INNER SYDNEY HIGH SCHOOL, SURRY HILLS

ACOUSTIC ASSESSMENT OF EARLY WORKS NOISE AND VIBRATION FOR REVIEW OF ENVIRONMENTAL FACTORS (REF)

Issued

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1 Introduction

The NSW Department of Education (DoE) are preparing a Review of Environmental Factors (REF) Assessment for early works associated with the 'Inner Sydney High School' (ISHS) project, located at the corner of Cleveland and Chalmers Street, Surry Hills (the 'site'), identified as 244 Cleveland Street, Surry Hills NSW 2010.

Acoustic Studio has been commissioned to carry out a noise impact assessment for the early works by the DoE.

This acoustic assessment has been prepared in support of the REF for the project.

The objectives of this assessment are to:

- Identify noise sensitive receivers that will potentially be affected by the early works.
- Carry out noise surveys to determine existing ambient and background noise levels at the nearest noise sensitive receivers that surround the site as well as quantify external noise levels with potential to impact on the site (particularly traffic noise).
- Establish the appropriate noise assessment criteria in accordance with the relevant standards and guidelines. Including:
    - NSW Industrial Noise Policy 2000
    - Interim Construction Noise Guideline 2009
    - Assessing Vibration: A Technical Guideline 2006
- Carry out a quantitative assessment to determine whether the relevant criteria can be achieved based on proposed early works methods. Where applicable, provide recommendations for any necessary acoustic control measures that will need to be incorporated as part of the early works in order to ensure compliance with the assessment criteria.

This report presents the findings of early works noise and vibration assessments. It includes measured environmental noise survey data and environmental noise limits based on the measured noise levels in the area. Compliance with these limits will ensure that any noise from the early works will not impact negatively on the nearest existing receivers and receivers which have been proposed for development. The report also provides recommendations for appropriate vibration level criteria during early works.

2 Project Overview

2.1 Description of Early Works

The early works associated with the Inner Sydney High School Project include:

- Removal of selected trees.
- Site services isolation.
- Demolition of Building 4 and all connecting bridge links on site.
- Construction of temporary works (for on-site truck turning, hoardings, site amenities, support gantry's and site services connections).
- Works which may also be include in this REF include the removal of hazardous material and the services strip out of Buildings 1, 2 and 3.

2.2 Site details

The site is located within an urban environment on the outskirts of Sydney CBD, characterised by high levels of activity throughout the day and medium to high noise levels in the evening and night.

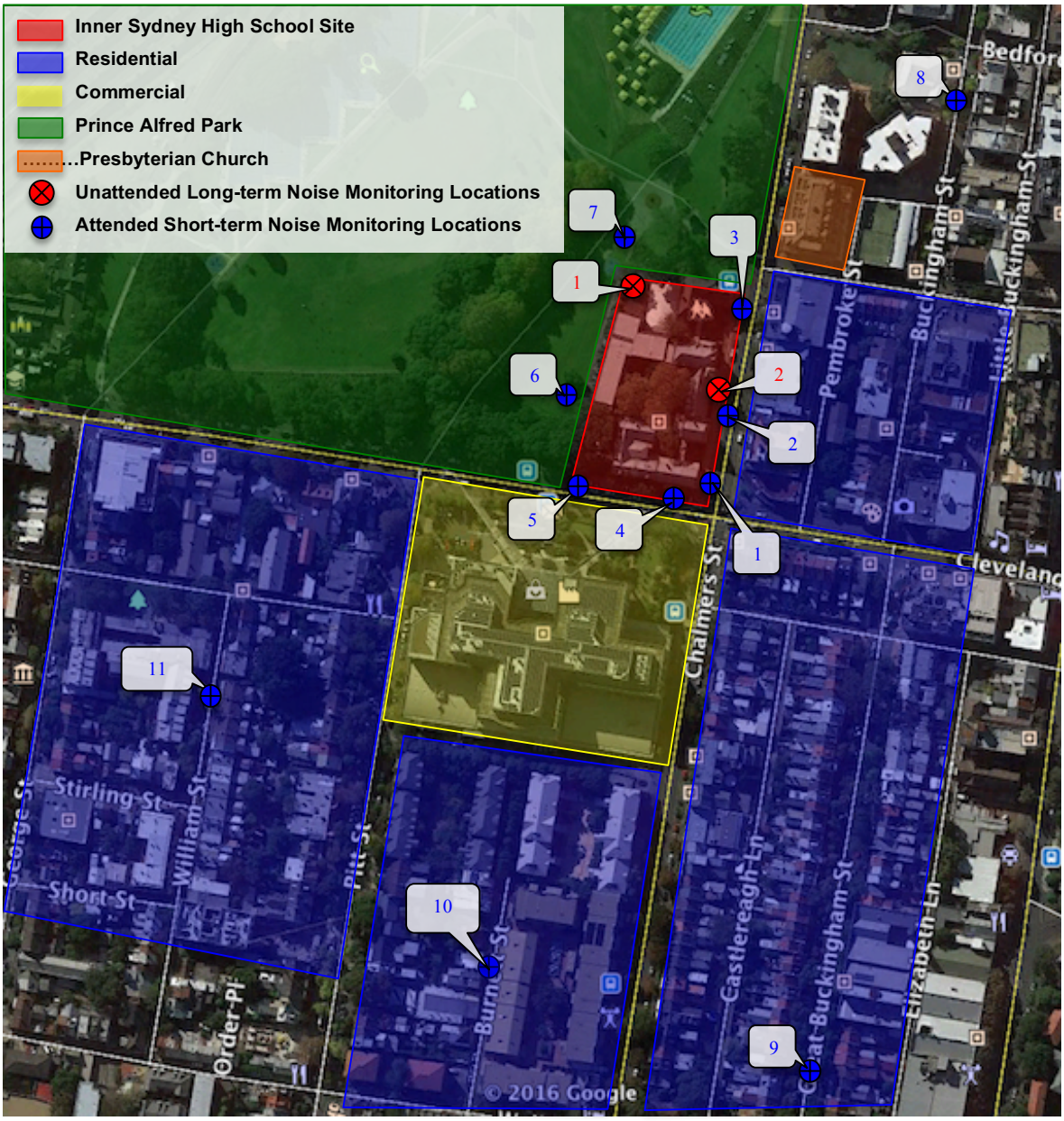


Figure 1: Proposed Inner Sydney High School site in relation to noise-sensitive receivers.

Existing neighbouring buildings and areas that surround the site are as follows:

- Prince Alfred Park and Pool areas to the North and West.
- Presbyterian Church of Australia to the North East.
- Residential buildings to the East and South East.
- Commercial properties across Cleveland Street to the South.

3 Existing Noise Environment

3.1 General survey information

A survey of the existing noise environment around the Cleveland Street, Chalmers Street and Prince Alfred Park site was conducted with two unattended noise monitors used to continuously record the noise levels on the site. Unattended long-term noise monitoring was carried out from Friday 31st March to Tuesday 11th of April 2017 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Unattended long-term noise monitoring was carried out with the following noise loggers:

- Logger 1: Ngara (Serial Number 878079).
    - This logger was used at Location 1 from 5th April to 11th April 2017; and
- Logger 2: RTA 02 (Serial Number 038).
    - This logger was used at Location 2 from 31st March to 11th April 2017.

The loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the 12-day measurement period. The calibrations of the loggers were checked before and after use and no variations were noted.

Operator attended short-term monitoring was also carried out on Thursday 23rd, Wednesday 29th and Friday 31st of March 2017 and on Wednesday 5th of April 2017, in order to supplement the long-term outdoor data across the site and at key surrounding receivers, plus to obtain spectral noise data for traffic noise at the proposed development site.

Attended short-term measurements were made with two Brüel & Kjær Hand-held Analysers Type 2250 (Serial Numbers 2832406 and 3010373). The calibrations of the analysers were checked before and after the surveys and no variation in levels occurred.

Windshields were used to protect the microphone of all the loggers and analysers. Weather conditions were calm and dry during the attended noise survey.

Anthony Cano and Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys.

The unattended long-term noise monitoring locations and attended short-term noise monitoring locations are shown in Figure 1.

3.2 Unattended Long-term monitoring results

The loggers were located at the proposed development site at the following locations:

- Location 1 – At the Northwest corner of the site, in the playground fronting Alfred Park to capture a combination of **ambient and background noise** levels at the site.
- Location 2 – at the East end of the proposed development site to capture existing **ambient and background noise** levels at the site along Chalmers Street.

These positions were chosen as it represented a secure place to leave the noise loggers unattended whilst obtaining typical representative traffic plus background and ambient noise levels at the nearest noise sensitive receivers. The unattended long-term noise monitoring locations are shown in Figure 1.

The detailed results of the unattended long-term noise monitoring at the two (2) logger locations are shown graphically in Appendix A.

3.2.1 Background and Ambient Noise

The logged data shows the background and ambient noise levels representative of the area. The recorded background noise levels have been used to establish limiting criteria for noise emitted from the operation of the new buildings.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

The background sound levels have been established in general accordance with the methodology described in the NSW INP, i.e. the 10^{th} percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment period. These background noise levels are shown in Table 1 below together with the L_{Aeq} ambient noise levels measured for each period.

In accordance with the INP, any data likely to be affected by rain, wind or other extraneous noises has been excluded from the calculations.

Location	Background Noise Levels (RBL), dB(A)			Leq Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Position 1 Playground, Facing Alfred Park	51	50	44	59	57	55
Logger Position 2 Chalmers Street	55	53	43	68	66	62

Table 1: Long-term background and ambient noise levels

From observations during our site visit, it is noted that both ambient and background noise levels around the proposed development site is generally dominated by traffic noise around the site.

3.3 Short-term monitoring results

Eleven (11) short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location 1** on the footpath in front of the existing Building 1 fronting Chalmers Street
- **Location 2** on the footpath in front of the Existing Building 2 fronting Chalmers Street
- **Location 3** on the footpath in front of the Existing Building 3 fronting Chalmers Street
- **Location 4** on the footpath in front of the Existing Building 1 fronting Cleveland Street
- **Location 5** on the footpath in front of the Existing School Car Park fronting Cleveland Street
- **Location 6** within Alfred Park at the façade of Building 4 with a direct line of site to Cleveland Street
- **Location 7** within Alfred Park at the façade of Building 3 with a direct line of site to Chalmers Street
- **Location 8** on the footpath in front of residential buildings on Buckingham Street
- **Location 9** on the footpath in front of residential buildings on Great Buckingham Street
- **Location 10** on the footpath in front of residential buildings on Burnett Street
- **Location 11** on the footpath in front of residential buildings on William Street

The measured values of the short-term background and ambient noise monitoring around the existing site are shown in Table 2.

