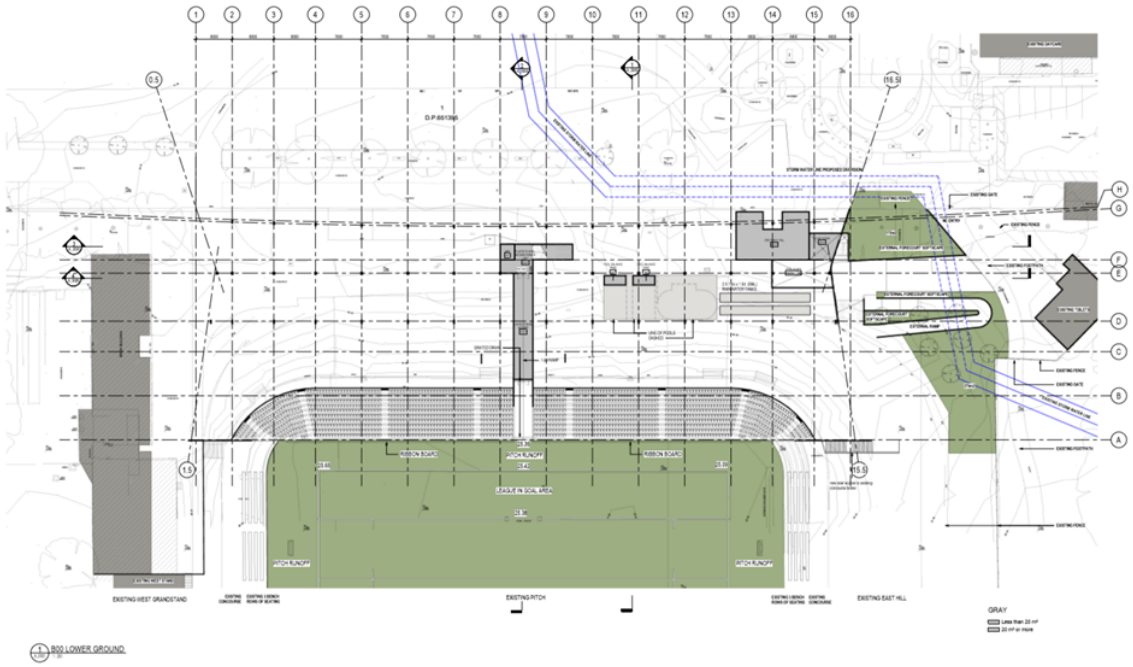


Figure 4 Proposed Concourse Level Plan

Figure 5 Proposed Upper Level Plan

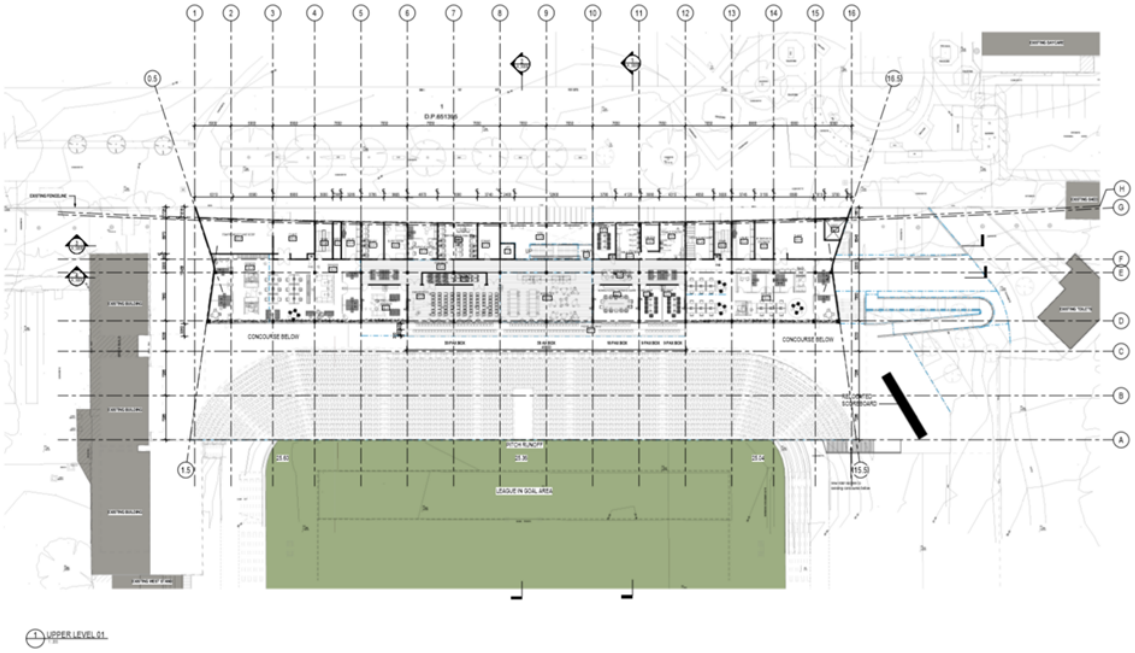
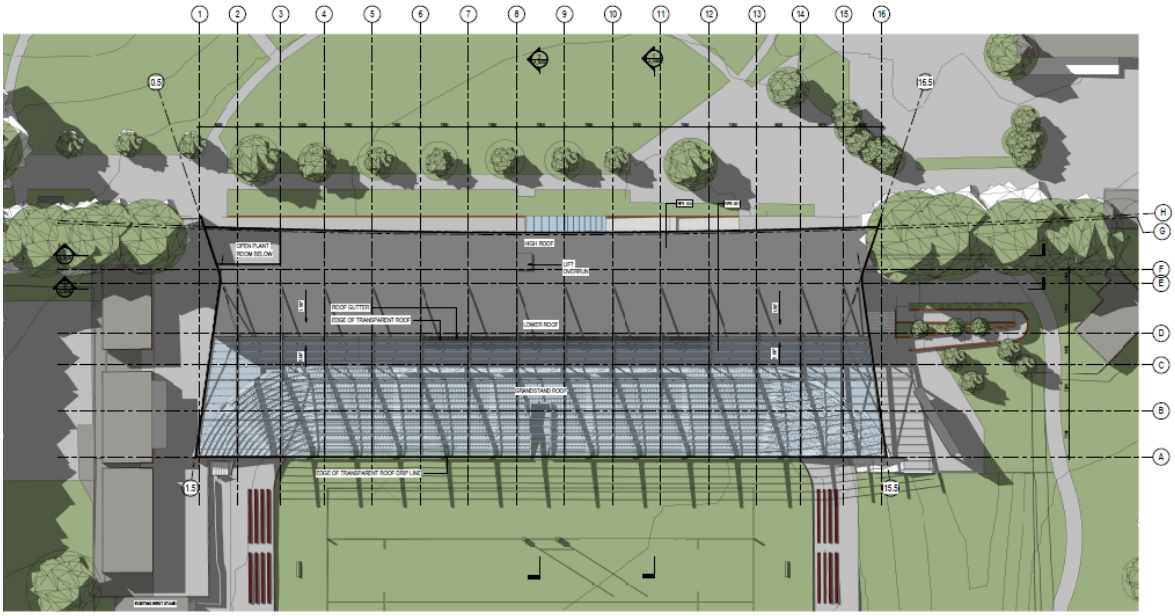


Figure 6 Proposed Roof Level Plan



2 NEAREST SENSITIVE RECEPTORS

A number of sensitive receivers are located in the vicinity of Brookvale Oval. As shown in Figure 7, residential receivers are located along Pine Avenue to the east, Federal Parade to the north and Alfred Road to the west.

Additionally, as shown in Figure 8, a number of non-residential receivers are located near the proposed Brookvale Oval Centre of Excellence. Childcare centres are located at 38 Federal Parade and Pittwater Road. Brookvale Park and St Augustine's College are adjoining receivers to the subject site and commercial receivers are located to the southeast.

The receptors utilised for noise predictions in this report are listed in Table 1 and presented in Figure 9.

Figure 7 Nearest residential receivers

Figure 8 Nearest non-residential receivers

Figure 9 Location of Considered Receivers

Table 1 Nearest Potentially Affected Receivers

Receptor ID	Address	Lot and DP	Type of Receiver
R1	16 Alfred Road, Brookvale	Lot 5 in DP 11209	Residential
R2	42 Alfred Road, Brookvale	Lot 12 in DP 568333	Residential
R3	1 Binba Place, Brookvale	Lot 6 in DP 227987	Residential
R4	10 Binba Place, Brookvale	Lot 18 in DP 227987	Residential
R5	40 Federal Parade, Brookvale	Lot 1 in DP 776771	Residential
R6	21-21A Pine Avenue, Brookvale	SP 76472	Residential
R7	17 Pine Avenue, Brookvale	SP 52715	Residential
R8	13 Pine Avenue, Brookvale	Lot 2 in DP 406507	Residential
R9	38 Federal Parade, Brookvale	Lot 2 in DP 776771	School classroom – internal
R10	Pittwater Road, Brookvale	Lot 1-2 in DP 1141128	School classroom – internal
R11	Federal Parade, Brookvale	Lot B in DP 395193	School classroom – internal
R12	Federal Parade, Brookvale	Lot B in DP 395193	Active recreation
R13	Pittwater Road, Brookvale	Lot 47 in DP 3674	Active recreation
R14	527 Pittwater Road, Brookvale	Lot 1 in DP 6681	Commercial

3 EXISTING ACOUSTIC ENVIRONMENT

3.1 Unattended Noise Survey

3.1.1 Methodology and Instrumentation

An unattended noise survey was conducted between 16 July 2019 and 24 July 2019, at the location shown in Figure 9. This survey was conducted in order to measure the existing ambient noise level. The location was selected, as the receiver is potentially one of the most impacted residential receptors by the proposed centre of excellence.

