Proposed Ancillary Works at Narrabeen North Public School in a Mapped Coastal Wetland Area

Construction Noise and Vibration Impact Assessment for Designated Development (DD)

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Glossary

Term	Definition
dB	Decibel is the unit used for expressing sound pressure level (SPL) or power level (SWL).
dB(A)	Decibel expressed as an 'A – weighted' sound pressure level, based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds.
Frequency	The rate of repetition of a sound wave. Frequency is measured Hertz (Hz), or cycles per second. Human hearing ranges approximately from 20 Hz to 20 kHz (2000 Hz).
Ground-borne noise	The transmission of noise energy as vibration of the ground. The energy may then be re-radiated as airborne noise.
$L_{1(period)}$	The sound pressure level that is exceeded for 1% of a measurement period. This is commonly accepted as the maximum noise level.
$L_{10(period)}$	The sound pressure level that is exceeded for 10% of a measurement period. This is commonly accepted as the maximum noise levels.
$L_{90(period)}$	The sound pressure level that is exceeded for 90% of a measurement period. This is commonly accepted as the background noise level.
$L_{Aeq(period)}$	The equivalent continuous sound pressure level. The level of noise equivalent to the energy average of noise levels occurring over a measurement period.
L_{Amax}	The highest sound pressure level recorded over a measurement period.
Octave Band Centre Frequency	The most commonly used frequency bands are octave bands, in which the centre frequency of each band is twice that of the band below it.
Rating Background Level (RBL)	Rating background level is the overall single-figure background level representing each assessment period (day/evening/night) over a measurement period.
Sound Power Level (SWL)	Expressed in dB, it is the total acoustic energy radiated by a plant or equipment to the environment
Sound Pressure Level (SPL)	Expressed in dB, it is the level of noise measured by a standard sound level meter and requires a description of where the noise was measured relative to the source
Vibration	Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structure-borne noise or human comfort issues respectively.

Initialisms

ACRONYM	Definition
CNVIA	Construction Noise and Vibration Impact Assessment
CEMP	Construction Environmental Management Plan
DA	Development Application
DD	Designated Development
DfMA	Design for Manufacture and Assembly
EFSG	Engineering Facilities Standards and Guidelines
ICNG	Interim Construction Noise Guideline (NSW EPA, 2009)
NMLs	Noise Management Levels
NPI	Noise Policy for Industry (NSW EPA, 2017)
MMC	Modern Methods of Construction
RBL	Rating Background Level
SI NSW	School Infrastructure NSW
NEP	Narrabeen Education Precinct
NNPS	Narrabeen North Public School
NSPS	Narrabeen Sports High School

1 Introduction

Acoustic Studio has been engaged by School Infrastructure NSW (SINSW) to assess the potential noise and vibration impacts of the proposed ancillary works at Narrabeen North Public School in a mapped coastal wetlands area. The Project Site(s) include:

- Narrabeen North Public School, located at 6 Namona Street, Narrabeen

This acoustic assessment has been prepared in support of the Designated Development (DD) works proposed for the project.

The objectives of this assessment are to:

- Identify noise sensitive receivers that will potentially be affected by the construction of proposed changes to the school.
- Carry out noise surveys to quantify the existing ambient and background noise levels at noise sensitive receivers on and surrounding the site.
- Establishing the appropriate noise and vibration criteria in accordance with the relevant standards and guidelines.
- A quantitative assessment of main noise and vibration generating sources associated with construction.
- Assessing whether the relevant criteria can be achieved and, where applicable, recommending measures to minimise and mitigate potential impacts.

This report presents the findings of construction noise and vibration assessments. It includes measured environmental noise survey data and environmental noise limits based on the measured noise levels in the area.

The report also provides recommendations for appropriate vibration level criteria during construction.

1.1 Project Overview

1.1.1 Proposal

Narrabeen North Public School (NNPS) forms part of the Narrabeen Education Precinct (NEP).

The Designated Development (DD) seeks consent for the following works at NNPS.

- Removal of eight (8) trees;
- New accessible pedestrian pathways;
- New substation on Namona Street frontage along with associated conduit connections;
- New fire hydrant booster and associated conduit connections;
- New hard and soft landscaping including planting of 12 new trees.