Location	Time	Descriptor	Measured sound level, dB re 20 µPa									
			Overall dB(A)	Octave band centre frequency[1], Hz								
				31.5	63	125	250	500	1k	2k	4k	8k
1	Between 8am and 9am, 23 March 2017	L_{eq}	74	75	84	77	75	71	69	66	60	55
		L_{90}	66	70	69	64	63	61	62	58	50	42
2	Between 9am and 10am, 23 March 2017	L_{eq}	75	77	81	74	75	71	70	66	61	55
		L_{90}	64	64	67	62	60	59	60	56	49	40
3	Between 9am and 10am, 23 March 2017	L_{eq}	79	82	88	77	76	79	71	68	65	67
		L_{90}	63	66	66	61	59	58	59	55	48	39
4	Between 9am and 10am, 23 March 2017	L_{eq}	75	85	84	79	76	70	70	67	63	61
		L_{90}	65	73	72	67	63	60	60	56	52	45
5	Between 9am and 10am, 23 March 2017	L_{eq}	73	78	82	75	69	68	69	66	61	55
		L_{90}	62	72	69	64	58	56	56	54	49	42
6	Between 9am and 10am, 23 March 2017	L_{eq}	60	72	73	65	57	53	54	52	51	48
		L_{90}	53	67	65	57	50	47	48	45	40	31
7	Between 10am and 10:30am, 23 March 2017	L_{eq}	57	68	70	65	59	51	51	48	42	33
		L_{90}	53	63	63	58	51	47	48	44	36	27
8	Between 3pm and 4pm, 5 April 2017	L_{eq}	55	68	67	58	53	51	50	46	43	38
		L_{90}	49	64	59	51	47	46	43	38	31	25
9	Between 3pm and 4pm, 5 April 2017	L_{eq}	47	60	59	50	45	43	43	40	37	29
		L_{90}	43	54	53	46	42	39	38	33	27	20
10	Between 4pm and 5pm, 5 April 2017	L_{eq}	44	55	54	49	43	43	39	35	32	24
		L_{90}	43	52	48	45	41	41	37	31	23	16
11	Between 4pm and 5pm, 5 April 2017	L_{eq}	44	52	50	47	43	39	37	35	37	32
		L_{90}	40	50	47	44	40	37	34	28	22	15

Table 2: Short-term traffic, background and ambient noise levels – Day time survey

4 Key Acoustic Considerations

The following acoustic issues are to be addressed as part of the early works noise impact assessment for the Inner Sydney High School:

Noise and Vibration emissions from early works activities - The impact of noise and vibration generated during the early works stage and associated activities on surrounding noise sensitive premises.

The project will contribute noise and vibration to the surrounding environment during the early works stage of the project. Typically, this will result from intermittent noise from equipment and plant commonly used on construction/demolition sites.

The early works noise and vibration limits and expected impacts are reported in Section 5 of this report.

Several residential locations have been considered in the Noise Impact Assessment of the early works Noise and Vibration, however the acoustic criteria have been derived using levels affecting the residential receivers across Chalmers Street only, which is the worst affected residential receiver location. Achieving criteria at the Chalmers Street residential receivers also means achieving at all other residential receivers.

5 Early Works Noise and Vibration Assessment

The following provides a preliminary early works noise and vibration assessment based on an indicative early works description provided by Root Partnerships and will be developed further once a contractor is appointed to confirm methodology and equipment.

5.1 Relevant codes and standards

In preparing this early works noise and vibration assessment, the following legislation, codes and standards have been found to be relevant for the Inner Sydney High School project:

- NSW Department of Environment and Climate Change (DECC) "Interim Construction Noise Guideline", 2009.
- NSW Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline", 2006
- The City of Sydney "Construction Hours / Noise within the Central Business District – Code of Practice", 1992
- Australian Standard "AS 2436 : Guide to Noise Control on Construction, Maintenance & Demolition Sites", 1981
- Australian Standard "AS 1055 : Acoustics – Description and Measurement of Environment Noise", 1997
- Australian Standard "AS 2670.2 : Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)", 1990
- British Standards Institution "BS 6472 – Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)", 1992
- German Institution for Standardisation "DIN 4150.3 : Structural vibration – Effects of vibration on structures", 1999
- Protection of the Environment Operations Act 1997

5.2 Criteria and limits

5.2.1 Airborne noise – Residential Criteria

City of Sydney Construction Hours / Noise within the Central Business District – Code of Practice (CoS-CP)

Table 3 below shows the different time frames and associated noise criteria for nominated affected residential receivers as presented in the CoS-CP as applicable to the Project.

At this stage, we understand works will be carried out during standard hours and not during the night time period. Therefore, night-time noise limits / criteria and assessment are not included in this quantitative assessment.

The CoS-CP describes criteria in the form of "average Lmax" (L_{Avmax}), which is equivalent to L_{A10}.

Day	Time Period	Airborne Construction Noise Criteria, dB L_{A10}	
Monday to Friday	00:00 – 07:00	Background + 0 dB	N/A
	07:00 – 08:00	Background + 5 dB	53 + 5 = **58**
	08:00 – 19:00	Background + 5 + 5 dB	55 + 10 = **65**
	19:00 – 23:00	Background + 3 dB	N/A
	23:00 – 24:00	Background + 0 dB	N/A
Saturday	00:00 – 07:00	Background + 0 dB	N/A
	07:00 – 08:00	Background + 5 dB	52 + 5 = **57**
	08:00 – 17:00	Background + 5 + 5 dB	53 + 10 = **63**
	17:00 – 23:00	Background + 3 dB	N/A
	23:00 – 24:00	Background + 0 dB	N/A

Table 3: CoS-CP construction airborne noise criteria for residential receivers

OEH Interim Construction Noise Guideline (OEH ICNG)

The relevant guideline applied for the assessment of construction noise is the DECC NSW, *"Interim Construction Noise Guideline (ICNG), 2009"*. This guideline provides construction noise criteria for Residential, Commercial and Industrial noise receivers as follows.

Section 4 of the ICNG provides recommendations for standard hours of work and suggests construction / demolition noise management levels that aim to minimise the likelihood of annoyance caused to noise sensitive receivers. These consider both airborne and ground borne noise level impacts.

Table 4 below outlines the methodology for determining construction / demolition noise criteria at nearby residential receivers surrounding the development site based on existing background noise levels.

Time of Day	Management level $L_{Aeq\ (15\ min)}$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL[1] + 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 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the 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(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

Table 4: Residential construction noise criteria for airborne noise

Based on the requirements detailed in Table 4 above and the measured data of existing conditions at the site (Section 3), the RBL has been calculated over the relevant periods

[1] The RBL is the overall single figure background level representing each assessment period (day/evening/night) over the whole assessment period. This is the level used for assessment purposes and is further described in the EPA *"NSW Industrial Noise Policy, 2000"*

and the corresponding project specific noise criteria levels for residential airborne noise has been determined. These are detailed in Table 5.

Location	Period		Rating Background Level RBL, dBA	Criteria $L_{eq\ (15\ min)}$ dBA	
Residential Receivers	Recommended Standard Hours	Monday to Friday 7am-6pm	55	RBL + 10	65
		Saturday 8am-1pm	53		63
	Outside Recommended Standard Hours	Saturday 7am-8am	52	RBL + 5	57
		Saturday 1pm-6pm	52		57

Table 5: Project specific residential noise criteria for airborne noise

Project Specific Airborne Noise Criteria

The CoS and ICNG criteria have both been considered and the more stringent of the two has been applied for the assessment as shown in Table 6. The time periods listed in Table 6 are based on the CoS time periods for sites which are outside of the city centre.

Day	Period	CoS-CP	ICNG	Project Specific Criteria
Monday to Friday	07:30 – 08:30	53 + 5 = 58	65	58
	08:30 – 17:30	55 + 10 = 65	65	65
Saturday	07:30 – 08:30	52 + 5 = 57	57	57
	08:30 – 13:00	53 + 10 = 63	63	63
	13:00 – 15:30	53 + 10 = 63	57	57

Table 6: Project specific residential noise criteria for airborne noise

5.2.2 Airborne noise – *Other Sensitive Land Uses*

OEH's "Interim Construction Noise Guideline" suggests construction noise management levels for other sensitive land uses surrounding construction sites. They are as follows:

- Offices, retail outlets: $L_{Aeq,15min}$ 70dBA (external)
- Classrooms: $L_{Aeq,15min}$ 45dBA (internal)
- Places of Worship: $L_{Aeq,15min}$ 45dBA (internal)
- Passive recreation areas: $L_{Aeq,15min}$ 60dBA (external)

Where reference is made to an internal noise level, an external noise level 10 dB above the internal noise levels are applied which should achieve the internal noise level where a window is adequately opened to provide natural ventilation. The NSW Industrial Noise Policy supports this methodology.

5.2.3 Ground-borne noise

The ICNG recommends internal ground-borne noise maximum levels at residences affected by nearby construction activities. Ground-borne noise is noise generated by vibration transmitted through the ground into a structure and can be more noticeable than airborne noise for some sensitive receivers. The ground-borne noise levels presented below from the OEH / EPA ICNG are for residential receivers during evening and night-time periods only, as the objective is to protect the amenity and sleep of people when they are at home.

- Evening: $L_{eq,15min}$ 40 dB(A) (internal)
- Night: $L_{eq,15min}$ 35 dB(A) (internal)

The internal noise levels are assessed at the centre of the most affected habitable room.

5.2.4 Plant and Equipment Noise Level Limits

The allowable $L_{A\ avmax}$ noise levels for construction appliances, which are equivalent to L_{A10}, as per City of Sydney CoS-CP are shown in **Table 7** below.

GROUP A (see Note 2)	GROUP B 90dBA	GROUP C 85dBA	GROUP D 80dBA	GROUP E 75dBA	GROUP F 70Dba
Pile drivers Hydraulic hammers Machine mounted rock breakers Sand blasters Steam cleaners Mole borers	Earthmoving equipment of engine capacity above 200kW NEP Warning sirens* Reversing alarms+ Trucks	Impulsive tools - air, electric or hydraulic Earthmoving equipment of engine capacity between 100kW and 200kW NEP Explosive power tools Impact wrenches Refuse chutes* Scabblers Chain saws Rock drills	Concrete agitators Concrete pumps Concrete saws Cranes (fixed) Cranes (mobile) Earthmoving equipment up to and including engine capacities of 100kW NEP Concrete vibrators Portable hand tools Vibratory compacters	Air compressors above 170 L/s capacity Construction dumpers over 1m^3 capacity Public address system* Internal combustion or electrically driven equipment (unless grouped elsewhere) over 14kW NEP	Air compressors up to 170 L/s capacity Fluid pumps Internal combustion or electrically driven equipment (unless grouped elsewhere) up to 14kW NEP

* To be measured at the site boundary closest to the affected area.
\+ Reversing alarms must be controlled so that noise levels produced do not exceed the background sound level by more than 10dBA.

Table 7: Listed appliances and allowable noise levels relevant to the Project as per CoS-CP

5.2.5 Vibration

There are three key items that should be considered in the assessment of vibration impacts from early works. These include vibration impacts in terms of:

- Human comfort
- Sensitive equipment and processes (where applicable)
- Structural damage

Relevant criteria for each of these are detailed in the sections that follow.

5.2.6 Human Comfort

The Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline", (2006) provides suitable criteria that can be applied to the assessment of vibration and human comfort. The guideline makes reference to the British Standard BS 6472: 1992, which shares many similarities to the Australian Standards AS 2670.2: 1990. This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration plus limits for critical areas in hospital buildings, and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time). Vibration in buildings may also occur from internal sources (within a building structure), such as building services and plant. As well as being sensitive to vibration, medical equipment can also be the source of vibration within the building.

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

- **Continuous vibration** continues uninterrupted for a defined period (usually throughout daytime and/or night-time). This type of vibration is assessed on the basis of weighted rms acceleration values.
- **Impulsive vibration** is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.
- **Intermittent vibration** can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose values.

The criterion also considers the type of vibration being assessed, namely continuous, impulsive and intermittent vibration. Examples of these vibration types are provided in Table 8 below.

Continuous	Impulsive	Intermittent
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jackhammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Table 8: Examples of vibration types

The relevant criteria for human exposure to continuous and impulsive vibration are detailed in Table 8. Vibration levels are assessed through the consideration of the summation of effects for vibration levels at frequencies from 1 to 80 Hz for all axes.

Human exposure to intermittent vibration is assessed using the Vibration Dose Value (VDV). The VDV accumulates the vibration energy experienced over an extended period (daytime and night-time periods) from intermittent events. Table 9 sets out the acceptable VDV values for intermittent vibration.