Instrumentation for the survey comprised of a Svan 971 unattended noise logger, serial number 74365. The noise logger was set up in the front yard of 10 Binba Place Brookvale, close to the Southern boundary, facing Brookvale Oval as shown in Figure 9.

Calibration of the loggers was checked prior to and following measurements. Drift in calibration did not exceed ±0.5 dB. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Charts presenting summaries of the measured daily noise data are attached in Appendix B. The charts present each 24-hour period and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels for the corresponding 15-minute periods. The L_{A90} noise descriptor is used to measure the background noise level. This descriptor represents the noise level that is exceeded for 90% of the time over a relevant period of measurement using 'A' frequency weighting and fast time weighting. The L_{Aeq} descriptor represents the level of average noise energy over the relevant period of measurement and takes account of peak noise levels as well as the degree of noise fluctuation. An explanation of common acoustic terms is included in Appendix A.

As per Appendix A4 of the Noise Policy for Industry, the gathered data has been filtered to exclude periods affected by adverse weather conditions. Weather data was sourced from the most representative Bureau of Meteorology Weather Station, being Terry Hills AWS (ID 066059). The Terrey Hills AWS is located 8.5km northwest of Brookvale Oval.

Measurement results for the unattended noise survey are summarised in Table 2 below. The L_{Aeq} and L_{A90} noise levels are presented for the day, evening and night periods as per Table 2.2 of the Noise Policy for Industry.

3.1.2 Measurement Results

3.1.2.1 Background Noise Levels

The noise levels measured at the logger location have been used to assess the noise impact of the development into the nearest noise affected receivers identified in Section 2. The time periods used to measure the background noise level are in accordance with the recommended periods in the NSW Noise Policy for Industry (NSW NPI). The measurement results are presented in Table 2 below.

Table 2 Measured ambient noise levels in accordance with the NSW NPI

Measurement Location	Daytime[1] 7:00 am to 6:00 pm		Evening[1] 6:00 pm to 10:00 pm		Night-time[1] 10:00 pm to 7:00 am	
	L_{A90}[2]	L_{Aeq}[3]	L_{A90}[2]	L_{Aeq}[3]	L_{A90}[2]	L_{Aeq}[3]
Logger Location (10 Binba Place, Brookvale)	41	55	39	52	33	46

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

4 APPLICABLE GUIDELINES AND RECOMMENDED CRITERIA

This section contains noise criteria on the mechanical equipment from the grandstand, construction noise criteria and construction vibration criteria.

The following criteria are relevant for the assessment of noise and vibration emissions from the Brookvale Oval redevelopment:

- For the assessment of the predicted operational noise emissions by the Brookvale Oval redevelopment: The criteria have been derived in accordance with the *Noise Policy for Industry* (EPA, 2017). Refer to Section 4.1.
- For the assessment of the road traffic noise impacts from the proposed redevelopment: The criteria have been derived in accordance with the *NSW Road Noise Policy* (DECCW, 2011). Refer to Section 4.2.
- The assessment of the noise impacts of the construction noise on the sensitive receivers: The criteria have been derived in accordance with the *Interim Construction Noise Guideline* (DECC, 2009). See Section 4.3.
- For the assessment of construction vibration impacts from the Brookvale Oval redevelopment: The criteria have been derived in accordance with Assessing Vibration: A Technical Guideline (DEC, 2006), BS 7385-2: 1993 and BS 6472: 1992. Refer to Section 4.4.

It is understood that the scope of works refers to the day to day operation of the centre of excellence. That is, noise from the reminder of Brookvale Oval, crowd noise from the venue and game day road noise impacts are outside the scope of works.

4.1 NSW Noise Policy for Industry

In NSW, the control of noise emissions is the responsibility of Local Government and the NSW Environment Protection Authority (NSW EPA). In October 2017, the NSW EPA released the *Noise Policy for Industry* (NSW NPI). The purpose of the policy is to ensure that noise impacts associated with particular industrial developments are evaluated and managed in a consistent and transparent manner. The policy aims to ensure that noise is kept to acceptable levels in balance with the social and economic value of industry in NSW.

The NSW NPI criteria for industrial noise sources have two components:

- Controlling the intrusive noise impacts for residential receivers in the short-term; and
- Maintaining noise level amenity of particular land uses for residents and sensitive receivers in other land uses.

The project noise trigger level is derived from the more stringent value out of the project intrusiveness noise level and the project amenity noise level.

4.1.1 Intrusive Noise Impacts (Residential Receivers)

The NSW NPI states that the noise from any single source should not intrude greatly above the prevailing background noise level. 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 (L_{Aeq}), measured over a 15-minute period, does not exceed the background noise level by more than 5 dB(A). This is often termed the Intrusiveness Criterion, as shown below.

$$L_{Aeq,\ 15\ minute} = \text{rating background noise level} + 5\ dB$$

Using the rating background noise level approach results in the intrusiveness criterion being met for at least 90% of the 15 minute time periods.

4.1.2 Protecting Noise Amenity (All Receivers)

To limit continuing increase in noise levels, the maximum ambient noise level within an area from all industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.2 of the NSW Noise Policy for Industry. The recommended amenity noise levels have been subjectively scaled to reflect perceived differential expectations and ambient noise environments of rural, suburban and urban communities for residential receivers.

Existing plus new industrial noise levels are recommended to remain within the recommended amenity noise levels for an area. Therefore, a project amenity noise level applies for each new source of industrial noise as follows:

Project amenity noise level for industrial developments = recommended amenity noise level minus 5 dB(A)

4.1.3 Area Classification

The amenity noise levels presented in Table 2.2 of the Noise Policy for Industry categorise residential receivers into rural, suburban and urban noise amenity areas. Table 2.3 of the Noise Policy for Industry characterises the “Suburban Residential” noise environment as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.

Additionally, from the Warringah Local Environmental Plan 2011, the potentially most impacted residential receivers to the north and to the west are zoned R2 Low Density Residential and the potentially most impacted residential receivers to the east are zoned R3 Medium Density Residential.

Based on Table 2.3 of the NSW NPI, suburban residences typically have the following background noise levels

- Daytime RBL lower than 45 dBA
- Evening RBL lower than 40 dBA
- Night time RBL lower than 35 dBA.

Based on the measured noise levels summarised in Table 2, the character of the surrounding area and the adjacent land zonings, a conservative assessment identifies the nearest receivers in the suburban residential category.

Figure 10 Extract from zoning map obtained through the Warringah Local Environmental Plan 2011

For the considered receptors in the suburban area, the recommended amenity noise level is shown in Table 3 below. When the existing noise level from industrial noise sources is close to the recommended “Amenity Noise Level” (ANL) given above, noise from the new source must be controlled to preserve the amenity of the area in line with the requirements of the NSW NPI.

Table 3 NSW NPI – Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day[1]	Recommended Amenity Noise Level ($L_{Aeq, period}$)[2]
Residence	Suburban	Day	55
		Evening	45
		Night	40
School Classroom	All	Noisiest 1-hour period when in use (external)	50 [3,4]
Areas for active recreation	All	When in use	55
Commercial premises	All	When in use	65

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Note 3: External noise level criterion estimated from internal noise level criterion assuming a 10 dB noise level difference for open windows.

Note 4: In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40dB $L_{Aeq(1hr)}$

4.1.4 Project Trigger Noise Levels

The intrusive and amenity criteria for industrial noise emissions derived from the measured data are presented in Table 4. The amenity and intrusive criterion are nominated for the purpose of determining the operational noise limits for noise sources associated with the development which can potentially affect noise sensitive receivers.

For each assessment period, the project trigger noise levels are the lower (i.e. the more stringent) of the amenity or intrusive criteria. The project trigger noise levels are shown in bold text in Table 4.

Table 4 External noise level criteria in accordance with the NSW NPI

Location	Time of Day	Project Amenity Noise Level, $L_{Aeq, period}$ [1] (dBA)	Measured $L_{A90, 15\ min}$ (RBL) [2] (dBA)	Measured $L_{Aeq, period}$ Noise Level (dBA)	Intrusive $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA) [3]	Amenity $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA) [3,4,5]
Residences (Suburban)	Day	50	41	55	**46**	53
	Evening	40	39	52	**44**	45[4]
	Night	35	33	46	**38**	39[4]
School Classroom	Noisiest 1-hour period when in use (external)	45	N/A	N/A	-	**45**[6]
Active recreation areas	When in use	50	N/A	N/A	-	**53**
Commercial premises	When in use	60	N/A	N/A	-	**63**

Note 1: Project Amenity Noise Levels corresponding to "suburban" areas, equivalent to the Recommended Amenity Noise Levels (Table 3) minus 5 dBA

Note 2: L_{A90} Background Noise or Rating Background Level

Note 3: Project Noise Trigger Levels are shown in bold

Note 4: Where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level, the project amenity noise levels can be set at 10 dB below existing industrial noise levels (if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time).

Note 5: According to Section 2.2 of the NSW NPI, the LAeq, 15 minutes is equal to the LAeq, period + 3 dB

Note 6: This value has conservatively assumed that $L_{Aeq, 15\ min}$ is equivalent to $L_{Aeq (1\ hr)}$

4.1.5 Sleep Disturbance

The sleep arousal criterion, obtained from the NSW Road Noise Policy (NSW RNP), provides an assessment criterion for the expected quality of sleep of the resident during the night.

An accurate representation of sleep disturbance impacts on a community from a noise source is particularly difficult to quantify mainly due to differing responses of individuals to sleep disturbance – this is found even within a single subject monitored at different stages of a single night's sleep or during different periods of sleep.

In addition the differing grades of sleep state make a definitive definition difficult, and even where sleep disturbance is not noted by the subject, factors such as heart rate, mood and performance can still be negatively affected.

