



Sydney Opera House (SOH) – Attended Construction Noise Measurements – 2nd February 2021

Sydney Opera House
Bennelong Point

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TABLE OF CONTENTS

1	INTRODUCTION	4
2	SITE DESCRIPTION	5
3	CONSTRUCTION NOISE OBJECTIVES	7
3.1	Sydney Opera House Building Renewal Noise Impact Assessment for DA3 – SSD 8663 – Arup Pty Ltd dated 15 th May 2018	7
3.2	<i>Construction Noise and Vibration Management Sub Plan</i> – Hibbs and Associates Pty Ltd dated 11 th February 2020.....	8
4	MEASURED CONSTRUCTION NOISE LEVELS	9
4.1	Attended Measurement Equipment	9
4.2	Measured Results	9
5	CONCLUSION	20
	APPENDIX A: ACOUSTIC TERMINOLOGY	21
	TABLES	
Table 1	Measured Attended Construction Noise Levels	10
	FIGURES	
Figure 1	Site Description and Measurement Location – Sourced from SixMaps NSW	5
Figure 2	Attended Construction Noise Measurement Location – Bennelong Apartments.....	6

1 INTRODUCTION

Pulse Acoustic Consultancy Pty Ltd (Pulse Acoustics) has been engaged by Sydney Opera House (SOH) to undertake attended noise measurements during construction works on Tuesday 2nd February 2021.

This report documents noise measurements from the concrete truck movements and concrete pour activities on Tuesday 2nd February 2021. Specifically, attended construction noise measurements have been undertaken to quantify any noise impacts during a concrete pour within the Sydney Opera House at the nearest potentially affected receiver, the Bennelong Apartments located along Macquarie Street.

Attended noise measurements as detailed below, were undertaken along the northern facade of the Bennelong Apartments and southern Sydney Opera House forecourt interface as shown in Figure 1 and Figure 2.

Construction noise levels from a concrete pour were measured between 7:00am and 11:15am on Tuesday 2nd February 2021 by this office.

Construction Noise Management Levels (NMLs) have previously been established by Arup Pty Ltd in the *Noise Impact Assessment for DA3 – SSD 8663*, dated 15th May 2018 on behalf of the Sydney Opera House and Hibbs & Associates Pty Ltd in the *Construction Noise and Vibration Management Sub Plan*, dated 11th February 2020 on behalf of Taylor Group Pty Ltd (i.e. Managing Contractor).

A list of acoustic terminology used in this report is included in Appendix A of this report.

2 SITE DESCRIPTION

The Sydney Opera House is located on the Bennelong Point Peninsula in Sydney Harbour. Located to the south west of the site is Sydney's major passenger ferry terminal known as Circular Quay, with ferry movements every few minutes. Located to the west of the site is the Harbour Bridge which carries an annual average daily traffic volume of 150,000+ vehicles. Located to the north across the harbour is existing single and multi-storey residential dwellings including Admiralty and Kirribilli House. Mrs Macquarie's chair, Sydney Royal Botanic Gardens, Government House, and its associated gardens wrap around from the east to the south east of the site. Finally, the Bennelong Apartments located along Macquarie Street is located immediately south of the Sydney Opera House with these being the nearest potentially most affected receiver, as shown in Figure 1 below.