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	0.20	0.14	0.40	0.28
	Night time	0.14	0.10	0.28	0.2
Offices, schools, educational institutions and places of worship	Day or night time	0.40	0.28	0.80	0.56
Workshops	Day or night time	0.80	0.58	1.6	1.16
Impulsive vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	6.0	4.2	12.0	8.4
	Night time	2.0	1.4	4.0	2.8
Offices, schools, educational institutions and places of worship	Day or night time	13.0	9.2	26.0	18.4
Workshops	Day or night time	13.0	9.2	26.0	18.4

Table 9: Preferred and maximum weighted rms values for continuous and impulsive vibration velocity (mm/s) 1-80 Hz

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

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

5.2.7 Sensitive Equipment

Neighbouring vibration receivers with sensitive equipment are likely to require a higher degree of vibration isolation than the values outlined in Table 9 and Table 10.

Vibration Criterion (VC) curves are used to provide the basis for the design and protection of highly vibration sensitive equipment. Table 11 details the VC curves applicable to a range of highly sensitive equipment that should be referred to and considered in conjunction with manufacturer guidelines specific to each type of equipment.

Curve	Max Value 8-80Hz	Detail Size	Equipment Types / Requirements
	Microns / sec, rms	Microns	
VC-A	50	8	Bench Microscopes < 400 x Magnification, optical and other precision balances, coordinate measuring machines and optical comparators
VC-B	25	3	Bench Microscopes > 400 x Magnification, microsurgery and neurosurgery
VC-C	12.5	1	Electron Microscopes < 30,000 x magnification, magnetic resonance imagers and microelectronics manufacturing equipment
VC-D	6	0.3	Electron Microscopes > 30,000 x magnification, mass spectrometers and cell impact equipment
VC-E	3	0.1	Un Isolated laser and optical research systems

Table 11: VC Curves for Highly Sensitive Equipment

Figure 2 shows the relationship between criteria for highly sensitive equipment and human exposure criteria shown in Table 9.

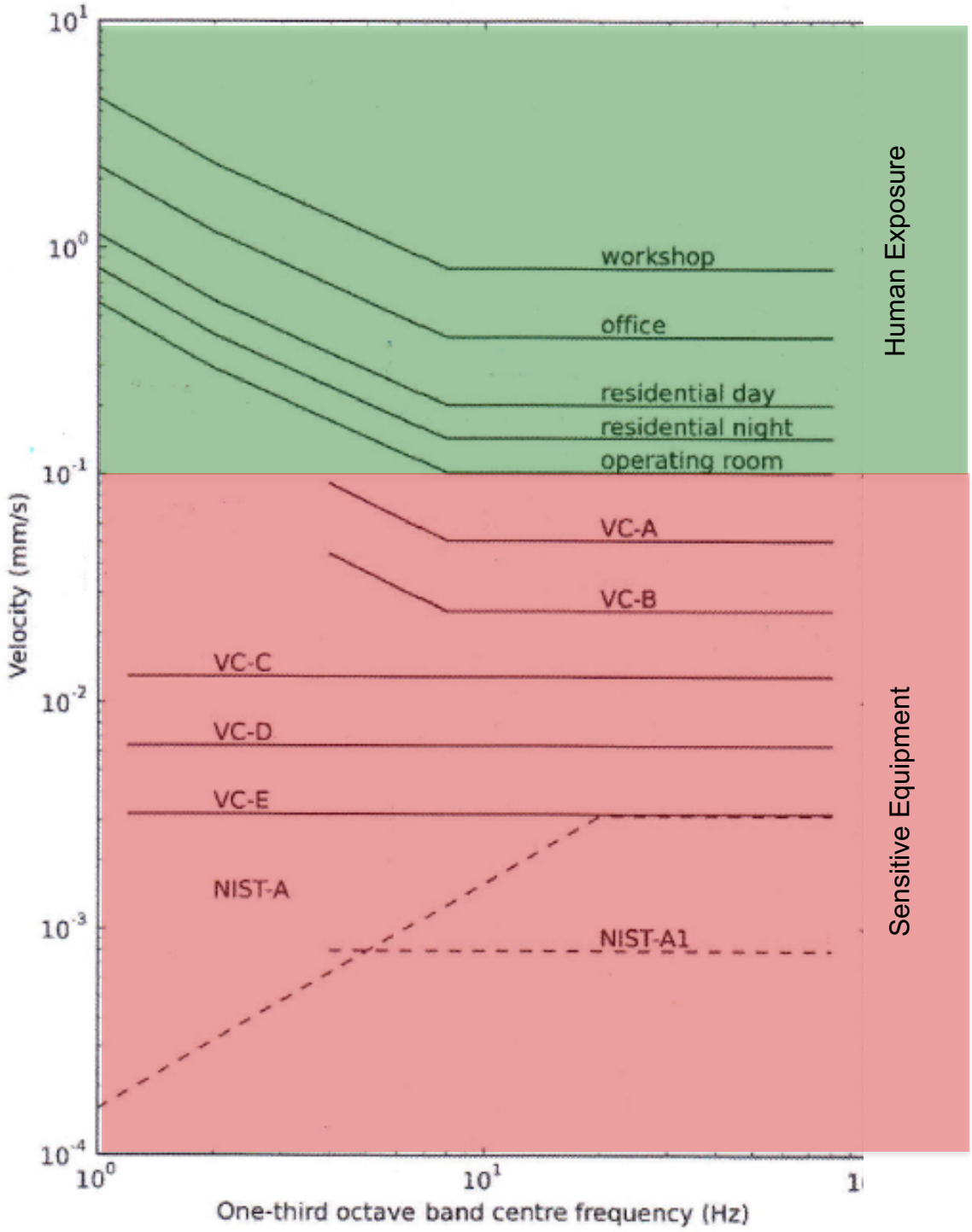


Figure 2: VC Curves - *Source: ANC Guidelines – Measurement and Assessment of Ground-borne Noise & Vibration, Association of Noise Consultants (2012)*

At this stage no structures at or surrounding the site have been identified as having particularly vibration sensitive equipment.

5.2.8 Structural Damage

Criteria to prevent building damage and disruption to equipment and processes are discussed in Appendix C.

Recommended approach to vibration management

The criteria given in Table 9 for Human Comfort shall generally form the limiting vibration criteria for the Project.

It is recommended that a precautionary approach for managing vibration-induced damage be taken for this project, whereby conservative vibration criteria are adopted in the first instance. It would be possible to relax these criteria if required, subject to review of specific buildings by a structural engineer and a regime of vibration monitoring.

The recommended precautionary criteria are:

- 3 mm/s (130 dB re 10^{-6} mm/s) for buildings surrounding the project site identified as "sensitive", which may include heritage. At this stage no structures at or surrounding the site have been identified as particularly sensitive to vibration-induced damage.
- 5 mm/s (134 dB re 10^{-6} mm/s) for residential dwellings.
- 20 mm/s (146 dB re 10^{-6} mm/s) for classrooms, commercial premises.

5.3 Early Works noise and vibration assessment

5.3.1 Proposed Hours

Proposed early works hours for the project are as follows:

- 7:30am to 5:30pm Monday to Friday.
- 7:30am to 3:30pm Saturday.

5.3.2 Description of proposed works

The Project Manager has developed an early works program that outlines the key activities in each particular location. Based on this, it is anticipated that the key activities to occur for each area / stage are as follows:

Stage of Works (Period)	Main Tasks	Typical Plant
Early Works (December 2017 to May 2018)	Removal of Selected Trees	Chain Saw / Wood Chipper
	Site Services Isolation and Diversion (Building 4)	Hand Tools / Grinder / Drill
	Demolition Building 4 and Connecting Bridges	Hand Tools / Mobile Crane / Tower Crane / Excavator / Skip Trucks / Demo Saw
	Construction Temporary Works	Skip Trucks / Hammer Drill / Hand Tools / Circular Saw
	Removal of Hazardous Material / Services Strip out (Building 1 to 3)	Hand Tools / Grinder / Drill

Table 12: Proposed Early Works

5.3.3 Noise and vibration sources

The key noise sources for the activites occurring during early works and the associated equipment noise levels are listed in Table 13 below. These values are based on Acoustic Studio's database plus Australian and International Standards.

Equipment Type	Item	Typical Noise Level $L_{A10,15min}$ SWL
Heavy Vehicles	Tipper Truck	114
	Bin Lift Truck	114
	Hiab Truck	116
	Delivery trucks (semi-trailers, rigid trucks)	108
	Concrete Mixer trucks	112
Site Machinery	Mobile Crane	111
	Bobcat	113
	Excavator (with rock breaker / rock saw)	119
	Excavator (8 Tonne w/bucket)	108
	Wood Chipper	120
	Concrete Vibrator	104
	Concrete pump	113
Hand Held Tools	Angle Grinder	104
	Drill	94
	Hammer Drill	107
	Jackhammer	113
	Hand Tools (Electric)	102
	Circular saw	115
	Chain Saw	117
	Demo Saw	122

Table 13: Anticipated airborne noise levels for equipment / plant during early works

Potential sources of vibration and ground-borne noise during the project works include:

- Demolition and excavation plant including rock-breakers and jack hammers.
- Grinding, cutting and drilling of existing building structures.

Vibration and ground-borne noise impacts are likely to be highest during the demolition and excavation stages of the project, when equipment such as rock breakers and jackhammers are used.

5.3.4 Sensitive receivers

Nearest sensitive receivers to the Inner Sydney High School site that will be potentially affected by noise and vibration associated with proposed early works are shown in Table 14.

Receiver	Location	Approximate Distance from demolition site (closest point)
Residential	Apartments to the East, across Chalmers Street	30m
Place of Worship	Presbyterian Church of Australia to the Northeast, across Chalmers Street	30m
Recreational	Prince Alfred Park and Swimming Pool surrounding site to the North and Northwest	10m
Commercial	Australia Post across Cleveland Street to the South	50m
Residential	Houses to the Southwest, on Williams Street	200m

Table 14: Noise sensitive receivers and approximate distance (closest point) to Project site

5.3.5 Methodology

A preliminary assessment of the likely noise impacts of the proposed works on the most-affected receivers surrounding the site has been carried out.

The assessment has considered the following:

- Typical activities considered in the noise impact assessment are as detailed in Table 12.
- Project specific criteria at each sensitive receiver location as outlined in Section 5.2.
- Noise level predictions are calculated using the noise data provided in Table 13.
- Noise level predictions consider for:
    - Distance attenuation
    - Ground and building reflections
    - Predictions for works carried out in Building 1 to 3 are considered as internal works with a minimum 20 dB noise reduction via the façade.
- L_{Aeq} noise levels are predicted for the operations of the nearest early works area on the site to each sensitive residential receiver location.
- The predictions consider a range from individual tasks and associated equipment up to the cumulative noise contribution from all key activities and corresponding equipment with plant running simultaneously for each phase and main task.
- The predictions assume continuous operation of equipment / plant over the 15-minute assessment period.

5.3.6 Noise assessment results

The following section presents the results of the preliminary noise assessment carried out for external works scheduled for the project.

This early works noise assessment determines the potential noise impact of activities and associated plant and equipment at the most affected receivers.

Tables 15-19 below present the predicted early works activity noise levels at the nearest affected locations, with comparison against the relevant criteria for varying construction hour periods.