An assessment of sleep disturbance should consider the maximum noise level or $L_{A1 (1\ minute)}$, and the extent to which the maximum noise level exceeds the background level and the number of times this may happen during the night-time period. Factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise events will occur;
- Time of day (normally between 10.00pm and 7.00am); and
- Whether there are times of day when there is a clear change in the existing noise environment (such as during early morning shoulder periods).

Currently the information relating to sleep disturbance impacts indicates that:

- Maximum internal noise levels below 50–55 dBA are unlikely to cause an awakening from a sleep state.
- One or two noise events per night with maximum internal noise levels of 65–70 dBA are not likely to affect health and wellbeing significantly.

As a result, the adopted sleep disturbance criterion for the project is an internal noise level of 50 - 55 dB L_{Amax}. This criterion is applicable for noise emissions generated by short term events occurring during the night time period. Therefore, allowing for a 10 dB noise reduction for open windows**, it is proposed that the noise screening criterion for sleep arousal should be 60 - 65 dB L_{Amax} external noise level at residential properties**.

4.2 NSW Road Noise Policy (RNP)

The NSW RNP aims to identify the strategies that address the issue of road traffic noise from:

- Existing roads
- New road projects
- Road redevelopment projects
- New traffic generating developments

The RNP also outlines the noise assessment criteria for the road traffic noise generated by the development.

4.2.1 Noise Assessment Criteria

Table 5 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use. These criteria are for assessment against façade-corrected noise levels when measured 1m in front of a building façade. Car parking for the redeveloped facility will be serviced from an expansion of the existing carpark on Alfred Street. Therefore, the relevant road category in Table 5 is a local road, corresponding to Alfred Street.

Alfred Street has been selected, as it is the road that will have the highest proportion of Centre of Excellence traffic utilising it. For other roads such as Pine Avenue and Federal Parade, the proportion of traffic from the Centre of Excellence will be lower and therefore, road traffic noise is not proposed to be assessed.

Table 5 Road Traffic Noise Assessment Criteria for Residential Land Uses

Road Category	Type of project/land use	Assessment Criteria (dBA)	
		Day (7 am – 10 pm)	Night (10 pm – 7am)
Local Roads	1. Existing residences affected by noise from new local corridors 2. Existing residences affected by noise from redevelopment of existing local roads 3. Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,(1\ hour)}$ 55 (external)	$L_{Aeq,\ (1\ hour)}$ 50 (external)

4.2.2 Relative Increase Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the RNP states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

4.3 Interim Construction Noise Guideline

The Interim Construction Noise Guideline (ICNG) sets out ways to deal with the potential impacts of construction noise on residences and other sensitive land uses. The ICNG presents assessment approaches that are tailored to the scale of construction projects.

A portion of the main objectives from Section 1.3 of the ICNG are presented below:

- Promote a clear understanding of ways to identify and minimise noise from construction works
- Focus on applying all “feasible” and “reasonable” work practices to minimise construction noise impacts
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses, including commercial and industrial premises.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The various NML categories for residential receivers have been reproduced from Table 2 of the Interim Construction Noise Guideline and are presented in Table 6 below.

Table 6 NMLs for quantitative assessment at residences (from ICNG)

Time of Day	Noise Management Level $L_{Aeq(15minute)}$ [1,2]	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 LAeq(15minute) 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 dBA	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, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 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 above the noise affected level, the proponent should negotiate with the community.

Note 1 *Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).*

Specific non-residential receivers in the vicinity of the proposed construction site, and their recommended noise management levels, are presented in Table 8.

Construction hours are understood to be as follows:

- Monday to Friday 7 am to 6 pm

- Saturday 8 am to 1 pm

Proposed construction hours only fall under the recommended standard hours outlined in the ICNG

Table 7 NMLs for quantitative assessment at non-residential receivers

Land Use	$L_{Aeq(15minute)}$ Construction NML
Classrooms at schools and other educational institutions	Internal noise level: 45 dBA External noise level: 55 dBA [1]
Active recreation areas	65
Commercial premises	70

Note 1: External noise level criterion estimated from internal noise level criterion assuming a 10 dB noise level difference for open windows

Table 8 NMLs as basis for the acoustic assessment

Receiver Types	NML, dB $L_{Aeq(15minute)}$
	Standard Hours Monday to Friday: 7 am to 6 pm Saturday: 8 am to 1 pm
Residences	51
Classrooms at schools and other educational institutions	55 (external)
Active recreation areas	65
Commercial premises	70

As no construction is expected to occur outside of standard hours, a sleep disturbance assessment for construction noise is not required.

4.4 Vibration Criteria

4.4.1 Standard BS 7385 Part 2 - 1993

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 "*Explosives - Storage and Use - Use of Explosives*" recommends the frequency dependent guideline values and assessment methods given in BS 7385-2: 1993 *"Evaluation and measurement for vibration in buildings Part 2*" be used as they are "applicable to Australian conditions".

The BS 7385-2: 1993 standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 9 and illustrated in Figure 11. It should be noted that the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building.

Table 9 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in Figure 11	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385-2: 1993 states that the values in Table 9 relate to transient vibration which does not cause resonant responses in buildings.

Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 9 may need to be reduced by up to 50% (refer to Line 3 in Figure 11).

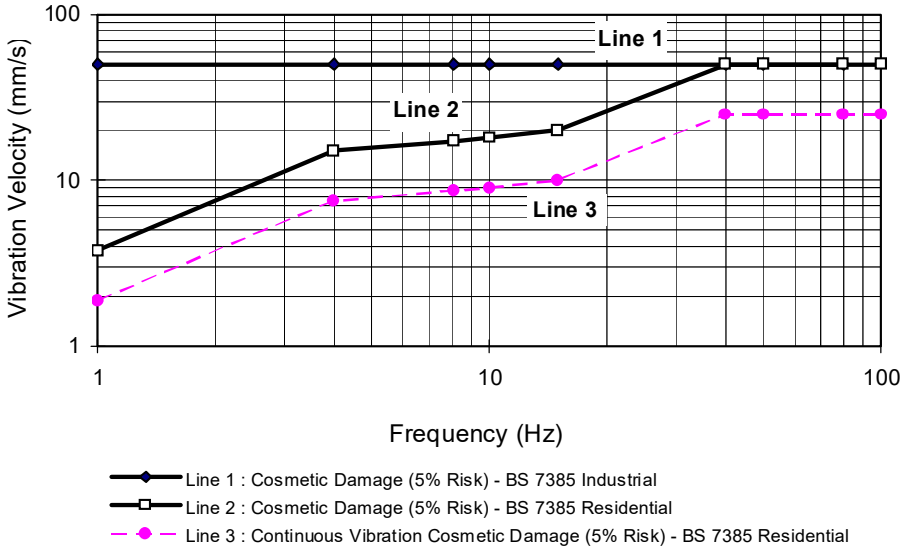
In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the recommended values corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 9, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 9 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measured at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 9.

Figure 11 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage



4.4.2 Human Comfort Criteria for Intermittent Vibration

Guidance in relation to assessing potential disturbance from ground-borne vibration is set out in British Standard 6472-1992 "Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)". This standard has recently been revised and the current standard is dated 2008. This 1992 version of the standard is however still recommended for use by the EPA.

BS 6472 includes detailed guidance on the use of Vibration Dose Values (VDVs) which allow an assessment of the severity of intermittent vibration to be carried out. These analysis and assessment procedures are most relevant to the character of the vibration generated during construction works.

The permissible rms particle velocity levels corresponding to the vibration dose value vary according to the duration of exposure. Table 10 shows the range of satisfactory vibration dose values for which various degrees of adverse comment may be expected in residential premises and office buildings. The most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

Table 10 Vibration Dose Values ($m/s^{1.75}$) above which Various Degrees of Adverse Comment May Be Expected in Residential Buildings, Offices

Location	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Residential buildings 16-hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Offices 16-hour day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2

Situations exist where motion magnitudes above the dose levels given in BS 6472 can be acceptable, particularly for temporary disturbances and infrequent events of short-term duration (e.g. construction project).

When short-term works such as piling, demolition or compaction give rise to impulsive vibrations, it should be borne in mind that undue restriction on vibration levels can significantly prolong these operations and result in greater annoyance.

In certain circumstances, the use of higher magnitudes of acceptability may be considered, e.g. for projects having social worth or broader community benefits or in view of the economic or practical feasibility of reducing vibration to the recommended levels. In such cases, best management practices should be employed to reduce levels as far as practical.

5 OPERATIONAL ACOUSTIC ASSESSMENT

Predictive noise modelling was carried out using the ISO 9613 algorithm within iNoise 2019.1. The iNoise software package allows a 3D computational model of the site and surrounding area to be created. Inputs into the noise model included terrain, ground absorption, surrounding buildings, receiver locations and noise sources.

5.1 Noise Generating Scenarios

This Noise Assessment includes assessment of mechanical plant and car parking activities from the proposed Centre of Excellence. Two noise generating scenarios are presented

- Day/Evening: Mechanical equipment operating, 6 cars arriving and 6 cars leaving the carpark and 1 truck arriving and 1 truck leaving per 15 minute period
- Night: Mechanical equipment operating, 3 cars arriving and 3 cars leaving the carpark per 15 minute period

At the DA stage, final selection of mechanical equipment has not been concluded. However, preliminary specification of 2 x Daikin EWAD240TZ-PR B1 chillers located on the rooftop has been conducted. In consultation with the mechanical engineers LCI Consultants, it is understood at this stage that possible mechanical equipment could include the following:

- Pumps and pool plant, located in the plant rooms on the lower ground level;
- Toilet exhaust fans, located on the concourse level;
- Mechanical plant, in the plant room located on the concourse level;
- Toilet exhaust fans, located on the upper level;
- Mechanical plant, in the plant room located on the upper level;
- Two Daikin EWAD240TZ-PR B1 chillers, located in the open roof plant room located on the roof level;

At this stage, the mechanical engineers predict that the two rooftop chillers will be the equipment with the largest sound power levels. Additionally, at this stage all mechanical equipment listed above is to be located indoors except for the chillers located on the rooftop plant room. Therefore, the noise levels observed at the neighbouring receivers will be almost entirely from the rooftop chillers.