Figure 1 Site Description and Measurement Location – Sourced from SixMaps NSW

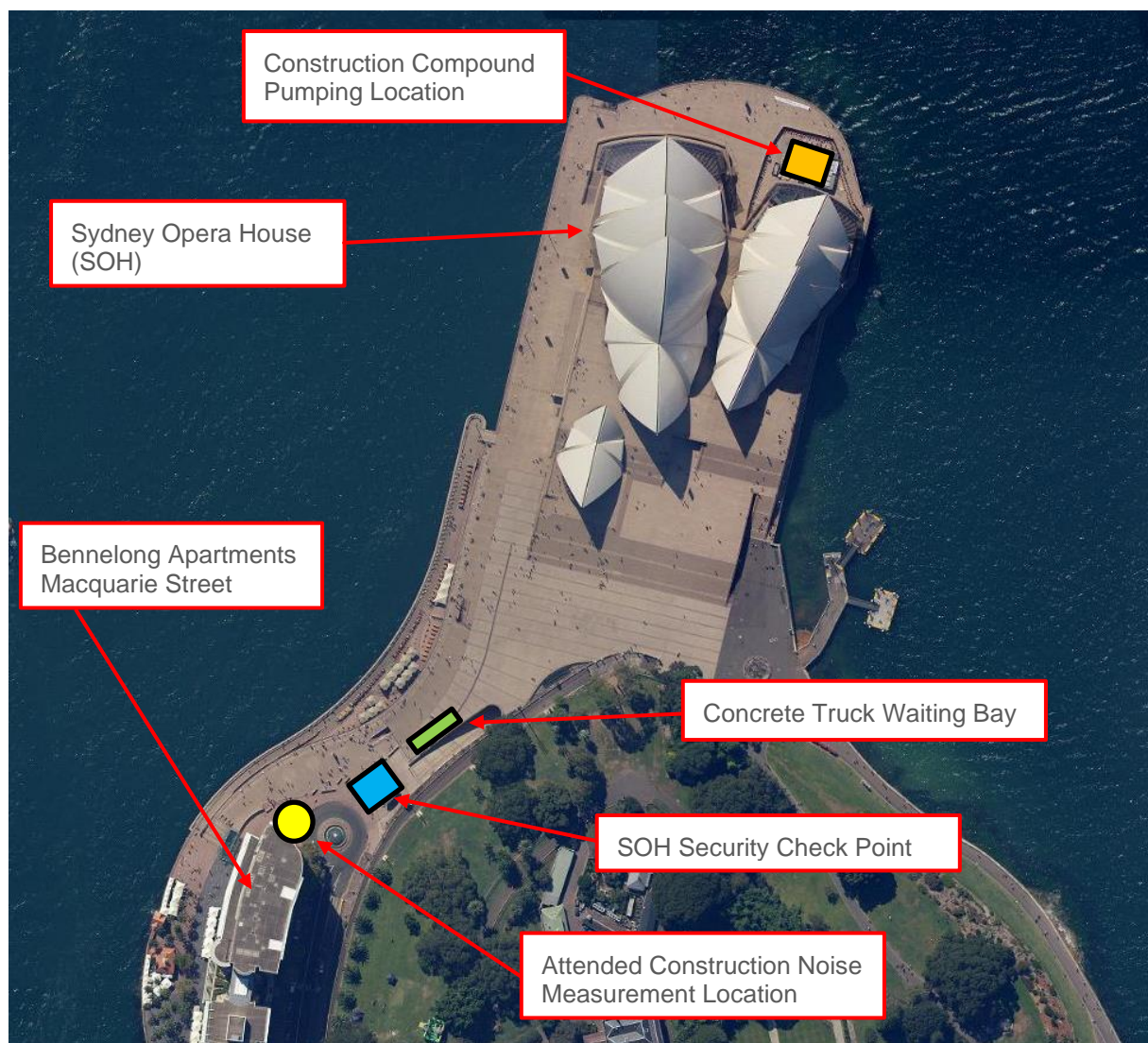


Figure 2 Attended Construction Noise Measurement Location – Bennelong Apartments



Note: Site photos are from a previous onsite attendance. All locations shown above are identical to the measurements outlined below.

3 CONSTRUCTION NOISE OBJECTIVES

As mentioned above, construction noise management levels have previously been determined by Arup Pty Ltd and Hibbs and Associates Pty Ltd in both the *Noise Impact Assessment* (Arup Pty Ltd) and *Construction Noise Vibration Management Sub Plan* (Hibbs and Associates Pty Ltd). As such, the construction noise objectives as established in these reports are reproduced below.

3.1 Sydney Opera House Building Renewal Noise Impact Assessment for DA3 – SSD 8663 – Arup Pty Ltd dated 15th May 2018

Section 2.1 of the Arup *Noise Impact Assessment* (report reference 2018-05-15 NOISE IMPACT ASSESSMENT (DA3)_ISSUE (REV A), dated 15th May 2018) outlines the following construction noise limits.

2.1 Construction Noise

Most of the construction works for the project are internal and will take place in spaces that are extremely well insulated against noise transfer. External work at night will be limited to *occasional* deliveries where these cannot be safely undertaken during normal working hours or because of large loads.

Calculations show that construction noise levels should not exceed the appropriate criteria at any time.

Notwithstanding the above, the Sydney Opera House (SOH) has recognised noise issues affecting nearby neighbours during external construction works in the past. Therefore the Sydney Opera House intends that contractors who are undertaking noisy external works identify mitigation measures for this work in their Construction Noise Management Plan (CNMP) which they will be required to prepare before work starts on site. This CNMP will be reviewed by the SOH and their noise consultants prior to approval and implementation on site.

The Contract with the Managing Contractor will include a clause allowing SOH to disallow any equipment that it considers to be excessively noisy. Similarly the Managing Contractor may include incentives, as it sees fit, for sub-contractors who can provide noise mitigation measures as part of their contract works.