Location (Criteria) and Early Works Activity (Monday to Friday, 7:30am-8:30am)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (58 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (45 dBA)
Early Works					
Removal of Selected Trees	80 to 84	75 to 80	89 to 94	80 to 84	63 to 66
Site Services Isolation and Diversion (Building 4)	57 to 77	52 to 73	66 to 87	57 to 77	40 to 61
Demolition Building 4 and Connecting Bridges	65 to 92	60 to 87	74 to 101	65 to 92	48 to 75
Construction Temporary Works	65 to 83	60 to 79	74 to 83	65 to 83	48 to 67
Removal of Hazardous Material / Services Strip out (Building 1 to 3)	37 to 57	32 to 53	46 to 67	37 to 57	20 to 41

Table 15: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Monday to Friday 7:30am to 8:30am criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Early Works Activity (Monday to Friday, 8:30am-5:30pm)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (65 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (50 dBA)
Early Works					
Removal of Selected Trees	80 to 84	75 to 80	89 to 94	80 to 84	63 to 66
Site Services Isolation and Diversion (Building 4)	57 to 77	52 to 73	66 to 87	57 to 77	40 to 61
Demolition Building 4 and Connecting Bridges	65 to 92	60 to 87	74 to 101	65 to 92	48 to 75
Construction Temporary Works	65 to 83	60 to 79	74 to 83	65 to 83	48 to 67
Removal of Hazardous Material / Services Strip out (Building 1 to 3)	37 to 57	32 to 53	46 to 67	37 to 57	20 to 41

Table 16: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Monday to Friday 8:30am to 5:30pm criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Early Works Activity (Saturday, 7:30am-8:30am)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (57 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (45 dBA)
Early Works					
Removal of Selected Trees	80 to 84	75 to 80	89 to 94	80 to 84	63 to 66
Site Services Isolation and Diversion (Building 4)	57 to 77	52 to 73	66 to 87	57 to 77	40 to 61
Demolition Building 4 and Connecting Bridges	65 to 92	60 to 87	74 to 101	65 to 92	48 to 75
Construction Temporary Works	65 to 83	60 to 79	74 to 83	65 to 83	48 to 67
Removal of Hazardous Material / Services Strip out (Building 1 to 3)	37 to 57	32 to 53	46 to 67	37 to 57	20 to 41

Table 17: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Saturday 7:30am to 8:30am criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Early Works Activity (Saturday, 8:30am-1:00pm)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (63 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (50 dBA)
Early Works					
Removal of Selected Trees	80 to 84	75 to 80	89 to 94	80 to 84	63 to 66
Site Services Isolation and Diversion (Building 4)	57 to 77	52 to 73	66 to 87	57 to 77	40 to 61
Demolition Building 4 and Connecting Bridges	65 to 92	60 to 87	74 to 101	65 to 92	48 to 75
Construction Temporary Works	65 to 83	60 to 79	74 to 83	65 to 83	48 to 67
Removal of Hazardous Material / Services Strip out (Building 1 to 3)	37 to 57	32 to 53	46 to 67	37 to 57	20 to 41

Table 18: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Saturday 8:30am to 1:00pm criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Early Works Activity (Saturday, 1:00pm-3:30pm)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (57 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (45 dBA)
Early Works					
Removal of Selected Trees	80 to 84	75 to 80	89 to 94	80 to 84	63 to 66
Site Services Isolation and Diversion (Building 4)	57 to 77	52 to 73	66 to 87	57 to 77	40 to 61
Demolition Building 4 and Connecting Bridges	65 to 92	60 to 87	74 to 101	65 to 92	48 to 75
Construction Temporary Works	65 to 83	60 to 79	74 to 83	65 to 83	48 to 67
Removal of Hazardous Material / Services Strip out (Building 1 to 3)	37 to 57	32 to 53	46 to 67	37 to 57	20 to 41

Table 19: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Saturday 1:00pm to 3:30pm criteria are in red. Predicted levels assume no noise mitigation in place.

There will be times / situations when early works activities are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers

For each of these activities and assuming that, in fact, these activities are found to exceed the noise criteria, then the noise control measures in Section 5.4.1 shall be considered and implemented wherever reasonable and feasible. In addition, the best practices presented in Section 0 shall be considered to minimise the noise impacts on the neighbourhood.

5.4 Control elements

5.4.1 Noise

As a general rule, prevention should be applied as universal work practice at any time of day, but especially for the occasional construction works to be undertaken at critical times outside normal daytime/weekday periods.

It is noted that the reduction of noise at the source and the control of the transmission path between the construction site and the receiver(s) are the preferred options for noise minimisation. Providing treatments at the affected residences or other sensitive land uses should only be considered as a last resort. Construction noise shall be managed by implementing the strategies listed below:

- Plant and equipment
  - Use quieter methods.
  - Use quieter equipment.
  - Operate plant in a quiet and effective manner.
  - Where appropriate, limit the operating noise of equipment.
  - Maintain equipment regularly.
  - Where appropriate, obtain acoustic test certificates for equipment.
- On site noise management
  - Strategically locate equipment and plant.
  - Avoid the use of reversing alarms or provide for alternative systems.
  - Maximise shielding in the form of existing structures or temporary barriers.
  - Schedule the construction of barriers and structures so they can be used as early as possible.
- Consultation, notification and complaints handling
  - Provide information to neighbours before and during construction.
  - Maintain good communication between the community and Project staff.
  - Have a documented complaints process and keep register of any complaints.
  - Give complaints a fair hearing and provide for a quick response.
  - Implement all feasible and reasonable measures to address the source of complaint.
- Work scheduling
  - Schedule activities to minimise noise impacts.
  - Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
  - Keep truck drivers informed of designated routes, parking locations and delivery hours.

5.4.2 Vibration

At this stage, we anticipate that early works will result in no adverse vibration impacts at surrounding receivers.

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating to determine whether the existence of significant vibration levels justifies a more detailed investigation.

A more detailed investigation will involve methods of constraining activities generating high vibration levels. A method of monitoring vibration levels will then need to be put in place. Vibration mitigation measures and a review of vibration criteria may then be necessary.

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

- Modifications to construction equipment used.
- Modifications to methods of construction.
- Rescheduling of activities to less sensitive times.

If the measures given above cannot be implemented or have no effect on vibration levels or impact generated, a review of the vibration criteria should be undertaken and the vibration management strategy amended.

5.4.3 Vibration surveys

Since the actual vibration levels experienced will be dependent upon the site characteristics and the specific equipment being used, early vibration level checks should be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

Shortly before the commencement of each activity the background vibration level could be measured and again once the activity has begun. If the survey indicates levels of vibration exceeding those expected, the vibration management strategy for that process could be re-assessed.

5.4.4 Additional noise and vibration control measures

If, during early works, an item of equipment exceeds ether the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with best practices presented in Section 5.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver. For example, residential receivers are likely to be more sensitive to noise before 9 am than the commercial receivers.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix E of AS2436.
- Limit the number of trucks on site at the commencement of site activities to the minimum required by the loading facilities on site.
- When loading trucks, adopt best practice noise management strategies to avoid materials being dropped from height into dump trucks.
- Avoid unnecessary idling of trucks and equipment.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc.) not specifically identified in this plan incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all internal and underground works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when noise goals cannot be met due to safety or space constraints.

5.5 Noise and vibration monitoring

5.5.1 Noise monitoring

The Contractor should consider implementing environmental noise monitoring at the locations described below.

- The boundary of the site at the closest receiver (Apartment on Chalmers St)

An allowance of 1 day per week, at least, should be dedicated to monitoring of noise and vibration for the first four weeks of early works. Further monitoring should be reviewed after this time or sooner should it be deemed necessary by the Acoustic Consultant and the Project Manager. This should take place mainly at the above location although other locations and plant and equipment monitoring should take place as and when necessary. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

5.5.2 Vibration monitoring

A vibration monitoring system could be implemented. This system would monitor vibration levels when there is potential for them to change. This could happen in various situations, such as, changes in equipment and activities or changes to work procedures that might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so that results obtained are readily comparable with results obtained earlier. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

5.5.3 Reporting

The Contractor should prepare a noise monitoring report each month for review by the Project Manager. The reports should summarise and interpret the results of the noise and vibration monitoring carried out during the past month.

5.6 Communication and complaints

The Contractor should establish a communications register for recording incoming complaints. The registration of a particular item will remain open until the complaint has been appropriately dealt with.

In addition, the following procedures are an example of the procedures that should be specifically adopted for complaints relating to noise.

Upon receipt of a complaint The Contractor should:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- Establish from the monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity should be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity should then cease.

Any activity which is directed to cease due to excessive noise should not recommence until the Project Manager is satisfied that the noise and vibration limits requirements can be met and has given permission to recommence the activity.

The Site Supervisor should ensure that a report of any incident is provided to the Project Manager.

The Project Manager should provide a report on the incident to the relevant stakeholders.

The Contractor should provide a 24 hour telephone contact number and this number should be prominently displayed on the site.

5.7 Non-compliances

Non-compliance reports can be used as appropriate to deal with failures to meet the vibration management and control requirements.

6 Summary and Conclusions

A noise and vibration assessment report has been produced to establish the potential noise and vibration impacts associated with the early works proposed in the Inner Sydney High School development project.

The existing noise environment has been established based on long-term and short-term monitoring data.

Appropriate criteria for both noise and vibration have been established based on relevant guidelines and standards.

A summary of the outcomes and recommendations of this noise and vibration assessment are as follows:

- Noise

  There will be times / situations when early works activities are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers

  If, during early works, an item of equipment exceeds the stated airborne noise criteria at any sensitive location, the additional noise control measures presented in Section 5.4, together with best practices presented in Section 5.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Vibration

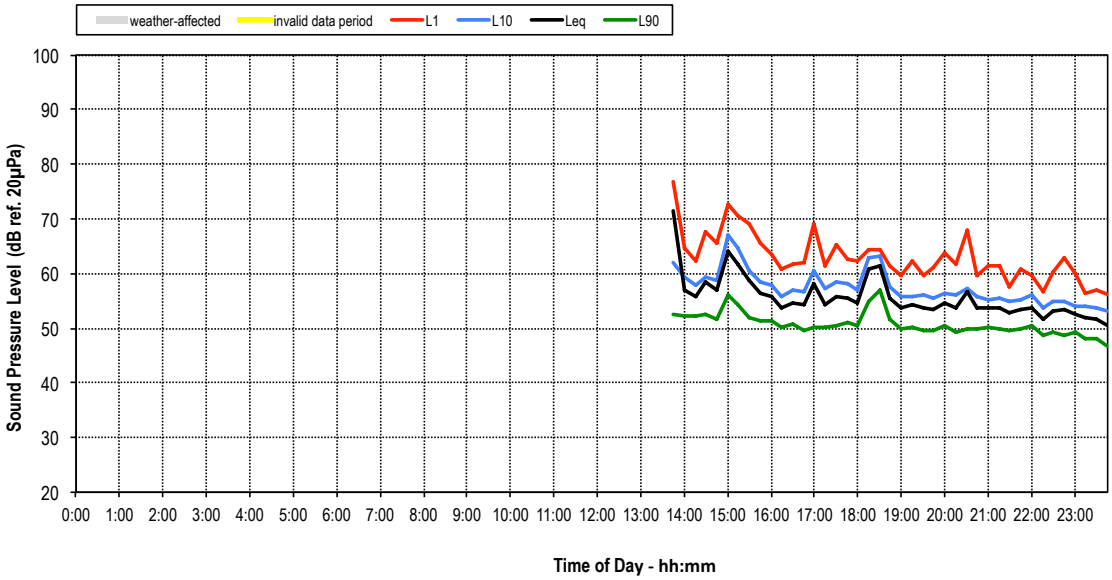
  At this stage, we anticipate that early works activities will result in no adverse vibration impacts at surrounding receivers.

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating activity to determine whether the existence of significant vibration levels justifies a more detailed investigation.