In this assessment, mechanical noise is assessed from the two rooftop chillers. A full assessment of all mechanical noise is recommended following the DA stage once all mechanical equipment has been specified.

The sound power levels of the two Daikin EWAD240TZ-PR B1 chillers is listed in Table 11.

Table 11 Sound power level of mechanical equipment

Location	Model	Frequency band (Hz)								Overall dBA	Max dBA
		63	125	250	500	1000	2000	4000	8000		
Chiller Unit, Open Plant Room, Roof	EWAD240TZ	75	72	72	75	70	65	57	50	**75**	**77**
Chiller Unit, Open Plant Room, Roof	EWAD240TZ	75	72	72	75	70	65	57	50	**75**	**77**

In addition to the mechanical units, operational noise from additional vehicles associated with the Centre of Excellence is also assessed. The sound power levels of car and truck noise sources are listed below in Table 12. Car door slams are assumed to take place over half a second, engine start up over two seconds, and car manouvering over one minute per car. Truck deliveries are assumed to take a minute to arrive and a minute to leave the site, with truck door slams taking place over half a second and truck engine start ups taking place over two seconds. The noise data has been obtained from noise measurements and from Pulse Acoustics extensive noise database.

Table 12 Operational scenarios and associated noise sources

Operation scenario	Equipment Type	Height (m)	Sound power level $L_{Aeq(15min)}$ dBA	LAMax dBA
Mechanical Equipment and Vehicle Activities (per one vehicle over a 15 min scenario)	Car engine start	1	62	93
	Car door close	1	58	90
	Car manouvering	1	68	88
	Truck engine start	2	75	106
	Truck door close	2	58	90
	Truck manouvering	2	85	102

Breakout noise from internal spaces within the Centre of Excellence was also considered in this assessment. Noise sources from the gymnasium in particular were considered. Pulse Acoustics has significant experience in assessing noise from gymnasiums and as a worst case scenario considered an internal noise level for the space of 75 dB(A). From the concourse level plans and the northern elevation drawings located in Appendix C, it is shown that the windows facing to the north are not able to be opened. Therefore considering the transmission loss through the glass and distances to receptors, noise breakout from the gymnasium will be negligible at any surrounding receiver.

Considered noise sources are modelled in the following locations for the day/evening and night scenarios

Figure 12 Scenario 1 – Day/Evening Activities

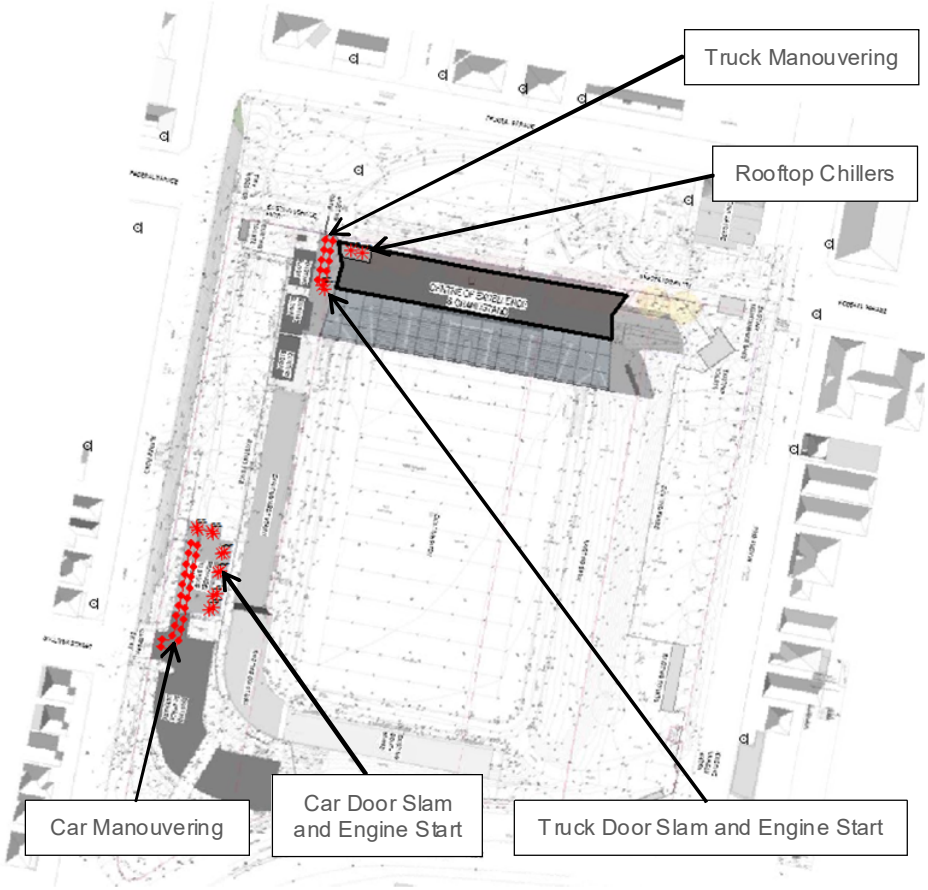
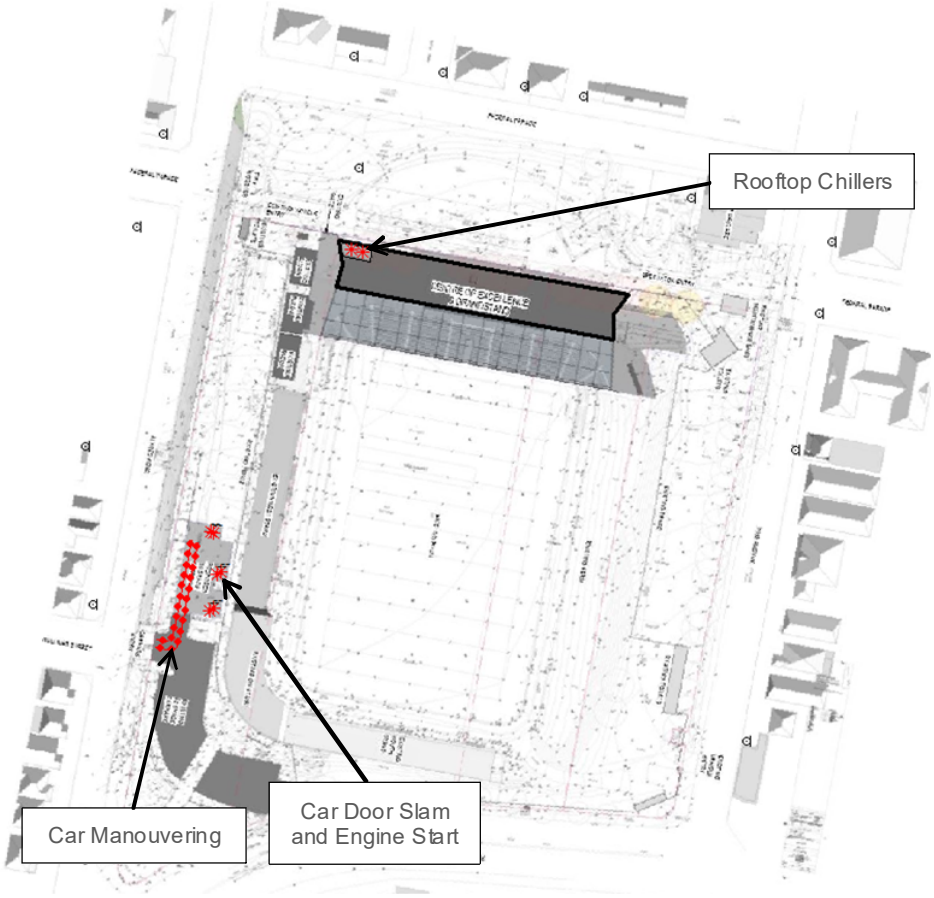


Figure 13 Scenario 2 – Night Activities



5.2 Modelling Assumptions

The following modelling assumptions are utilised in this noise impact assessment:

- Noise generating scenarios are modelled on a worst case 15 minute period;
- Terrain has been sourced from the NSW Land and Property Information database Sixmaps;
- Ground Absorption has been included in the model with the site and surrounding land areas having an absorption factor of 0.25;
- All receptors are modelled 1.5m above the ground;
- Off-site structures such as buildings have been included in the model where relevant;
- The noise sources and sound power levels have been modelled with respect to the information presented in Table 11 and Table 12;
- Mechanical equipment is assumed to operate 24/7;
- Car movements associated with the Centre of Excellence are assumed to arrive on site at a rate of 6 per 15 minutes during the day and evening period (scenario 1) and 3 per 15 minutes during the night period (scenario 2).

- Truck movements associated with the Centre of Excellence are assumed to arrive on site at a rate of 1 per 15 minutes during the day and evening period (scenario 1). No trucks are proposed to arrive during the night period (scenario 2).
- Internal spaces of the Centre of Excellence including the gymnasium, offices and plant rooms are assumed to be operational 24 hours a day.

5.3 Predicted Noise Levels

5.3.1 L_{Aeq} Results

The predicted L_{Aeq} results of the modelled operational scenarios are presented below in Table 13.

Table 13 Predicted Noise Levels, Operational Scenarios, $L_{Aeq\ (15\ minute)}$

Receiver	Criteria			Predicted Noise Levels	
	Day	Evening	Night	Day/Evening Scenario	Night Scenario
R1	46	44	38	40	36
R2	46	44	38	43	27
R3	46	44	38	41	31
R4	46	44	38	38	29
R5	46	44	38	34	27
R6	46	44	38	26	18
R7	46	44	38	20	18
R8	46	44	38	19	15
R9	45	N/A	N/A	32	25
R10	45	N/A	N/A	29	19
R11	45	N/A	N/A	40	30
R12	63	N/A	N/A	43	28
R13	63	N/A	N/A	48	34
R14	53	N/A	N/A	20	12

Noise contours of the modelled operational scenarios are shown below in Figure 14 and Figure 15.