The following noise limits will be applied:

Receiver	Time Period ¹	Warning level, L _{Aeq} (15min)	Maximum Level, L _{Aeq} (15min)
Bennelong Apartments	Day (standard hours)	65 dB	68 dB
	Day (outside hours)	60 dB	63 dB
	Evening	59 dB	62 dB
	Night	50 dB	53 dB
Kirribilli	Day (standard hours)	61 dB	64 dB
	Day (outside hours)	56 dB	59 dB
	Evening	54 dB	57 dB
	Night	48 dB	51 dB
Potts Point	Day (standard hours)	58 dB	61 dB
	Day (outside hours)	53 dB	56 dB
	Evening	53 dB	56 dB
	Night	47 dB	50 dB

Should complaints be received, attended acoustic monitoring will be undertaken to ascertain the ‘noisier’ work activities and address specific work practices and locations to better alleviate noise complaints from that particular activity.

Following identification that all noise levels have returned to being consistently below the above maximum levels the monitoring will revert to remote monitoring.

Nearby residents will be provided with a notice that informs them of the nature of the works, the duration and the extent of works being undertaken. 24hr contact details will be provided to allow complaints to be logged and addressed as soon as possible by the Opera House.

3.2 Construction Noise and Vibration Management Sub Plan – Hibbs and Associates Pty Ltd dated 11th February 2020

Section 2.3 of the Hibbs and Associates *Construction Noise and Vibration Management Sub Plan* (report reference S11163-R01-CNVMS-PA1, dated 11th February 2020) outlines the following construction noise limits.

2.3 Noise Management Levels

SOH's Noise Impact Assessment (NIA) ³ conducted noise surveys at the nearest NSRs and calculated NMLs from these in accordance with the ICNG. The Construction Management Plan sets out work patterns as:

- 1030 hours to 1800 hours – General construction/no major noise generating activities
- 1800 hours to 2330 hours – Planning and quiet activities which are compatible with the live performances occurring in other venues within the site
- 2330 hours to 1030 hours – Works which will otherwise be disruptive to Opera House operations but not audible outside of the building

Based on this, only the NMLs for standard daytime working hours apply.

Table 2.1: Project Noise Management Levels

PASR	Kirribilli	Bennelong Apartments	Potts Point
Warning level, $L_{Aeq,15m}$ (dB)	61	65	58
Maximum Level, $L_{Aeq,15m}$ (dB)	64	68	61

4 MEASURED CONSTRUCTION NOISE LEVELS

4.1 Attended Measurement Equipment

The attended noise measurements were conducted using a Brüel & Kjær Type 2270 sound level meter (serial number 2679267). Calibration of the sound level meter was checked prior to and following the measurements using a Brüel & Kjær Type 4231 sound calibrator (serial number 3009148). The calibrator emitted a calibration tone of 94 dB at 1 kHz. The drift in calibration did not exceed ± 0.5 dB. All equipment carries appropriate and current NATA (or manufacturer) calibration certificates.

Attended noise measurements were undertaken on Tuesday 2nd February 2021 between 7:00am and 11:15am.

4.2 Measured Results

Results of the attended noise measurements are outlined in Table 1. The results show that the noise contribution from the construction works was below both the warning and maximum criteria during all measurements.