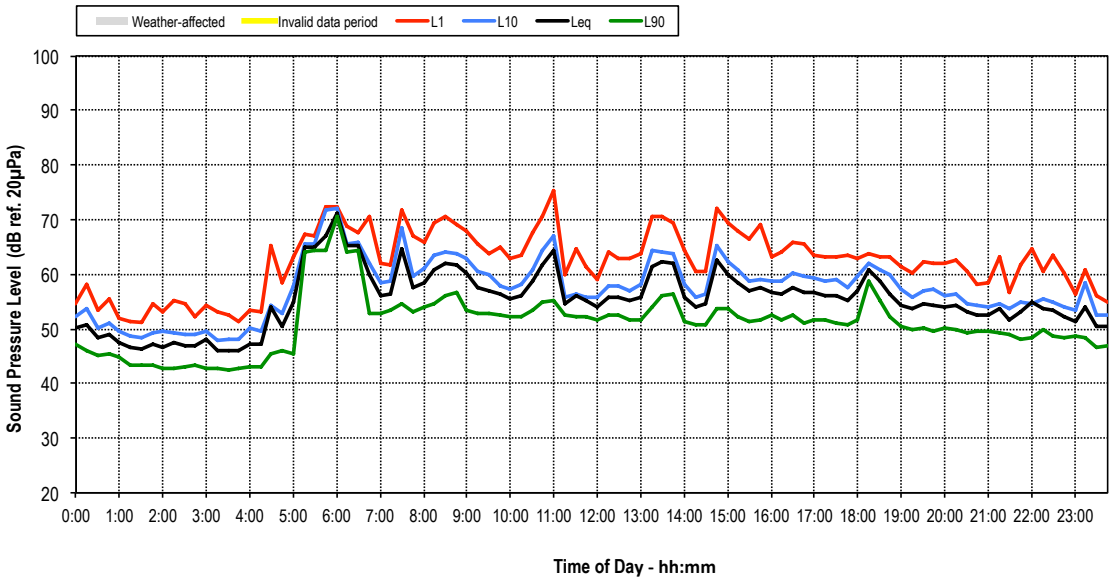
Appendix A : Noise Logger Data

Logger Position 1 – Ambient Noise Logger

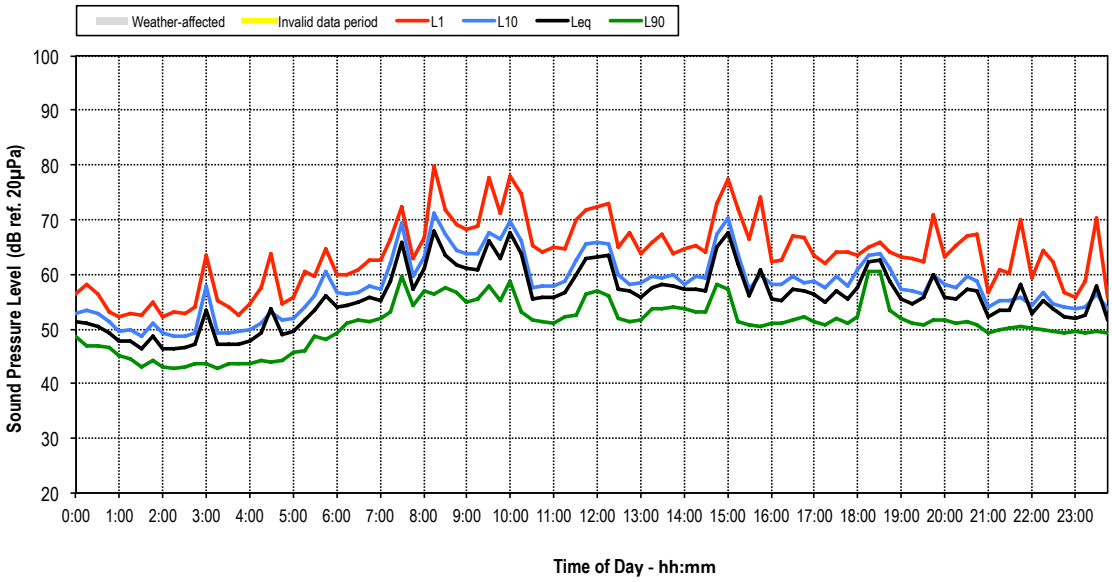
Inner Sydney High School, Playground - Wednesday 05 April 2017



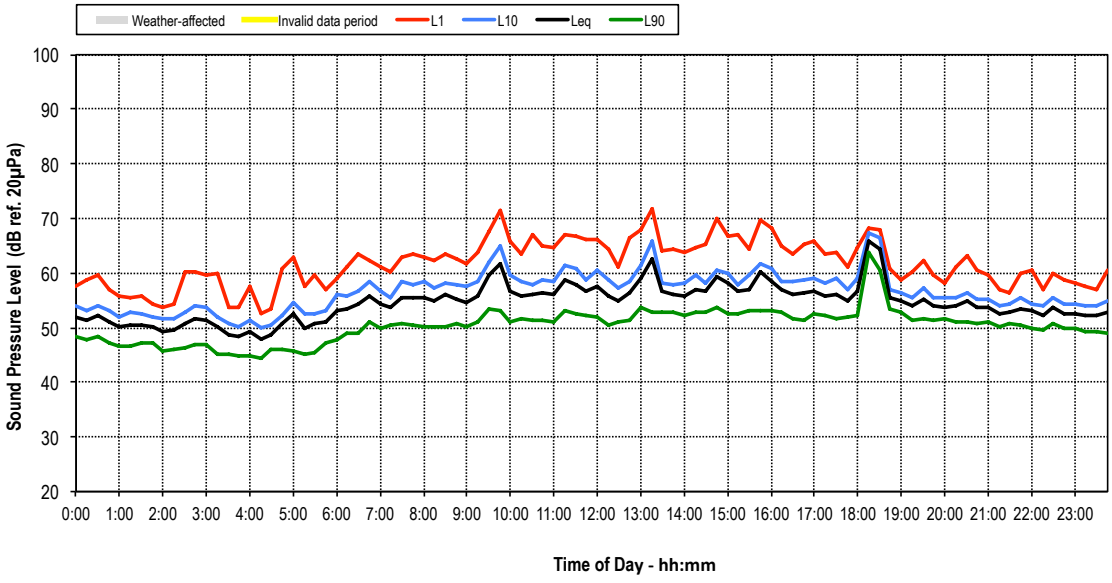
Inner Sydney High School, Playground - Thursday 06 April 2017



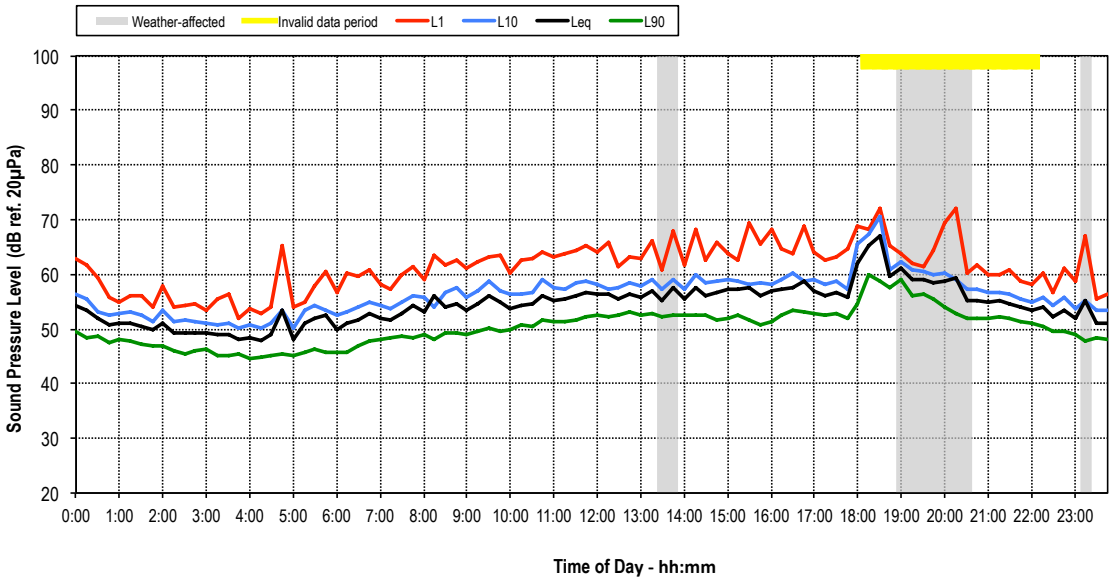
Inner Sydney High School, Playground - Friday 07 April 2017



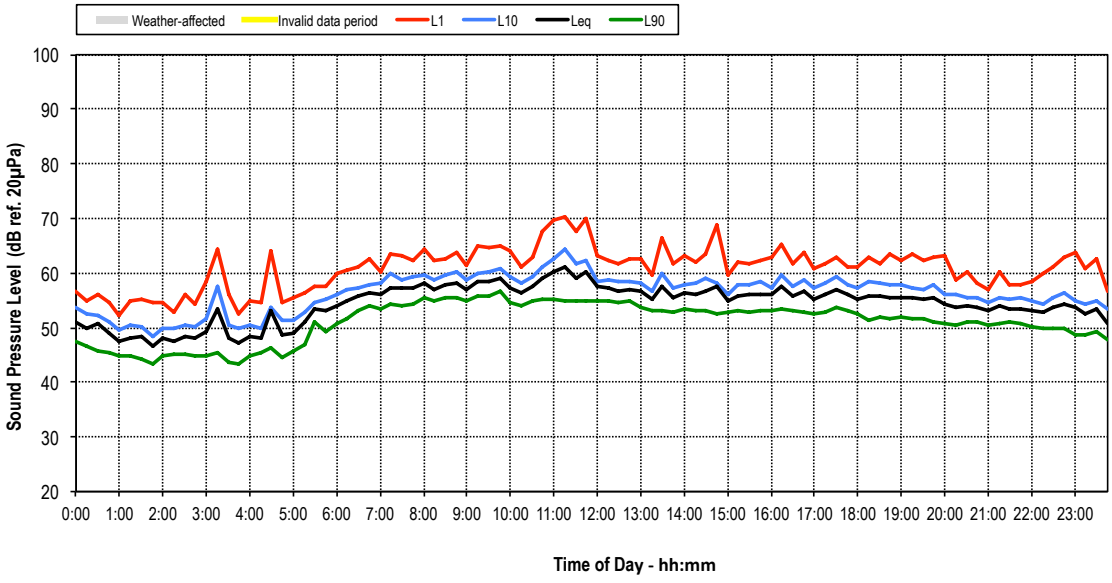
Inner Sydney High School, Playground - Saturday 08 April 2017



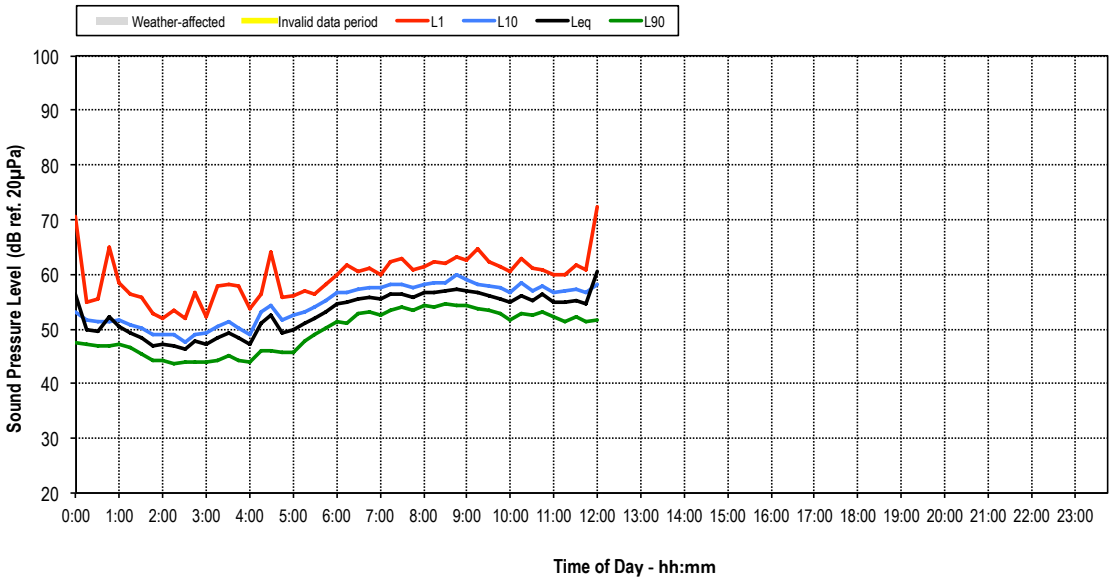
Inner Sydney High School, Playground - Sunday 09 April 2017