Other development works are occurring on the site under separate planning pathways including:

- Development Application (DA);
- Tree Removal (DA);
- Development without Consent (REF); and
- Exempt development

The proposed development does not seek to increase staff or student numbers.

1.1.2 SEARS

Planning Secretary's Environmental Assessment Requirements (SEARs) have been provided for the Designated Development application (SEAR 1718), in alignment with Section 4.12(8) of the Environmental Planning and Assessment Act 1979; Part 8 of the Environmental Planning and Assessment Regulation 2021 for Designated Development.

The SEARS includes the following key issues are addressed in relation to noise and vibration:

- ***Construction noise and vibration – including:***

  Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protection Authority (EPA) guidelines. The assessment must detail construction and vibration impacts on nearby sensitive receivers and structures, considers noise intrusion, and outline the proposed management and mitigation measures that would be implemented.

This noise and vibration assessment is detailed within the following sections.

1.1.3 Site Description

The subject site is located at 6 Namona Street, North Narrabeen and falls within the local government area of Northern Beaches Council. The Narrabeen Education Precinct has a total area of 9.84 hectares.

Narrabeen North Primary School (NNPS) is located on the northern side of Namona Street, North Narrabeen and is legally described as Lot 3 Deposited Plan (DP) 1018621. NNPS is surrounded by residential dwellings to the east, grassed sporting fields (Warriewood Valley Sportsground) to the north and Northern Beaches Indoor Sports Centre to the west.

NNPS contains two (2) Binishell domes (Block A and Block B) which are identified as a local heritage item under the *Pittwater Local Environmental Plan 2014*. The two (2) Binishell Domes are listed as State significant on DoE's Section 170 Heritage and Conservation Register. The Double Binishell Dome (Block B) is listed on the State Heritage Register (SHR).

Narrabeen Sports High School is located to the south of Namona Street.

Figure 1: Site Aerial Map, Source: Nearmap

1.1.4 Noise and Vibration Assessment Scope

The scope of the noise and vibration assessment is limited to noise impacts associated with the upgrade and additions noted above to include:

- Construction noise and vibration associated with:
    - Removal of trees;
    - New accessible pedestrian pathways;
    - New substation on Namona Street frontage along with associated conduit connections;
    - New fire hydrant booster and associated conduit connections; and
    - New landscaping

2 Surrounding Land Uses

2.1 Subject Site

The existing NNPS site is located within a suburban environment in Narrabeen, characterised by medium levels of activity throughout the day / evening and low noise levels in the night. The existing site is zoned as SP2 (educational establishment).

The following land-uses surround the project site:

- R2 - Low density residential.
- SP2 – Community facility.
- RU2 - Rural Landscape.
- B2 – Local Centre.
- RE1 – Public Recreation.
- SP2 – Infrastructure (Classified Road).
- B6 – Enterprise Corridor.
- C4 – Environmental Living (residential).