Table 1 Measured Attended Construction Noise Levels

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
7:00am to 7:15am	66	69	56	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Slight rain and tyres on wet roads. • 1 garbage truck around roundabout. • 2 off-site trucks around roundabout. • Street sweeping nearby. • 1 ferry pass-by.
7:15am to 7:30am	63	66	55	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Slight rain and tyres on wet roads. • Street sweeping nearby. • 2 unrelated truck arrivals.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
7:30am to 7:45am	61	64	57	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Street sweeping nearby. • Slight rain and tyres on wet roads. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 2 unrelated truck arrivals.
7:45am to 8:00am	61	64	57	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Slight rain and tyres on wet roads. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Loud trolley. • 1 off-site truck around roundabout. • 1 unrelated truck departure. • 1 bus around roundabout.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
8:00am to 8:15am	61	63	57	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Slight rain and tyres on wet roads. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 1 unrelated truck arrival.
8:15am to 8:30am	60	62	57	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Slight rain and tyres on wet roads. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 2 off-site trucks around roundabout.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
8:30am to 8:45am	61	63	56	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Slight rain and tyres on wet roads. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Ferry horn. • 1 helicopter fly-by.
8:45am to 9:00am	61	62	56	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Slight rain and tyres on wet roads. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 2 unrelated truck arrivals. • 2 off-site trucks around roundabout. • Test alert tone over the Security speaker system (Safety Warden's voice + evacuate test drill). • Alarm in UGG Store for 20 seconds.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
9:00am to 9:15am	60	63	55	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 1 unrelated truck departure. • 1 off-site truck around roundabout.
9:15am to 9:30am	62	65	57	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Background music from The UGG Store. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 1 off-site concrete truck around roundabout. • 2 off-site trucks around roundabout. • 2 unrelated truck departures. • 1 unrelated truck arrival. • Helicopter hovering overhead for 3 minutes.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
9:30am to 9:45am	61	63	57	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Background music from The UGG Store. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • 1 garbage truck around roundabout. • 2 off-site trucks around roundabout. • 1 unrelated truck departure. • 1 unrelated truck arrival. • 1 unrelated truck departure. • Helicopter hovering overhead for 3 minutes.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
9:45am to 10:00am	63	66	59	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Background music from The UGG Store. • 2 off-site trucks around roundabout. • Garbage truck idling for 12 minutes. • Concrete truck 1 and 2 arrival – 9:50am. • Concrete truck 1 and 2 idling at entry gate – 9:50am to 9:51am. • Concrete truck 1 starts pumping – 9:58am. • Concrete truck 2 idling at holding bay – 9:51am to 10:00am. • Garbage bin wheeled away.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
10:00am to 10:15am	61	64	56	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Background music from The UGG Store. • Garbage truck idling for 5 minutes. • Concrete truck 2 idling at holding bay – 10:00am to 10:08am. • Concrete truck 1 pumping. • Concrete truck 1 leaves concrete pour – 10:03am. • Concrete truck 1 leaves site – 10:08am. • 1 unrelated truck departure. • 1 unrelated truck arrival. • Concrete truck 2 starts pumping – 10:12am. • 2 off-site trucks around roundabout. • 1 helicopter fly-by.
10:15am to 10:30am	59	61	55	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Concrete truck 2 pumping. • Background music from The UGG Store. • 2 off-site trucks around roundabout.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
10:30am to 10:45am	60	63	55	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Concrete truck 2 pumping. • Mopping floor behind sound level meter for 1 minute. • Background music from The UGG Store. • 1 helicopter fly-by.
10:45am to 11:00am	62	63	58	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity nearby on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Background music from The UGG Store. • Concrete truck 2 pumping. • 3 off-site trucks around roundabout. • 1 unrelated truck arrival.

Date and Time	Measured Noise Level dBA			Observations during survey interval
	LAeq (15-minutes)	LA10 (15-minutes)	LA90 (15-minutes)	
11:00am to 11:15am	63	64	61	<ul style="list-style-type: none"> • Vehicle movements Macquarie Street roundabout and Harbour Bridge. • Pedestrian movements along foreshore. • Marine Activity Circular Quay and Harbour. • Mobile crane located within construction compound. • Distant mechanical noise from Circular Quay. • Chirping of birds. • Construction activity nearby on Macquarie Street (idling vehicles + Cherry Picker to do gardening on rockface). • Background music from The UGG Store. • Concrete truck 2 pumping. • 1 unrelated truck departure. • Concrete truck 2 leaves concrete pour – 11:05am. • Concrete truck 2 leaves site – 11:11am.

5 CONCLUSION

Pulse Acoustic Consultancy Pty Ltd (Pulse Acoustics) has been engaged by Sydney Opera House (SOH) to undertake attended noise measurements during construction works on Tuesday 2nd February 2021.

In this document, attended construction noise measurements have been undertaken to quantify any noise impacts during the concrete pour within the Sydney Opera House at the nearest potentially affected receiver, the Bennelong Apartments located along Macquarie Street.

Measured construction noise levels at the Bennelong apartments northern façade have indicated compliance with the project NMLs (both warning and maximum levels).

APPENDIX A: ACOUSTIC TERMINOLOGY

<i>Ambient Sound</i>	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
<i>Audible Range</i>	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.
<i>Character, acoustic</i>	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
<i>Decibel [dB]</i>	<p>The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds;</p> <ul style="list-style-type: none">0dB the faintest sound we can hear30dB a quiet library or in a quiet location in the country45dB typical office space. Ambience in the city at night60dB Martin Place at lunch time70dB the sound of a car passing on the street80dB loud music played at home90dB the sound of a truck passing on the street100dB the sound of a rock band115dB limit of sound permitted in industry120dB deafening
<i>dB(A)</i>	<p><i>A-weighted decibels</i> 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.</p>
<i>Frequency</i>	Frequency is synonymous to <i>pitch</i> . 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.
<i>Loudness</i>	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
<i>L_{Max}</i>	The maximum sound pressure level measured over a given period.
<i>L_{Min}</i>	The minimum sound pressure level measured over a given period.
<i>L₁₀</i>	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
<i>L₉₀</i>	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).
<i>L_{eq}</i>	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
<i>Sound Pressure Level, L_P dB</i>	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.