Inner Sydney High School, Playground - Monday 10 April 2017

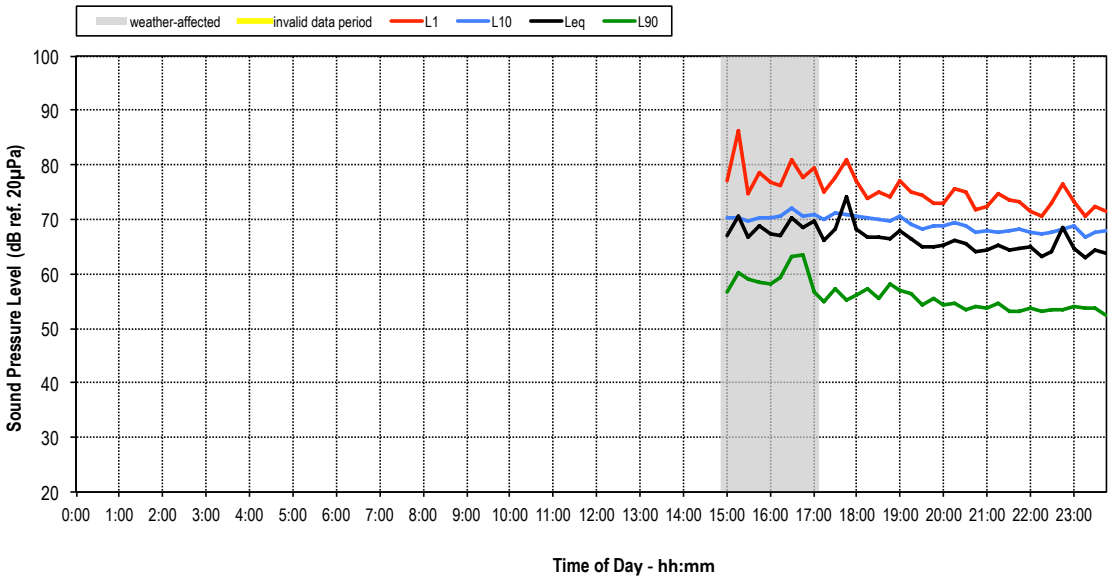


Inner Sydney High School, Playground - Tuesday 11 April 2017

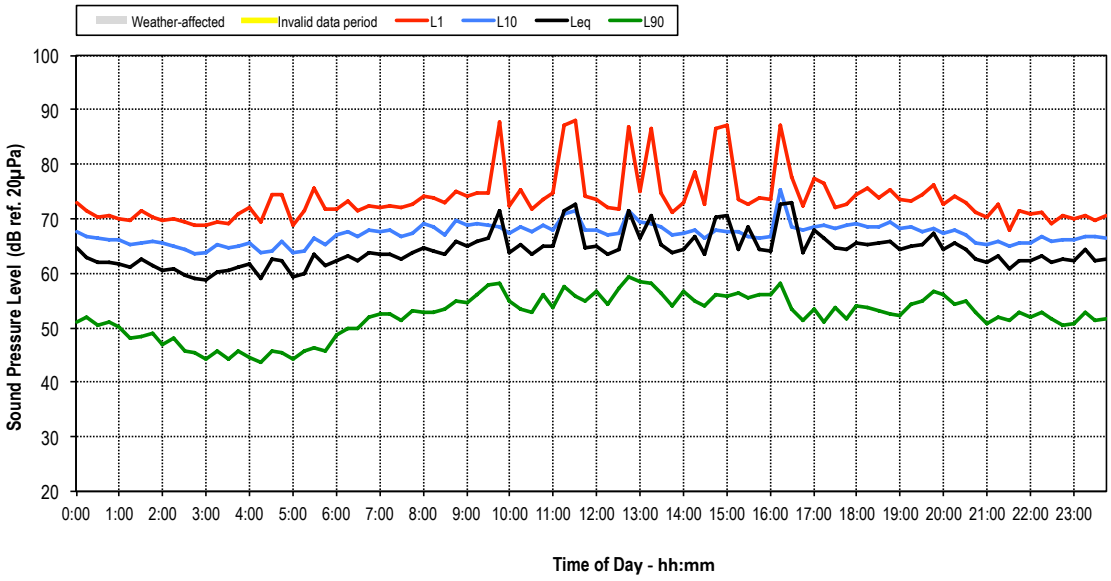


Logger Position 2 – Background Noise Logger

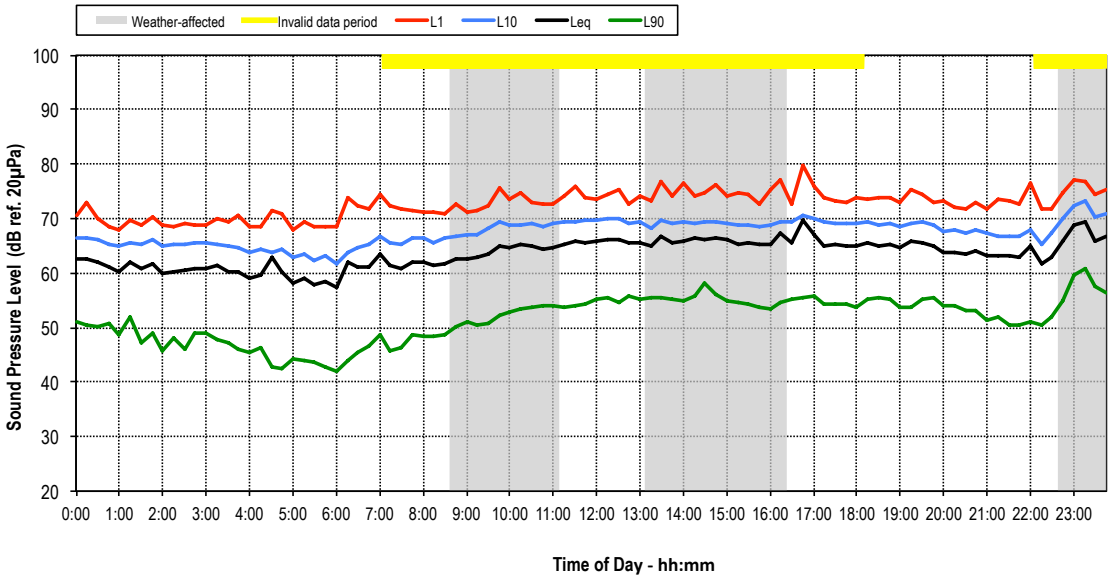
Inner Sydney High School, Chalmers St - Friday 31 March 2017



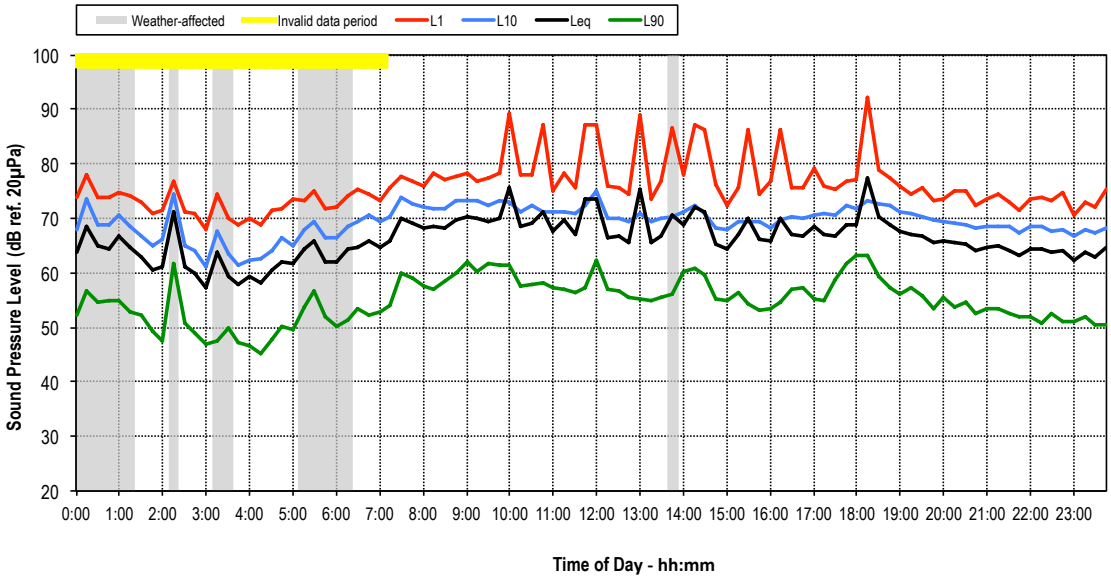
Inner Sydney High School, Chalmers St - Saturday 01 April 2017



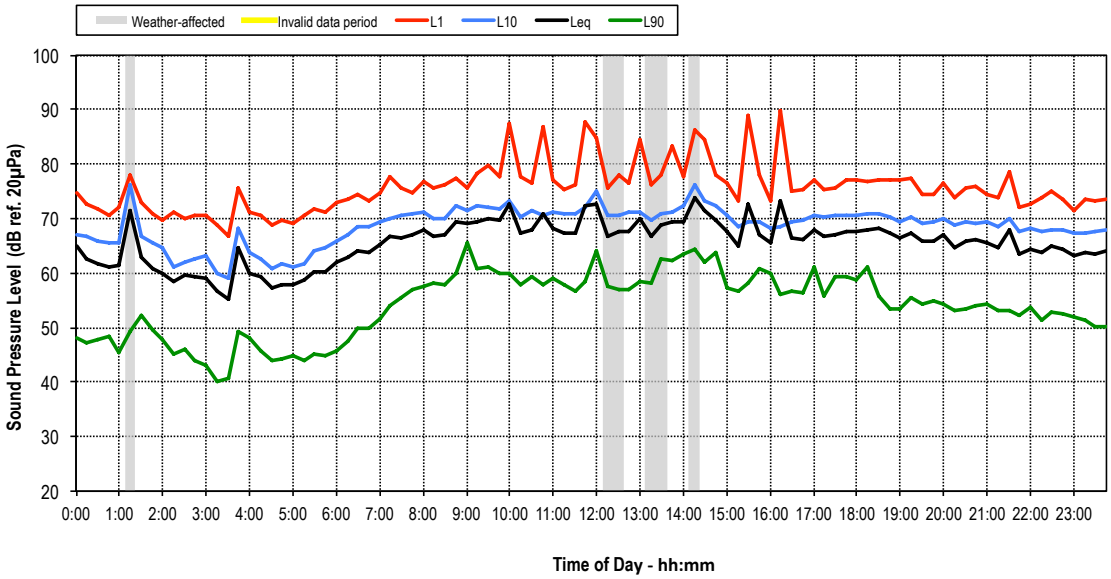
Inner Sydney High School, Chalmers St - Sunday 02 April 2017