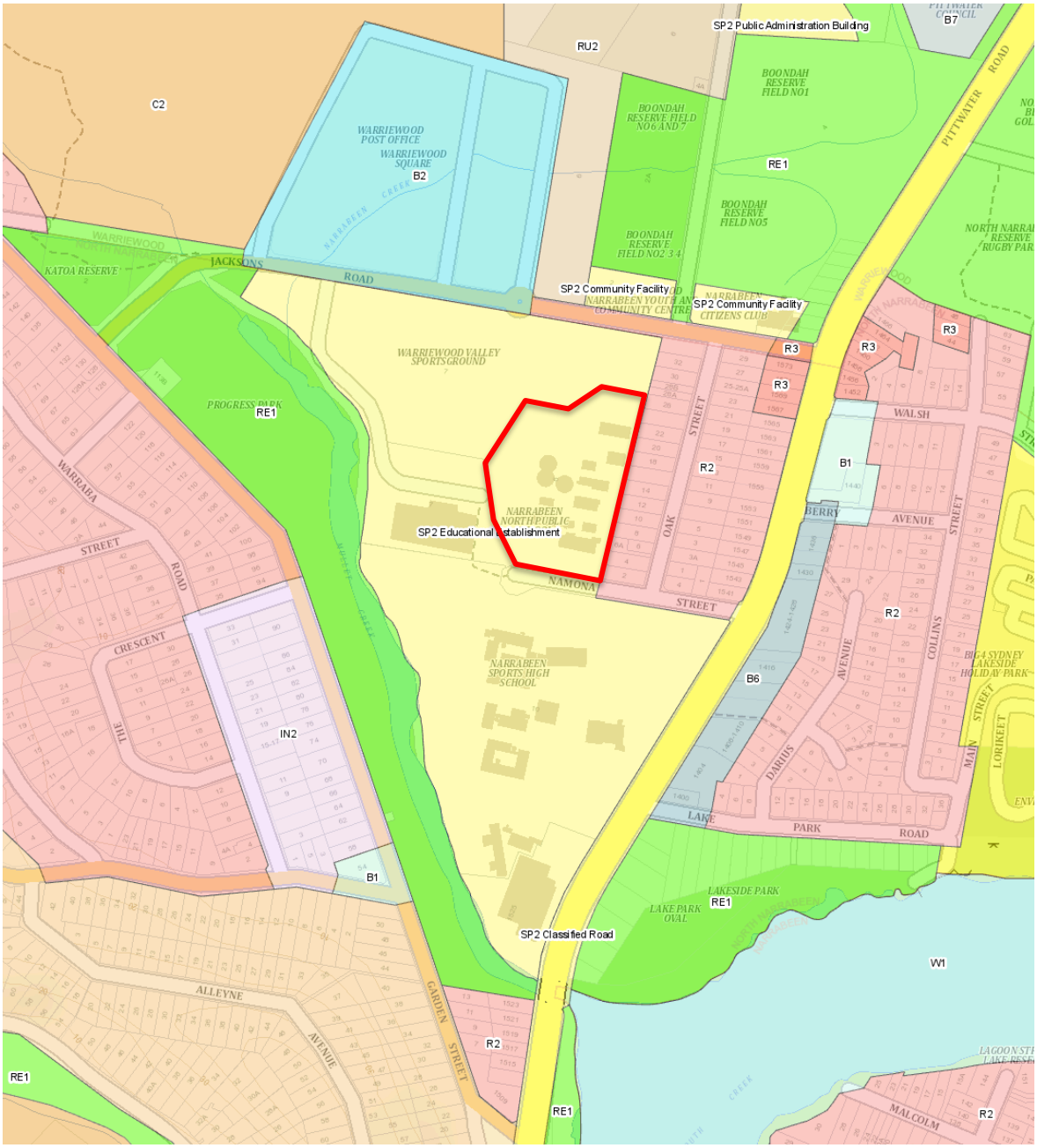


Figure 2: NNPS Site(s) (red outline) and surrounding land uses

The following noise sensitive receivers surround the existing the project boundaries:

- Residential receivers
    - Residential dwellings to the north east of the site at the shared border, along Oak Street (considered reasonably most-affected for both school sites)
    - Residential dwellings to the east of the site, beyond Pittwater Rd
    - Residential dwellings to the west of the project site, along Garden St
    - Residential dwellings to the south west of the site
- Commercial Receivers
    - Businesses to the north of the site at Warriewood Square, across Jacksons Road
    - Pittwater Sports centre, top the south of the site at 1525 Pittwater Road
    - Northern Beaches Indoor Sports Centre to the west of the site, at Jacksons Rd.
    - Ted Blackwood Youth and Community Centre to the North of the site, across Jacksons Road
    - Businesses to the east of the site, across Pittwater road
- Industrial receivers
    - To the west of the site, along Garden St
- Active Recreation
    - Warriewood Valley Sports Ground, to the north west of the site
- Passive Recreation
    - Progress Park to the west of the site

Figure 3 presents the project site in context of the surrounding land uses, and displays long-term noise monitoring locations plus off-site, short term monitoring locations.