Figure 14 Operational Scenario 1 – Day/Evening Activities

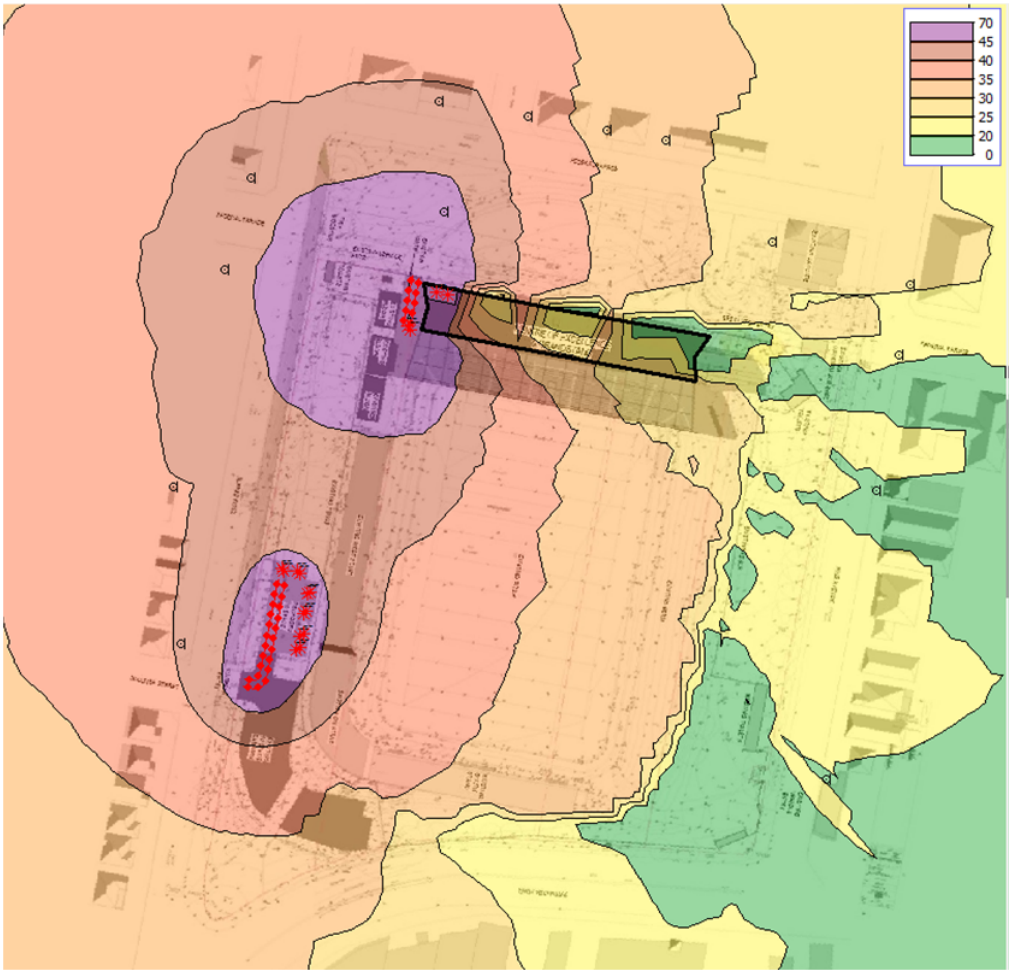
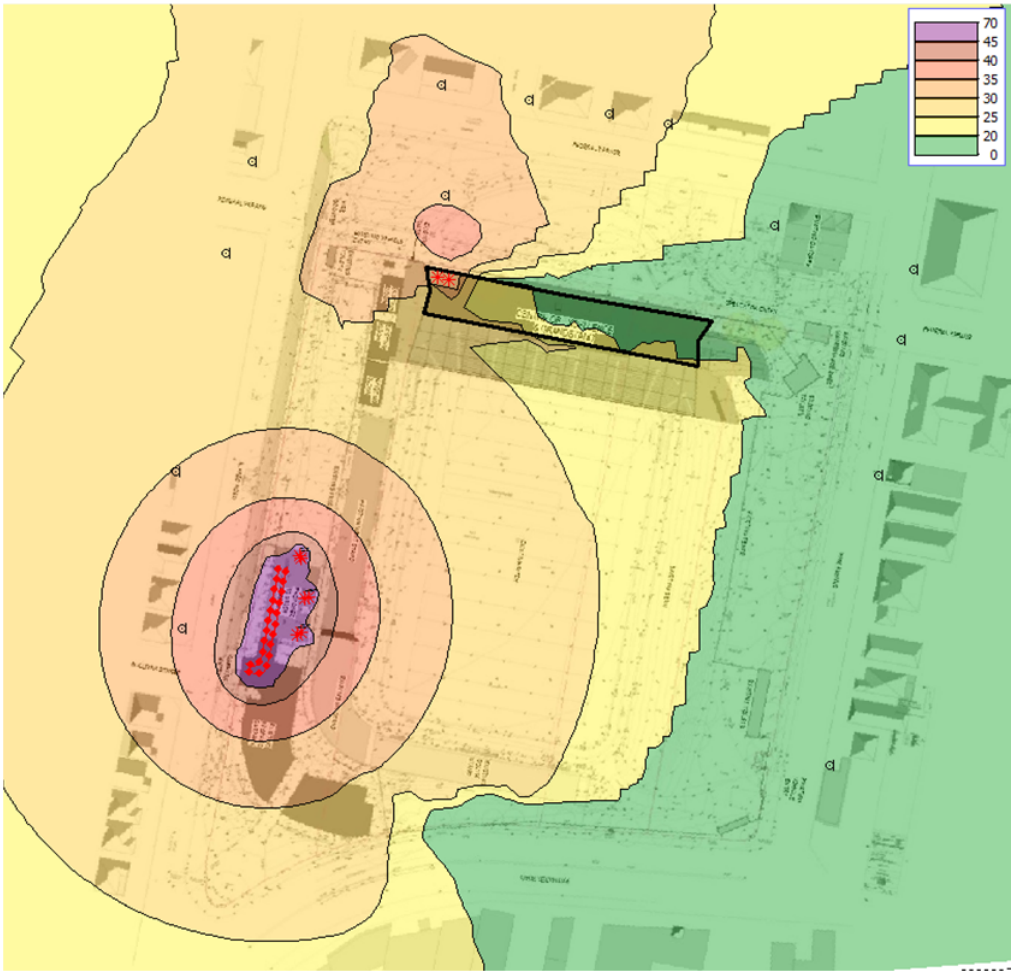


Figure 15 Operational Scenario 2 – Night Activities



Results from Table 13, Figure 14 and Figure 15 show the L_{Aeq} noise levels are predicted to comply with the noise criteria at all surrounding receptors during all time periods.

5.3.2 L_{AMax} Results

The predicted L_{AMax} results of the night operational scenario are presented below in Table 14. The maximum noise levels are predicted to comply with the sleep disturbance criteria at all considered receivers. Therefore additional impacts from sleep disturbance are considered unlikely.

Table 14 Predicted Noise Levels, Operational Scenarios, L_{AMax}

Receiver	L_{AMax} Criteria	Predicted Noise Levels
	Night	Night Scenario
R1	60	51
R2	60	40
R3	60	39
R4	60	30
R5	60	28
R6	60	35
R7	60	35
R8	60	32
R9	N/A	N/A
R10	N/A	N/A
R11	N/A	N/A
R12	N/A	N/A
R13	N/A	N/A
R14	N/A	N/A

5.4 Indicative Noise Control Measures

As this assessment is for the DA stage of the development, final selection of mechanical equipment has not occurred. Final selection of equipment is expected before at the Construction Certificate (CC) stage. It is therefore recommended that following the final selection of equipment, the predicted noise levels from mechanical equipment be predicted at the nearest receivers.

Noise emissions from mechanical equipment are to be acoustically treated to achieve compliance with the external noise level criteria discussed in Section 4.1. The following acoustic treatments are in-principle recommended, with a review of these controls following full selection of mechanical equipment.

5.4.1 Plant Rooms

Plant rooms are recommended to be treated, in-principle, as follows:

- Plant room external walls should achieve a minimum weighted sound reduction index of 45 - 50 dB Rw. Plant rooms should not be accessible from outside the building. Consequently, ornamental louvres are not recommended in these plant rooms, however acoustic louvres can be considered depending on the noise emission from mechanical plant items.
- All plant room walls and roofs should be internally lined with insulation which achieves a minimum NRC rating of 0.8. Insulation should have a perforated metal facing with more than 20 % perforated area, or woven cloth facing.
- Plant room floors should comprise a 200 mm thick concrete slab with 2,400 kg/m^3 minimum density. For plant rooms located immediately below internal spaces, ceiling constructions should comprise a concrete slab as recommended for the floor construction.
- All plant room construction should be fully sealed (air tight), fully closed and free of gaps

- All door accessing plant rooms should be acoustically treated in order to achieve a minimum sound insulation performance of Rw 30.

It is advised that the conceptual measures listed above should be investigated and developed further during detailed design stages of the project

5.4.2 Building Services – External Noise Emissions

Acoustic treatment should be implemented for external noise emissions by mechanical plant. This treatment should be especially considered for plant items located in the open air roof plant room.