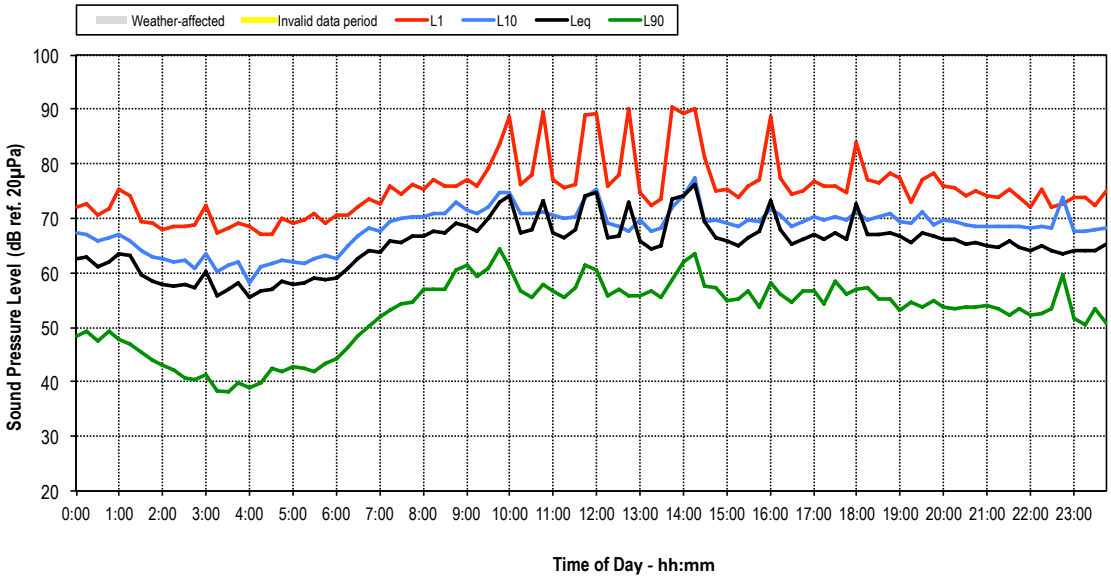
Inner Sydney High School, Chalmers St - Monday 03 April 2017



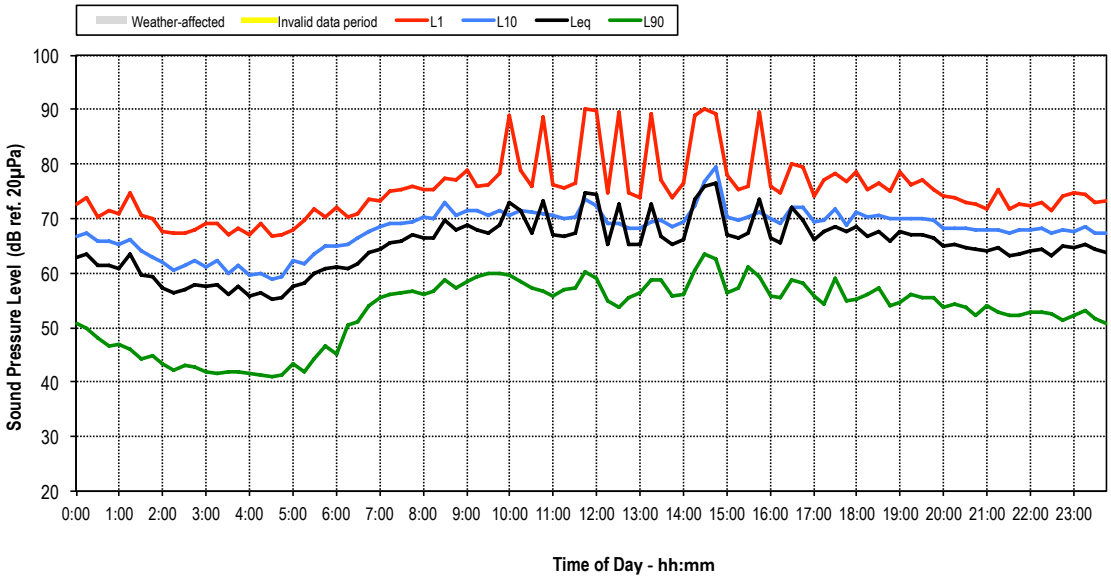
Inner Sydney High School, Chalmers St - Tuesday 04 April 2017



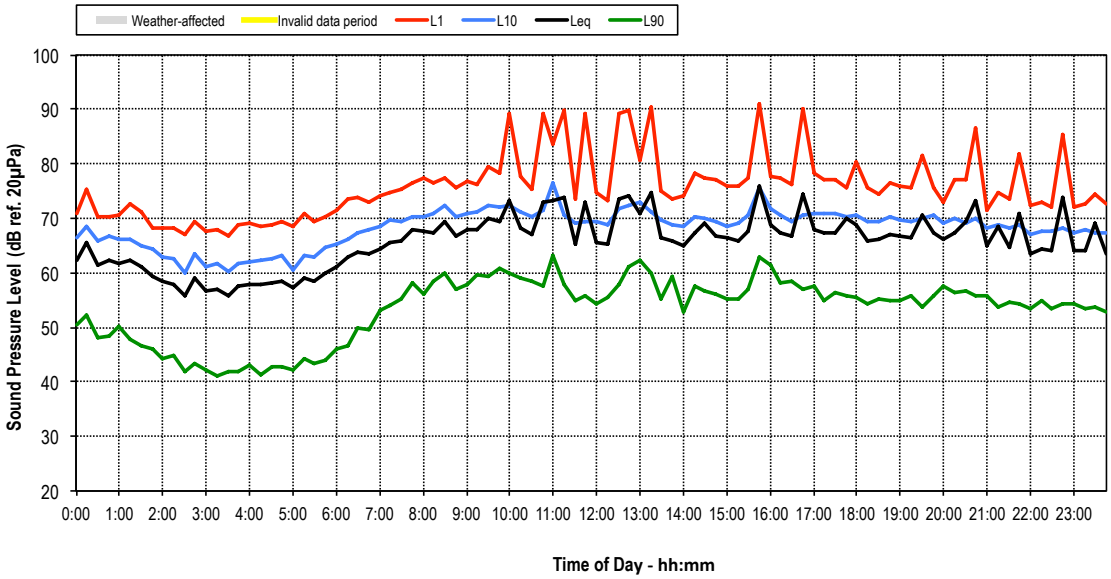
Inner Sydney High School, Chalmers St - Wednesday 05 April 2017



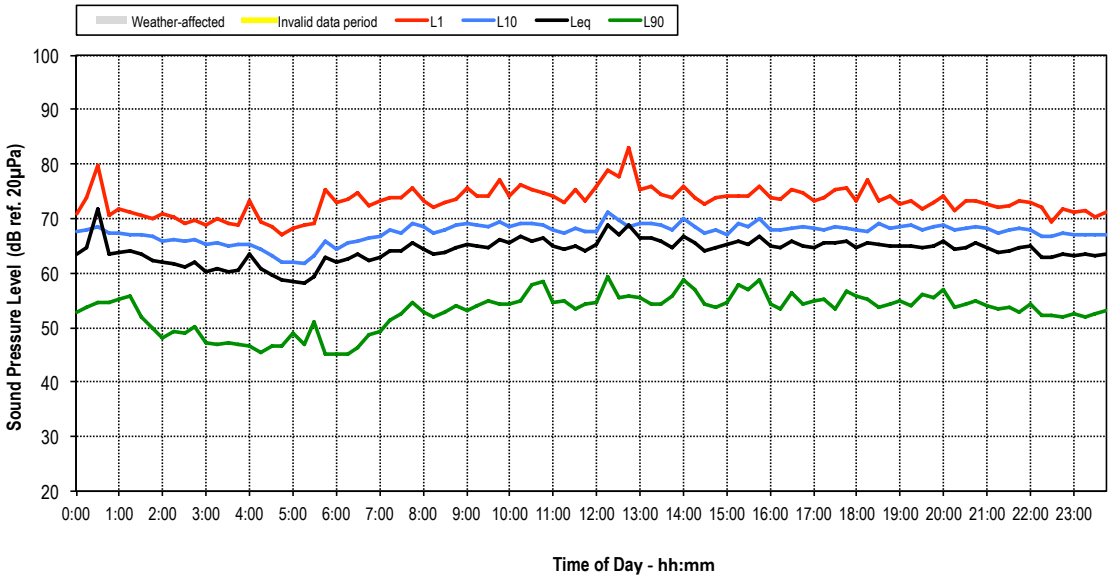
Inner Sydney High School, Chalmers St - Thursday 06 April 2017



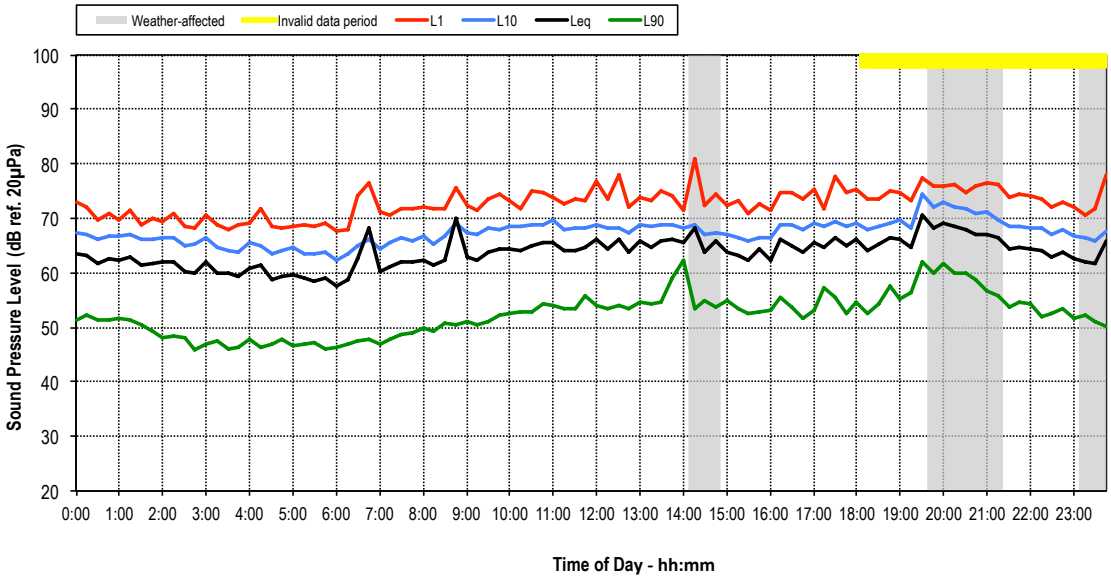
Inner Sydney High School, Chalmers St - Friday 07 April 2017