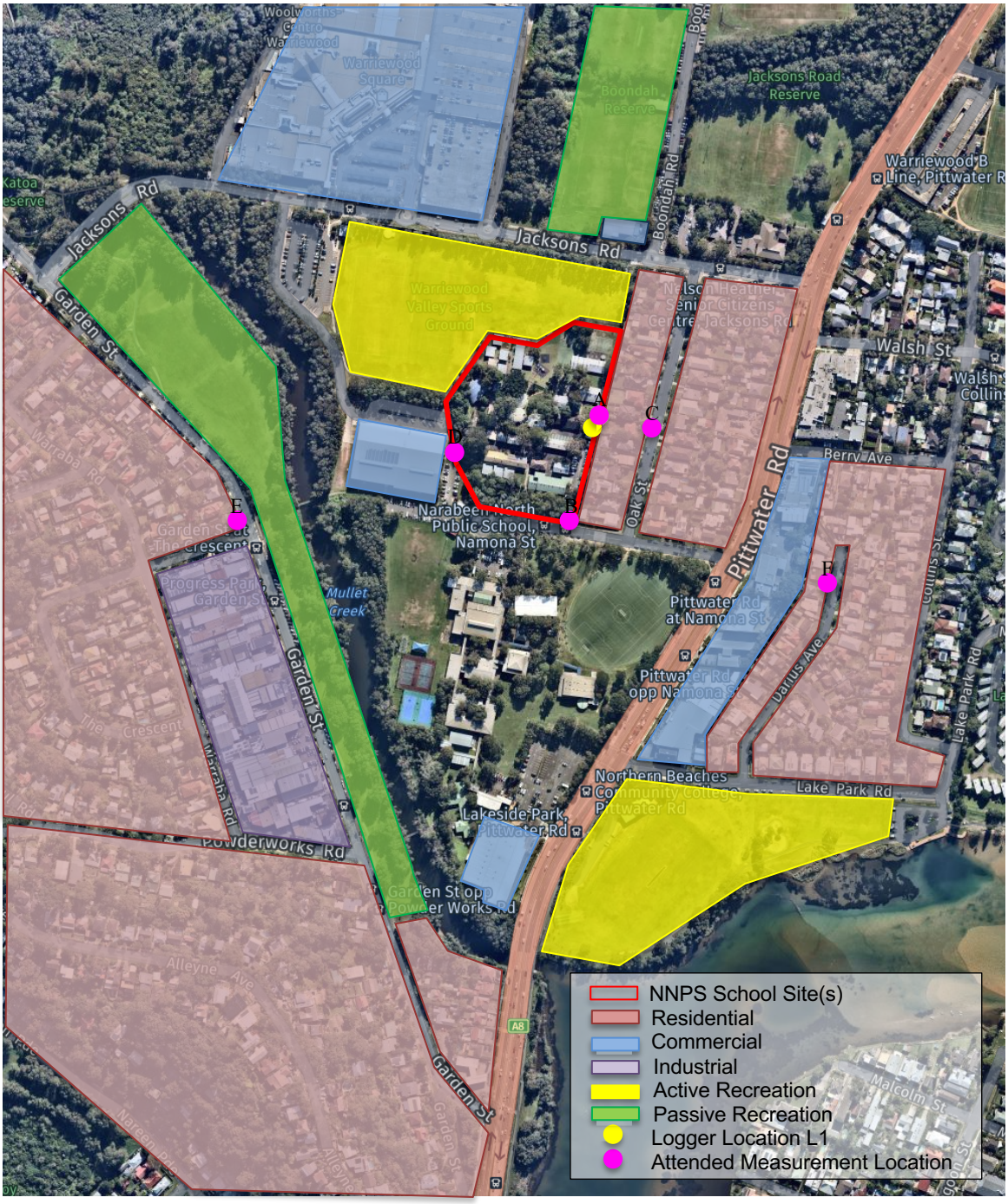


Figure 3: Site Aerial View showing Narrabeen Education Precinct School Site in relation to noise-sensitive receivers, and locations of long- and short-term noise monitoring. Source: Nearmap.

3 Existing Noise Environment

3.1 General Survey Information

A survey of the existing noise environment at and around the site was conducted through unattended noise monitoring to continuously record the noise levels on the site.
Unattended long-term noise monitoring was carried out for the following periods:

- Period 1 – Friday 8th April to Friday 15th April 2022 (during school holidays)
- Period 2 – Tuesday 26th April to Monday 2nd May 2022 (during school term)

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

- Logger 1 (All periods): Ngara (Serial Number 878190).

The noise loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the measurement period. The calibration of the loggers was checked before and after use and no variations were noted.
Operator attended, short-term monitoring was also carried out as follows:

- Monday 2nd May 2022.