In order to achieve the recommended external noise level criteria, the following in principle measures will need to be considered during the detailed design stage:

- Within a plantroom, the following treatments are recommended:
    - All external air intakes and exhausts should be fully ducted to the relevant plant item (i.e. AHU, FCU or fan). These ducted components should include internally lined ductwork (typically with minimum 50 mm insulation), whose extent should be recommended at a detailed design stage. Wherever possible these intakes and exhausts should aim away from nearest affected receivers.
    - Only relief air paths should have openings through the external plant room walls provided that these include acoustic louvres. It is also recommended that these air openings be installed in the plant room roof.
- Install internally lined return air / outside air mixed boxes behind AHUs.
- Install silencers or internally lined ductwork on external air inlets or outlets, especially for fans.
- Implement variable speed drive units whenever possible.
- In the open roof compartment where the chillers will be located, the walls should be constructed from acoustic louvres (i.e. ornamental louvres might not provide sufficient attenuation). Wall heights should extend as a minimum to the top of the cooling towers (height to be confirmed at a detailed design stage).

It is advised that the conceptual measures listed above should be investigated and developed further during detailed design stages of the project.

6 ROAD NOISE ASSESSMENT

As part of the Centre of Excellence development, the existing car park on the western side of the ground is to be expanded by 15 car parking spaces. Access to the car park is off Alfred Street. Alfred Street has been selected for this road noise assessment, as it is the road that will have the highest proportion of traffic travelling to/from the Centre of Excellence on it. For other roads such as Pine Avenue and Federal Parade, the proportion of traffic from the Centre of Excellence will be lower and therefore, road traffic noise is not proposed to be assessed.

The traffic consultant is yet to finalise their report on the proposed development. However, advice has been given that the worst case 1 hour period will feature approximately 5 vehicle movements in and out of the car park for the additional ten car park spaces.

Under section 3.4.1 of the Road Noise Policy “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 2 dB above that of the corresponding ‘no build option’”.

A 2 dB increase equates to approximately a 60% increase in total traffic along the subject road. Any proportional traffic increase along Alfred Street from the additional car parking spaces is predicted to be far smaller than this amount. Therefore it is predicted that road traffic noise levels will not increase by 2 dB or more. The proposed road movements are thus predicted to comply with the Road Noise Policy and no further noise mitigation measures are recommended.

7 CONSTRUCTION NOISE AND VIBRATION

This Acoustic Report is to be submitted for the DA stage of the proposed development. As such, details on the methods of demolition and construction are not yet available. A Construction Noise and Vibration Management Plan (CNVMP) is recommended to be carried out during the Construction Certificate stage of the development.

As part of this CNVMP, construction noise impacts are recommended to meet the criteria outlined in section 4.3, while construction vibration impacts are recommended to meet the criteria presented in section 4.4.

8 CONCLUSIONS

Pulse Acoustic Consultancy Pty Ltd (Pulse Acoustics) has been engaged by Manly Warringah Sea Eagles (MWSE) c/o Hassell (the client) to undertake a Noise Impact Assessment for the proposed Brookvale Oval Redevelopment. The proposal includes a new state of the art Centre of Excellence and 3000 seat covered Grandstand at the Northern end of the subject site.

This document assesses the potential operational noise impacts of the Centre of Excellence and Northern Grandstand. In particular, operational impacts of the mechanical equipment, gymnasium and vehicle movements from the centre of excellence are analysed.

In this assessment, the nearest receivers are identified, and project criteria are derived. Operational noise criteria is taken from the *Noise Policy for Industry*, road noise criteria is derived from the *Road Noise Policy*, construction noise criteria is taken from the *Interim Construction Noise Guideline* and vibration criteria are derived from *Assessing Vibration: A Technical Guideline*, *BS 7385-2* and *BS 6472*. Noise modelling of the potential operational impacts is conducted in iNoise 2019.1.

The following sub-sections summarise the outcomes of this assessment.

8.1 Operational Acoustic Assessment

8.1.1 Hours of Operation

Spaces within the Centre of Excellence including the gymnasium may be utilised 24 hours a day.

8.1.2 Truck Movements

Truck deliveries to the centre of excellence are recommended to take place during the day and evening periods, that is between 7am and 10pm.

8.1.3 Plant Rooms

External noise emissions from plant rooms should be acoustically treated in order to achieve compliance with the external noise level criteria discussed in Section 4.1.

Conceptual recommendations are provided in Section 5.4.1 for consideration and further investigation. These treatments include recommended wall constructions, roof and floor slab constructions, internal lining to plant room walls and ceilings, and acoustically sealed doors that achieve a Rw 30 sound insulation performance.

8.1.4 External Noise Emissions

Acoustic treatment should be implemented for external noise emissions by mechanical plant items in order to achieve the external noise level criteria discussed in Section 4.1. This treatment should be especially considered for plant items located in the roof plant room.

Conceptual recommendations are provided in Section 5.4.2 for consideration and further investigation. These recommendations include the following:

- Internally lined ductwork for external air intake and exhaust paths, including internally lined return air / outside air mixed boxes behind AHUs.
- Acoustic louvres for relief air paths through plant room walls
- Silencers

- Implementation of variable speed drive units whenever possible.
- Acoustic louvres for chillers.

8.2 Noise Impact on Local Roads

A 2 dB increase equates to approximately a 60% increase in total traffic along the subject road. As any proportional traffic increase is predicted to be much smaller than this amount, it is predicted that road traffic noise levels will not increase by 2 dB or more. Therefore the proposed road movements are predicted to comply with the Road Noise Policy and no further noise mitigation measures are recommended.

8.3 Construction Noise & Vibration Assessment

The details on the methods of demolition and construction are to be made available by the Construction Certificate (CC) stage of the proposal. As such, a Construction Noise and Vibration Management Plan (CNVMP) is recommended to be carried out as part of the Construction Certificate period.

As part of this CNVMP, construction noise impacts are recommended to meet the criteria outlined in section 4.3, while construction vibration impacts are recommended to meet the criteria presented in section 4.4.

8.4 Final Remarks

Based on the findings from this Noise Impact Assessment, should the assumptions in this report be carried out, the proposed development is predicted to comply with the recommended noise criteria.

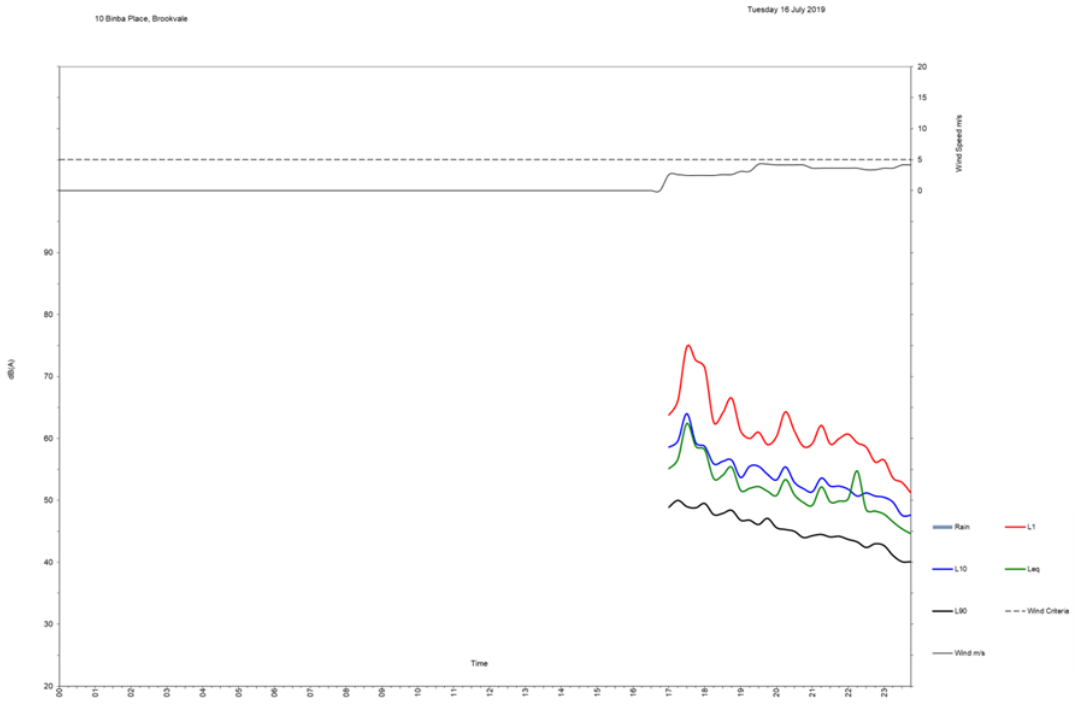
APPENDIX A: ACOUSTIC GLOSSARY

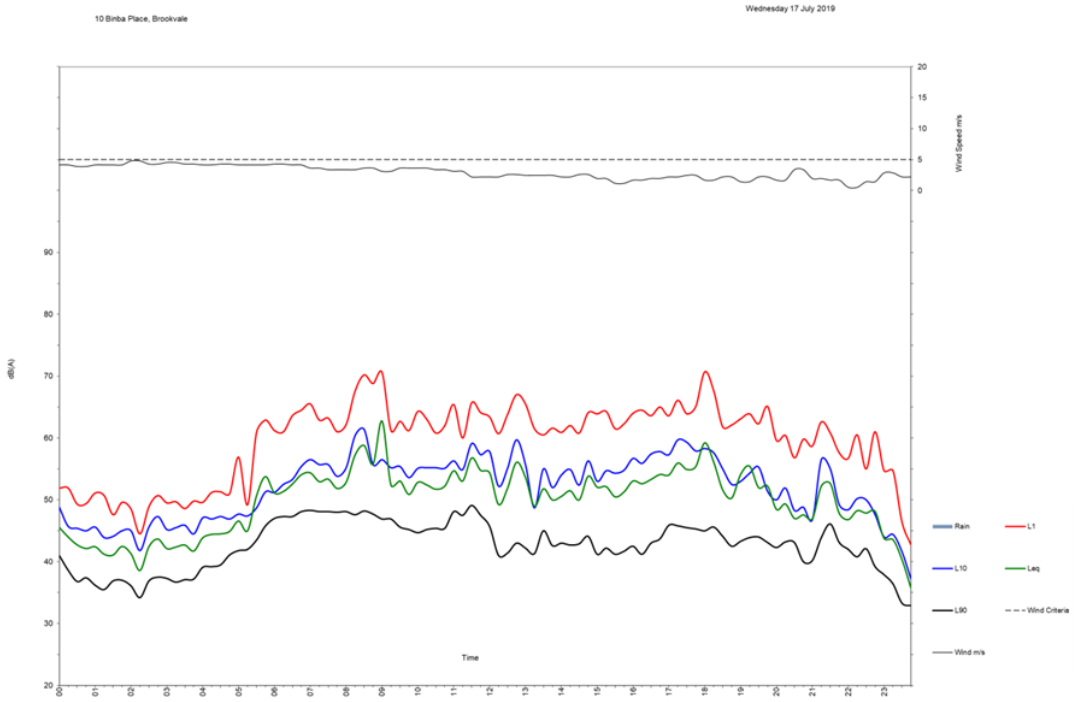
The following is a brief description of the acoustic terminology used in this report.