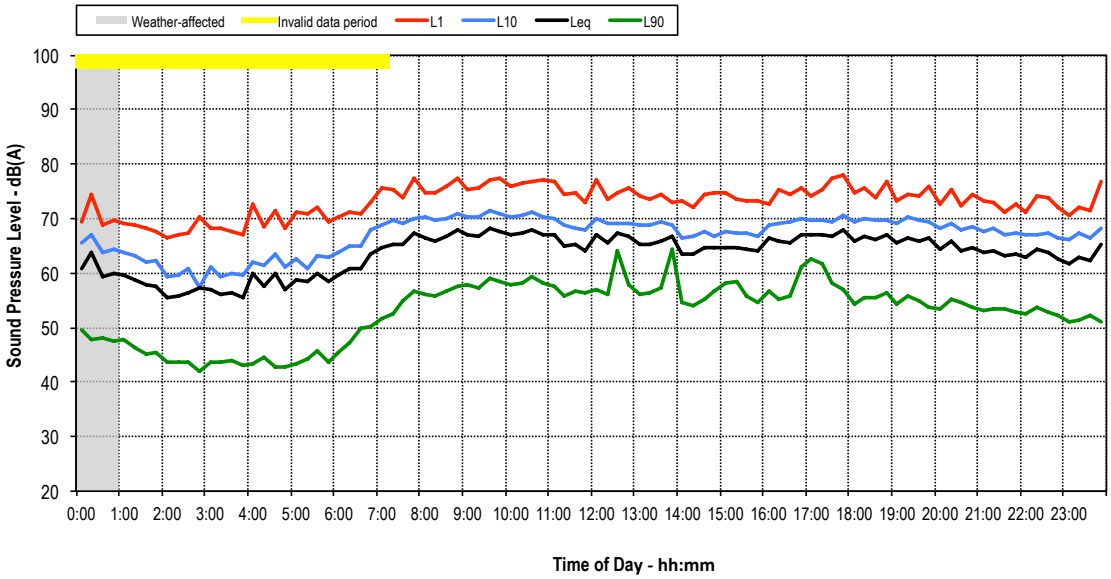
Inner Sydney High School, Chalmers St - Saturday 08 April 2017



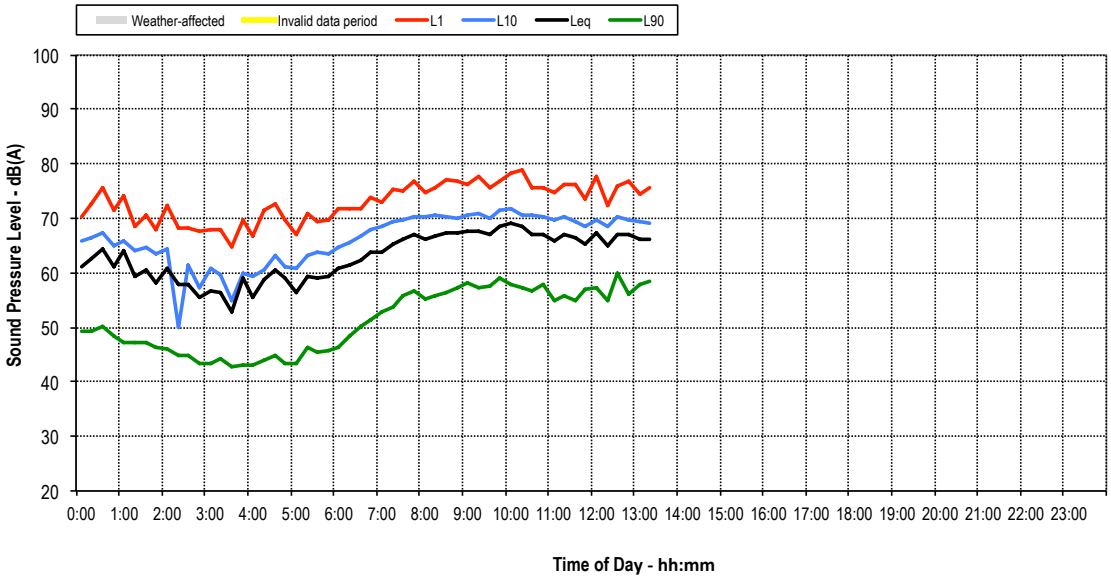
Inner Sydney High School, Chalmers St - Sunday 09 April 2017



Inner Sydney High School, Chalmers St - Monday 10 April 2017



Inner Sydney High School, Chalmers St - Tuesday 11 April 2017



Appendix B : Derivation of Environmental Noise Break-out Limits (NSW INP)

The NSW INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. Both are used to derive the project specific noise level.

Assessing intrusiveness

The intrusiveness criterion essentially means that the equivalent continuous noise level of the source should not be more than 5 dB above the measured existing background noise level.

Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise, including plant. The existing noise level from industry (or plant) is measured - if it approaches the criterion value, then the noise levels from new plant need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion.

The cumulative effect of noise from all industrial or plant sources is considered in assessing impact.

Project specific noise level

For any new plant, the more stringent of the intrusive and the amenity criteria sets the project specific noise level.

The derivation of the project specific noise levels is provided below.

B.1 Existing Background and Ambient Noise Levels

The rating background level (RBL) has been determined from $L_{A90,15min}$ measured during the long-term noise survey in accordance with the methodology prescribed in NSW INP.

Three time periods are considered (consistent with the operating times of the plant associated with the development and the time of day classifications in the Policy):

- Day - 7 am to 6 pm
- Evening - 6 pm to 10 pm
- Night - 10 pm to 7 am

From the noise logged data presented in Appendix A, the calculated RBL's and measured ambient noise levels are shown below in Table B1.

Location	L_{90} Background Noise Levels, dB(A)			L_{eq} Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Position 1 Playground Facing Alfred Park	51	50	44	59	57	55
Logger Position 2 Chalmers Street	55	53	43	68	66	62

Table B1: Long-term background and ambient noise levels measured around the ISHS Site

From observations during our site visit, it is noted that both ambient and background noise levels around the proposed development site is generally dominated by traffic noise around the site.

B.2 Determination of intrusiveness criterion

The intrusiveness criterion is defined as:

$$L_{Aeq,15\ minute} \leq \text{rating background level plus 5}$$

The intrusiveness criterion has been determined from the RBL's presented in Table B.1 for each period and from the short-term measurements presented in Section 3. The intrusiveness criterion is established for residential receivers and in this instance is based on Logger Position 2.

- Day Intrusiveness criterion of 55 + 5 = **60 dB(A)**
- Evening Intrusiveness criterion of 53 + 5 = **58 dB(A)**
- Night Intrusiveness criterion of 43 + 5 = **48 dB(A)**

B.3 Determination of amenity criterion

To limit continuing increases in noise levels, the maximum ambient noise levels within an area from industrial noise sources should not normally exceed the acceptable noise levels appropriate for the type of area (e.g. the acceptable noise level in a rural area would be less than that in an urban or industrial area).

Recommended L_{Aeq} noise levels from industrial noise sources within NSW INP

The Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy) are given in Table B2 below.

The nearest residential receivers to the project are considered to be in a Noise Amenity Area characterised by the NSW Industrial Noise Policy as Urban.

Type of Receiver	Period	Recommended $L_{Aeq,\ period}$ Noise Level (ANL)	
		Acceptable	Recommended Maximum

Type of Receiver	Period	Recommended $L_{Aeq, period}$ Noise Level (ANL)	
		Acceptable	Recommended Maximum
Residential – Urban (external)	Day	60	65
	Evening	50	55
	Night	45	50
Place of Worship (external)	When in use	50[8]	45
Passive Recreation Area	When in use	50	55
Commercial Premises (external)	When in use	65	70
School Classroom (Internal / External)	Noisiest 1-hr period when in use	35 / 45[2]	40

Table B2: Recommended LAeq noise levels from industrial noise sources at residential and commercial receivers

For the purpose of this assessment, "Acceptable" noise levels as presented in the table above are to be adopted.

Existing L_{Aeq} levels

The existing L_{Aeq} levels, determined from the ambient noise level measurements, are as follows:

Type of Receiver	Period	Existing L_{Aeq} Level
Residential – Urban (external)	Day	68
	Evening	66
	Night	62
Commercial / Classroom	When In Use	68[3]

Table B3: Existing LAeq Levels for nearest residential receiver location for project

[2] The NSW INP specifies an internal ANL of 35 and 40 for school classroms and places of worship respectively. The NSW INP also states that where internal noise levels are specified, external noise 10 dB above internal noise levels can be applied which should achieve an internal noise level where a window is adequately opened to provide natural ventilation.

[3] When considering both day and night

Amenity criterion

The amenity criterion is determined from the relationship of the existing L_{Aeq} noise level from industrial sources and the Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy).

This process is summarised below in Table B4.

Receiver	Period	Existing L_{Aeq} Level	ANL	Adjustment to ANL	Amenity Criterion
Residential	Day	68	60	Existing L_{Aeq} minus 10	58
	Evening	66	50	Existing L_{Aeq} minus 10	56
	Night	62	45	Existing L_{Aeq} minus 10	52
Commercial	When in Use	68	65	Existing L_{Aeq} minus 10	58
Educational	Noisiest 1-hour period When In Use	68	45	Existing L_{Aeq} minus 10	58

Table B4: Determination of amenity criterion for residential receivers

B.4 Project specific noise level

The Project Specific Noise Level is defined as the lower of the intrusiveness and the amenity criteria. On this basis, the Project Specific Noise Levels (PNLs) for new roof plant associated with the site are shown in Table B5 below (PNLs shown shaded in grey).

Type of Receiver	Period	Intrusiveness Criterion	Amenity Criterion
Residential – Urban (external)	Day	60	58
	Evening	58	56
	Night	48	52
Commercial (external)	When in use	-	58
Classroom (Internal)	Noisiest 1-hr period when in use	-	58

Table B5: Determination of project specific noise levels for Inner Sydney High School

Appendix C : Building damage vibration criteria

There is little reliable data on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage. This lack of data is one of the reasons that there is variation between international standards, why the British Standards Institution (BSI) did not provide guidance before 1992 and why there are still no International Organisation for Standardisation (ISO) guidance limits.

There are however several standards that can be referred to.

German Standard

The relevant German standard is DIN 4150: Part 3: 19862. This standard gives guidelines for short-term and steady state structural vibration. For short-term vibration in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
	less than 10Hz	10 to 50 Hz	50 to 100 Hz	Frequency mixture
Commercial, Industrial or Similar	20	20 to 40	40 to 50	40
Dwellings or Similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

Table C1: Guideline Values of Vibration Velocity, vi, for Evaluating the Effects of Short-term Vibration

The guidelines state that:

Experience to date has shown that, provided the values given in Table D2 are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of table D2 are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary.

Swiss Standard

The relevant Swiss standard is SN 640 312:1978. For steady state vibration, form machines, traffic and construction in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s	
	Foundation	
	10 to 30Hz	30 to 60Hz
Commercial, Industrial including retaining walls	12	12 to 18
Foundation walls and floors in concrete or masonry. Retaining walls and ashlar construction	8	8 to 12
Foundations and basement floors concrete, with wooden beams on upper floors. Brick walls.	5	5 to 8
Particularly sensitive	3	3 to 5

Table C2: Guideline Values of Vibration Velocity, vi, for Evaluating the Effects of Steady State Vibration

British Standard

The relevant standard is BS7385: Part 2: 1993[4]. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

The Standard proposes the following limits on the foundations of the building:

Structural type	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15Hz increasing to 50mm/s @ 40Hz and above

Table C3: Transient Vibration Guide Values for Cosmetic Damage

The standard states in Annex A, that … *the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance.* It is recommended that buildings of

[4] British Standards 7385:1993 Part 2 "*Evaluation and Measurement for vibration in Buildings. Guide to damage levels from ground-borne vibration"*

importance be considered on a case-by-case basis with detailed engineering analysis being carried out if necessary.

Annex B of the Standard gives a breakdown of data that should be recorded. Included in this are details of the building structure, such as general condition of the structure, list of defects, photographs, details of all major extensions, repairs and renovations. A crack exposure report should be prepared both pre and post exposure, both internally and externally.

Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2 - 1993[5], which, in Appendix J, recommends maximum peak particle velocities, measured at the ground surface due to blasting. The lower recommended peak particle velocity is 10 mm/s. The standard states however, that structures that may be particularly susceptible to ground-borne vibration should be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

[5] AS 2187.2 - 1993 Explosives - Storage, transport and use. Part 2: Use of explosives