The short-term monitoring was conducted in order to supplement the long-term outdoor data across the site and at key surrounding receivers, and to obtain spectral noise data for traffic noise at the proposed site. These short-term measurements included measurements at the property boundaries of the closest residential properties, which were used to confirm that the long-term monitoring is representative of the background and ambient noise levels at the nearest noise sensitive receivers.

Attended short-term measurements were made with a Brüel & Kjær Hand-held Analyser Type 2250 (Serial Number 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 microphones of the logger and analyser. Weather conditions were wet and windy during the first period, and generally calm and dry during the attended noise surveys. The captured data which was affected by weather was excluded and not used for the analysis in the following sections.

Isaac Bradbury of Acoustic Studio Pty Ltd carried out the surveys.

3.2 Noise Monitoring Locations

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

- Location L1 – on the eastern border of the NNPS site, at the nearest, reasonably most-affected residential receiver

The unattended long-term noise monitoring location is shown in Figure 3.
The detailed results of the unattended long-term noise monitoring at the logger location is shown in Appendix A.

This location was chosen as it:

- Was a secure place to leave the noise loggers unattended, and
- Was judged to provide representative of background and ambient noise levels at the reasonably most-affected noise sensitive receivers (both adjacent to the schools and across Garden St / Pittwater Road). This was confirmed with comparison against attended measurements at Garden Street and Darius Avenue.

3.3 Unattended Long-term Monitoring Results

3.3.1 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 noise targets for noise emitted from the construction and operation of the new building.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The Rating Background Noise Level (RBL) provides a single figure that represents the background noise level over the entire monitoring period for assessment purposes. 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 Noise Policy for Industry (NPI), i.e. the 10th 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.

Logging Period	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
Period 1	41	43	36	56	55	48
Period 2	42	40	32	55	49	47

Table 1: Long-term background and ambient noise levels

Based on our observations during the site inspections, both ambient and background noise levels around the Project Site are generally dominated by local and distant traffic noise plus general suburban hum around the site.

3.4 Short-term Monitoring Results

Six (6) short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location A –** Logger location (NNPS Residential boundary).
- **Location B –** NNPS Carpark Entrance.
- **Location C –** 14 Oak Street.
- **Location D –** Western boundary of NNPS, near Northern Beaches Indoor Sports Centre.
- **Location E** – Corner Garden Street and The Crescent.
- **Location F** – 23 Darius Avenue.

A summary of the measured values of the short-term background and ambient noise monitoring around the existing site is provided in Table 2.
The attended measurements were taken for a period which accurately captured the noise environment / profile which was being measured (between 2-15 minutes).

Location	Time (May 2nd, 2022)	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
A	Between 1:30-2pm	L_{eq}	55	58	54	47	44	46	51	50	45	35
		L_{90}	50	54	48	41	39	42	45	44	40	30
	Between 2-2:30pm	L_{eq}	46	56	53	44	40	40	41	38	38	31
		L_{90}	41	54	47	39	37	37	38	35	31	25
B	Between 1:30-2pm	L_{eq}	53	57	56	51	43	43	47	47	47	41
		L_{90}	49	54	51	43	39	40	45	43	38	29
C	Between 1:30-2pm	L_{eq}	55	59	59	52	48	49	51	48	42	36
		L_{90}	46	55	53	46	40	40	43	39	31	22
	Between 1:30-2pm	L_{eq}	57	61	60	52	50	50	53	51	43	35
		L_{90}	43	55	52	45	39	38	40	36	29	21
D	Between 2-2:30pm	L_{eq}	46	60	60	51	40	40	41	38	38	31
		L_{90}	42	57	54	45	36	37	37	33	28	21
E	Between 2-2:30pm	L_{eq}	69	67	69	64	64	64	67	61	53	47
		L_{90}	55	60	59	54	51	49	52	48	40	31
F	Between 2-2:30pm	L_{eq}	46	58	54	48	42	43	41	38	37	33
		L_{90}	41	53	48	42	37	36	37	32	24	19

Table 2: Summary of short-term traffic, background and ambient noise levels

4 The Key Acoustic Considerations

The following acoustic considerations are to be addressed as part of the assessment:

Construction Noise and Vibration - The impact of noise and vibration generated during the construction stages of the Project on surrounding noise and vibration sensitive premises.