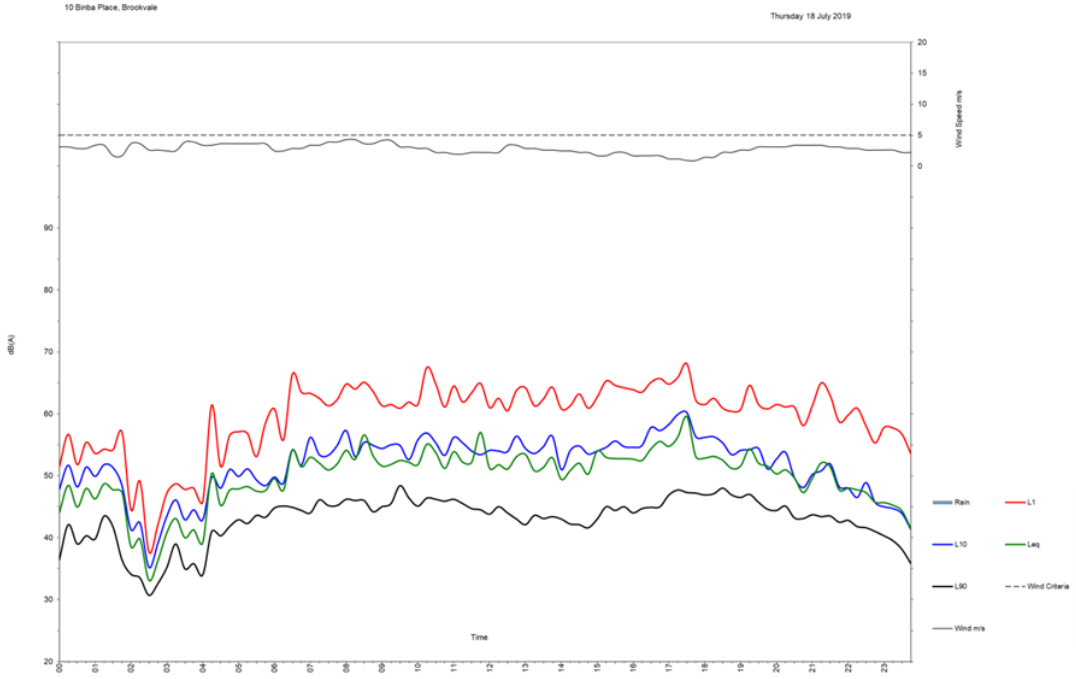
Ambient Sound	The totally encompassing sound in a given situation at a given time usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictates a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
L_{max}	The maximum sound pressure level measured over a given period.
L_{min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.

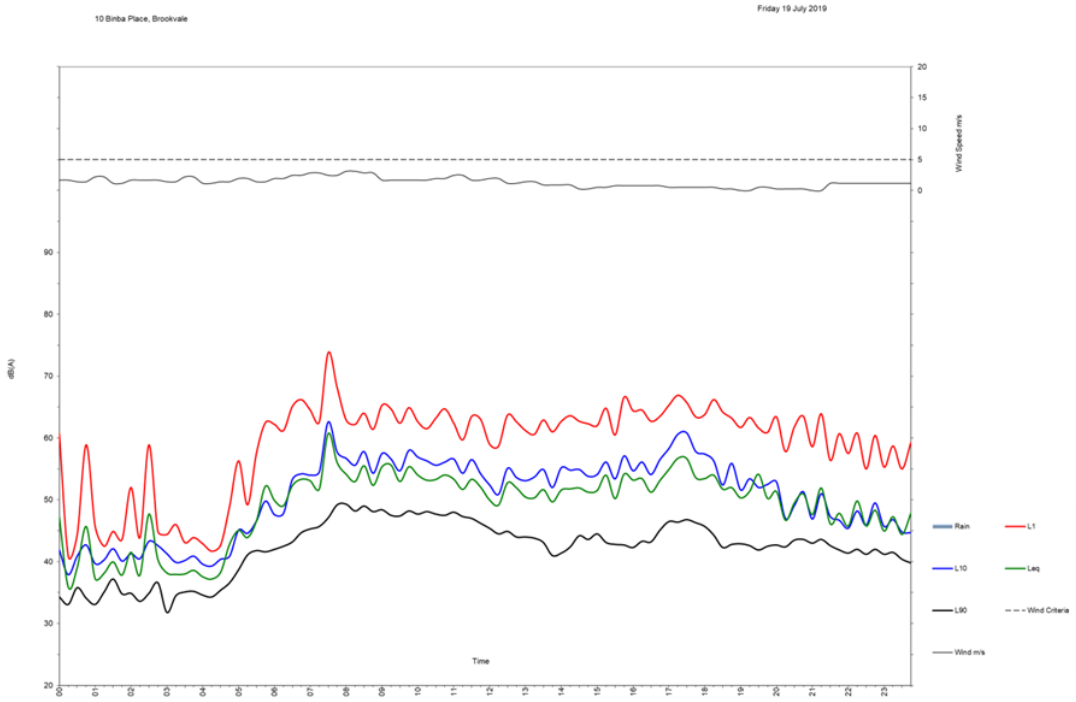
APPENDIX B: NOISE LOGGER SUMMARY

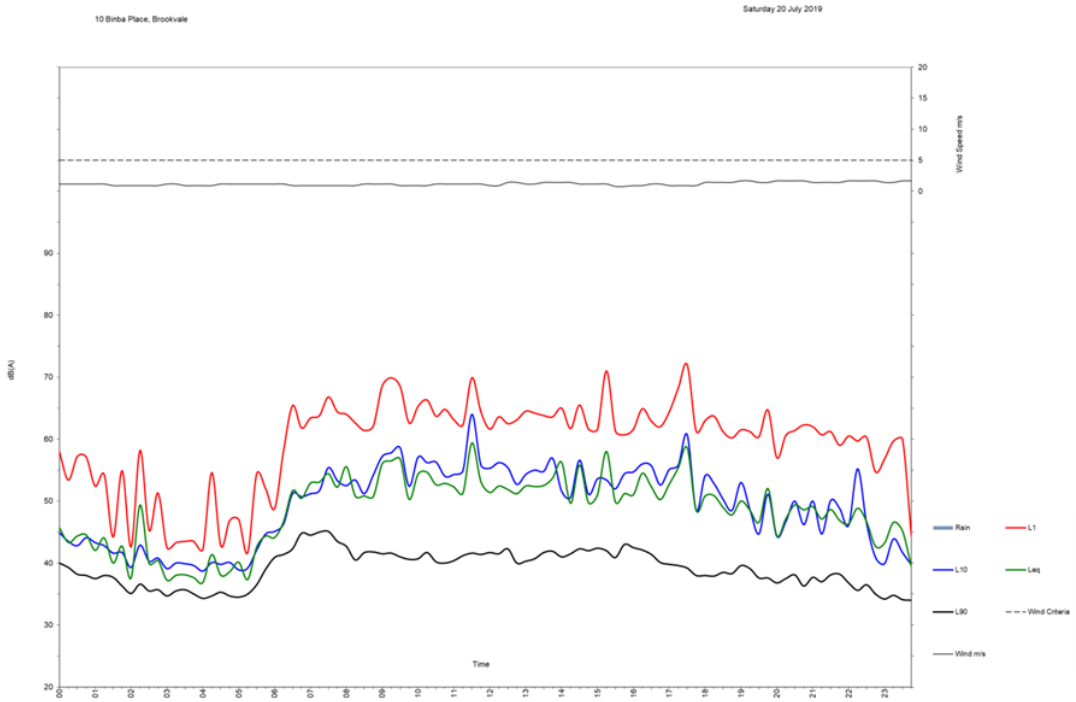
Logger Location: 10 Binba Place, Brookvale