- The development will contribute to an increase in noise and vibration to the surrounding environment during construction. Typically, this will result from a combination of intermittent and continuous noise from construction and excavation equipment, construction traffic and plant commonly used on construction sites.
- Design noise and vibration targets have been set for the Project and construction noise impacts have been anticipated from standard construction procedures.
- The noise and vibration targets and expected impacts are reported in Section 4 and Section 6 of this report. Where the noise and vibration impacts are predicted to be above the NMLs, then all reasonable and feasible noise and vibration mitigation measures must be considered as detailed in Section 6.5.

The engaged Contractor would be required to prepare a Construction Environmental Management Plant (CEMP) based on their proposed plant, equipment and construction methodology, prior to the commencement of any works.

The CEMP is to provide the following:

- A quantitative construction noise and vibration assessment, which includes:
    - Identifying noise and vibration sensitive receivers potentially affected by the proposed works.
    - Reference the appropriate construction noise and vibration criteria outlined in Section 1.1 of this report.
    - Identifying noise and vibration sources associated with the proposed works.
    - Providing an assessment of noise and vibration generated by the proposed works against the relevant management levels.
    - Determining the likely need for noise and vibration mitigation and management measures.
- A control strategy for construction noise and vibration mitigation to best minimise potential impacts through implementation of reasonable and feasible measures.
- Noise and vibration monitoring as required, using monitors equipped with alert/notification systems to ensure works are carried out in accordance with the applicable Guidelines and Standards.

5 Project Noise and Vibration Targets

5.1 Relevant Standards and Guidelines

The following acoustic standards and guidelines have been considered in establishing noise and vibration criteria and assessment for this project.

- Pittwater Local Environmental Plan (LEP) 2014.
- Pittwater 21 Development Control Plan (DCP).
- NSW EPA Noise Policy for Industry (NSW NPI) 2017.
- NSW EPA Road Noise Policy (RNP) 2011.
- NSW Department of Environment and Climate Change (DECC) "Interim Construction Noise Guideline" (ICNG) 2009.
- NSW Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline" (AVTG) 2006.
- NSW Department of Planning "Development Near Rail Corridors and Busy Roads – Interim Guideline" 2008.
- NSW Protection of the Environmental Operations (POEO) Act 1997.
- Australian Standard "AS 2436 : Guide to Noise and Vibration Control on Construction, Demolition & Maintenance Sites" 2010.
- Australian Standard "AS 1055 : Acoustics – Description and Measurement of Environment Noise" 1997.
- State Environmental Planning Policy (Transport and Infrastructure), 2021 ('SEPP')

5.2 Construction Noise and Vibration

5.2.1 Noise Management Levels

The relevant guideline applied for the assessment of construction noise is the ICNG. This guideline provides construction NMLs for Residential, Commercial and Industrial noise receivers as follows.

Residential Receivers

Section 4 of the ICNG provides recommendations for standard hours of work and suggests construction NMLs that aim to minimise the likelihood of annoyance caused to noise sensitive receivers. These consider both airborne and ground borne noise level impacts. Table 3 outlines the methodology for determining construction NMLs 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 + 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: Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

Table 3: Residential construction Noise Management Levels for airborne noise as outlined in the ICNG

The project-specific construction Noise Management Levels are shown in Table 4 based on the measured background noise levels at the site (in Section 3).

Location	Period		Rating Background Level RBL, dB(A)	Noise Management Level (External) $L_{eq\ (15\ min)}$ dB(A)
Residential	Recommended Standard Hours	Monday to Friday 7am to 6pm	41	RBL + 10 = 51
		Saturday 8am to 1pm	41	RBL + 10 = 51

Table 4: Project Specific residential construction Noise Management Levels for airborne noise

Non-Residential Receivers:

The ICNG also provides recommended construction NMLs for relevant non-residential receivers surrounding the construction site, which are as follows:

Occupancy	Management level $L_{eq\ (15\ min)}$ dB(A)
Commercial	75 dB(A) - External / 65 dB(A) - internal[1]
Active Recreation	65 dB(A)
Passive Recreation	60 dB(A)
Existing Classrooms	55 dB(A) – External / 45 dB(A) - Internal

Table 5: Non-residential Noise Management Levels for airborne noise

[1] Minimum 10 dB loss from a façade with windows sufficiently open for natural ventilation.

5.2.2 Vibration Criteria

Construction vibration is to be assessed in terms of:

- Human comfort
- Disruption to sensitive equipment
- Structural damage

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

Human Comfort

The DEC AVTG 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 targets for critical areas in hospital and educational buildings, and provides recommendations for measurement and evaluation techniques. 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.

Examples of these vibration types are provided in Table 6 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, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Table 6: Examples of vibration types

The relevant criteria for human exposure to continuous and impulsive vibration are detailed in Table 7. 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.

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

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 8 sets out the acceptable VDV values for intermittent vibration.

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

Sensitive Equipment

Areas with sensitive equipment are likely to require a higher degree of vibration isolation than the values in Table 7 & Table 8.

Vibration Criterion (VC) curves are used to provide the basis for the design and protection of highly vibration sensitive equipment. Table 9 details the VC curves applicable to a range of highly sensitive equipment that is to 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 9: VC Curves for Highly Sensitive Equipment

Figure 4 shows the relationship between criteria for highly sensitive equipment and human exposure criteria shown in Table 7.

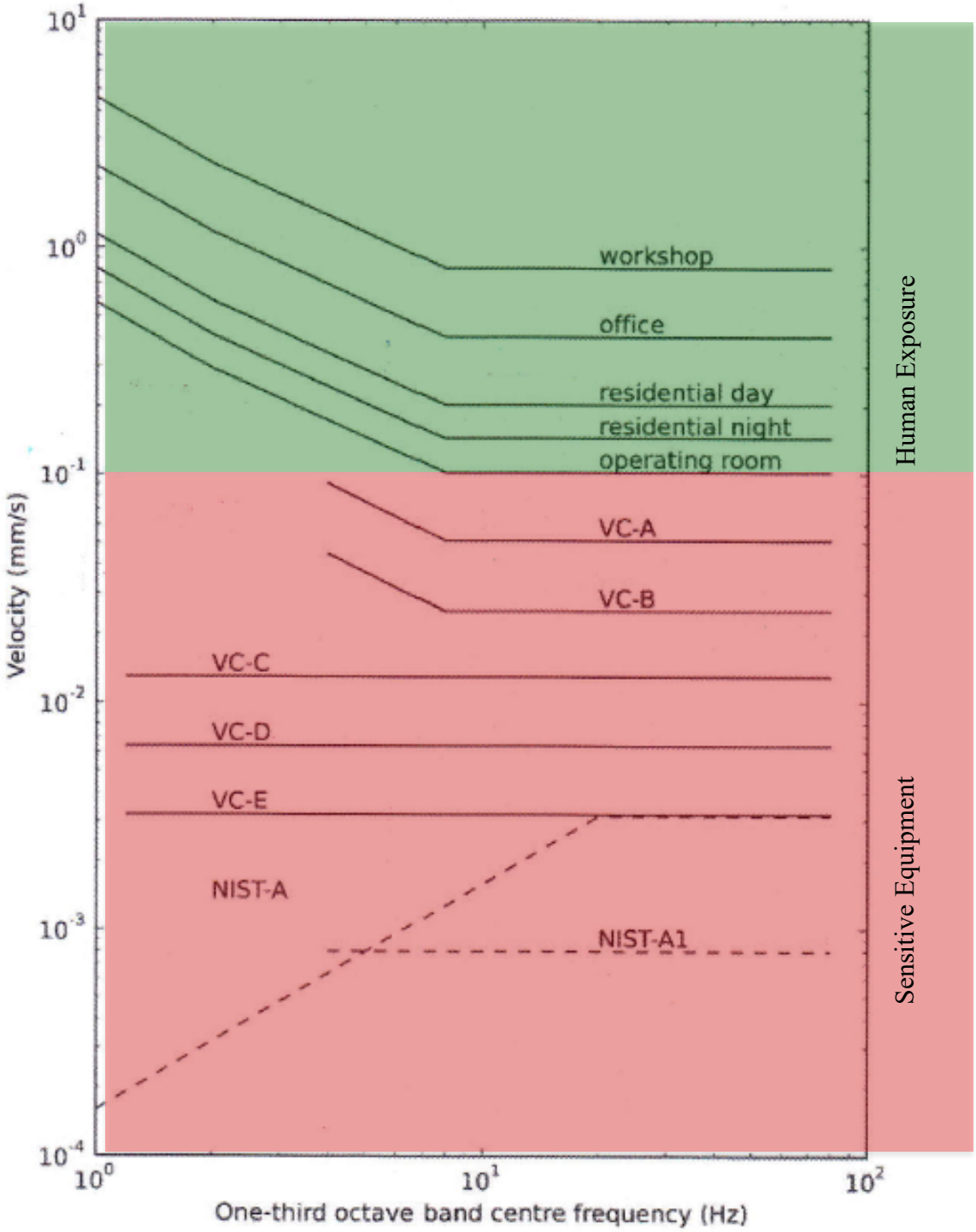


Figure 4: VC Curves - Source: ANC Guidelines – Measurement and Assessment of Ground-borne Noise & Vibration, Association of Noise Consultants (2012)

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

Structural Damage

Vibration-induced damage of buildings and structures is a common concern, but it is actually rare in practice. This explains why there is limited reliable data on the threshold of vibration-induced damage in buildings and there is no directly relevant Australian Standard. There are guidelines available in a number of international standards, although these vary significantly. Criteria to prevent building damage and disruption to equipment and processes are discussed in Appendix B.

Recommendations

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 vibration management levels are:

- 3 mm/s (130 dB re 10^{-6} mm/s) for buildings surrounding the Project identified as "sensitive". 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, and commercial premises.