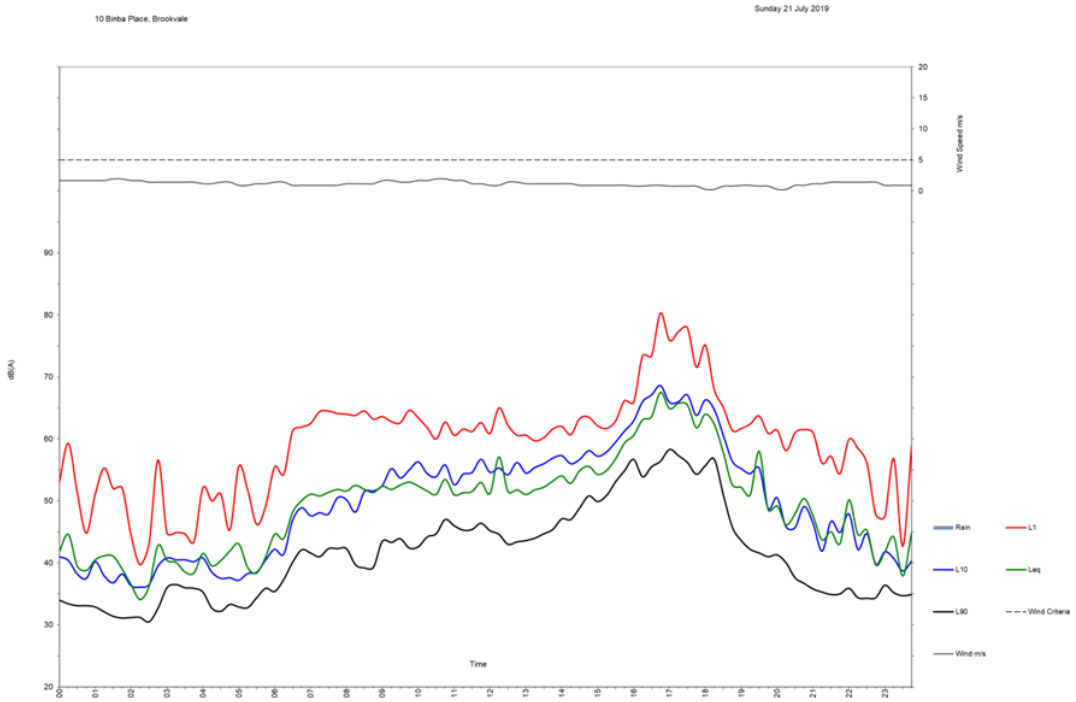


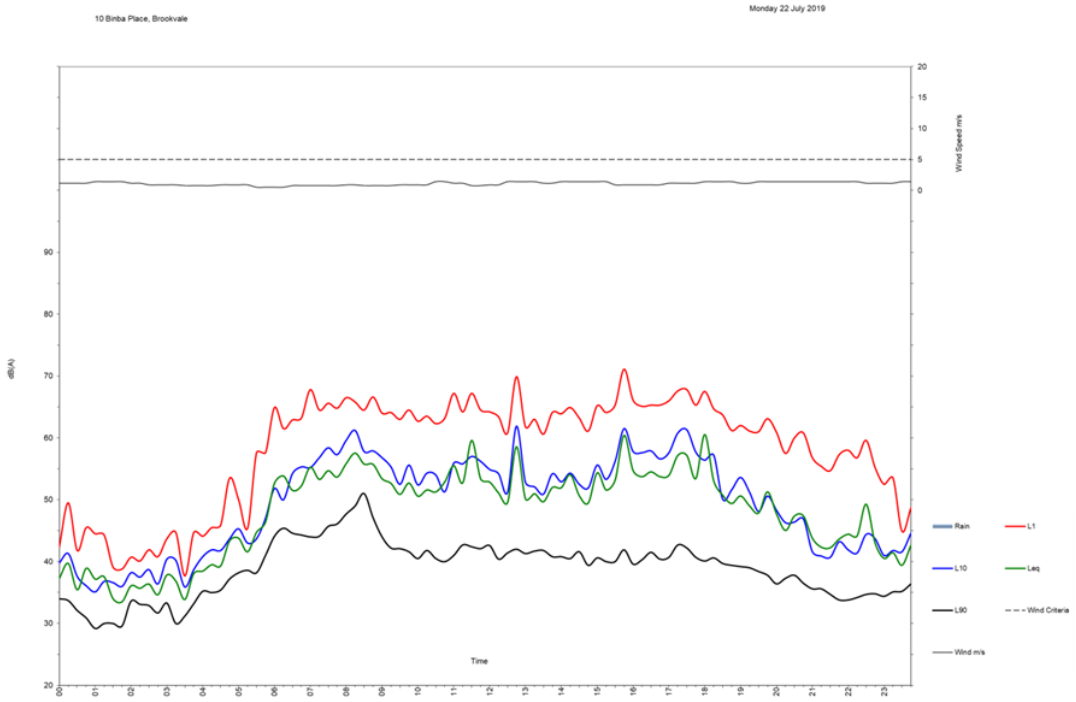

10 Binba Place, Brookvale
Wednesday 17 July 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

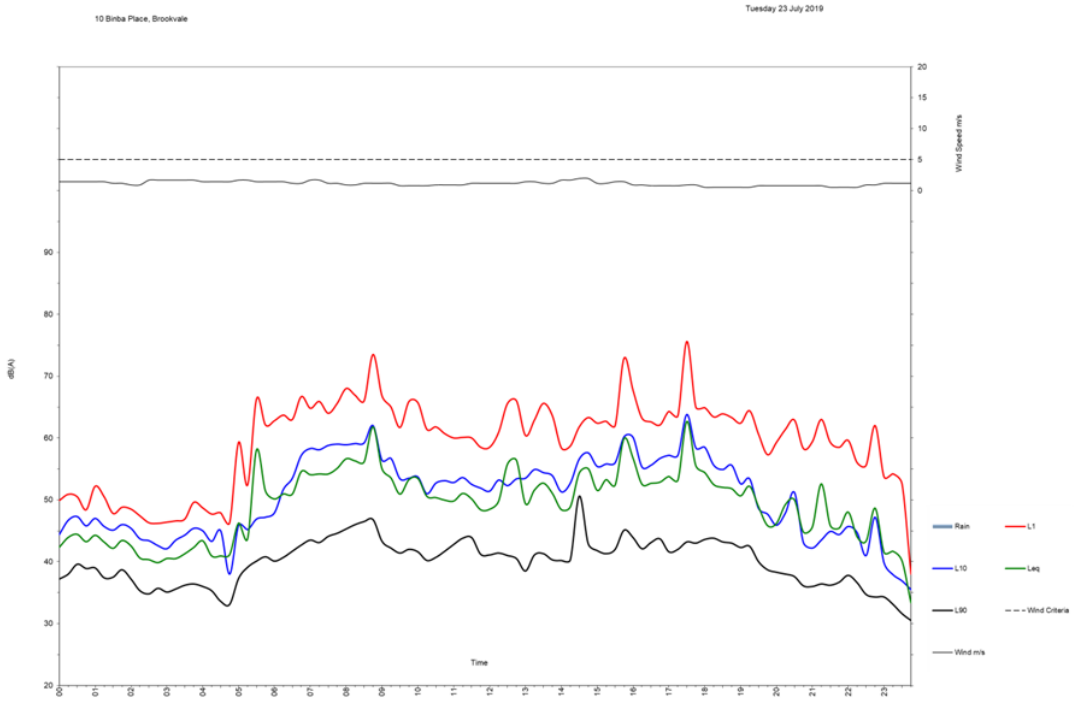

10 Binba Place, Brookvale
Thursday 18 July 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

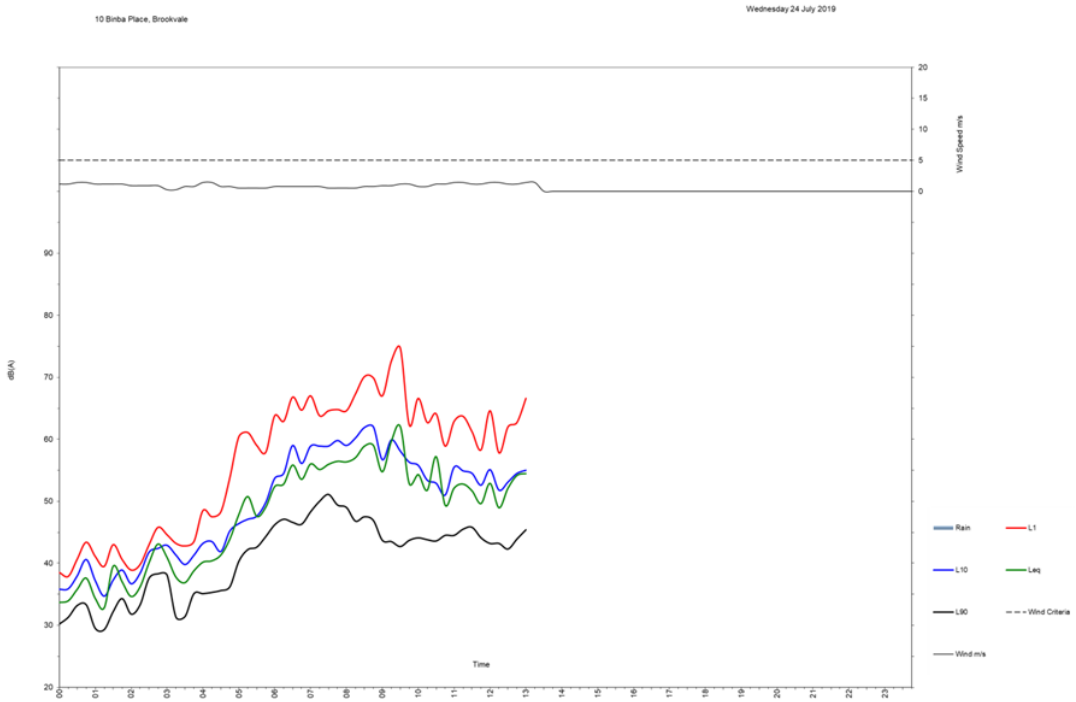

10 Binba Place, Brookvale
Friday 19 July 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


10 Binba Place, Brookvale
Saturday 20 July 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


10 Binba Place, Brookvale
Sunday 21 July 2019
Wind Speed m/s
dB(A)
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


10 Binba Place, Brookvale
Monday 22 July 2019
Wind Speed m/s
dB(A)
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


10 Binba Place, Brookvale
Tuesday 23 July 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


10 Binba Place, Brookvale
Wednesday 24 July 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

APPENDIX C: ARCHITECTURAL DRAWINGS - Refer to Appendix H