These vibration management levels apply across the full frequency range of relevance (i.e. typically 1 Hz – 100Hz encountered in building construction).

6 Construction Noise and Vibration Assessment

6.1 Proposed Hours

Proposed construction hours for the Project are during Standard Construction Hours outlined in the ICNG as follows:

- Monday to Friday - 7:00am to 6:00pm
- Saturday - 8:00am to 1:00pm
- Sunday and Public Holidays – No works.

Note that the duration for each stage would be confirmed by the Contractor once appointed.

6.2 Description of Proposed Works

An indicative construction works program has been developed by the Project Manager that outlines the key activities in each particular location. Detailed construction works program will be finalised by the contractor.

It is anticipated that the key activities to occur for each area / stage are as follows.

6.2.1 NNPS

The works the subject of the Designated Development at NNPS comprise:

- Removal of eight (8) trees;
- New accessible pedestrian pathways;
- New substation on Namona Street frontage along with associated conduit connections;
- New fire hydrant booster and associated conduit connections;
- New hard and soft landscaping including planting of 12 new trees.

6.2.2 Key activities and equipment

Activity	Key Equipment
Site Establishment	Truck, Forklift Hiab (mobile crane) truck Front end / Wheeled loader Generator, diesel
Concreting (Paths/substructure)	Truck, Forklift Hiab (mobile crane) truck Mobile crane Generator, diesel Electric Hand Tools Cement Mixer Concrete Vibrator Concrete pump
External works / landscaping	Electric Hand Tools Mulcher Bobcat / Forklift Chainsaw Skidsteer loader (½ tonne)
Demobilisation	Truck, Forklift Electric Hand Tools Front end / Wheeled loader Mobile crane

Table 10: Typical key construction activities and equipment for the NNPS DD

6.3 Construction Noise

The following sections outline the preliminary assessment carried out for construction noise emissions.

6.3.1 Noise Sources

The key noise sources for the activities occurring during construction works and the associated equipment sound power levels are listed in Table 11. These values are based on Acoustic Studio's database and the relevant Australian and International Standards including AS2436:2010 and BS5228-1:2009.

Noise Source / Plant	Sound Power Level, $L_{eq,T}$ dB(A)	Sound Pressure Level, $L_{eq,T}$ dB(A), at 10m
Dump Truck (tipping material)	117	89 (+5dB penalty – tonal reversing alarm)
Truck, Forklift *(vibration source)*	107	79 (+5dB penalty – tonal reversing alarm)
Tipper / Bin lift Truck	111	83 (+5dB penalty – tonal reversing alarm)
Hiab (mobile crane) truck	113	85 (+5dB penalty – tonal reversing alarm)
Bobcat / Forklift	110	82 (+5dB penalty – tonal reversing alarm)
Front end / Wheeled loader	111	83 (+5dB penalty – tonal reversing alarm)
Skidsteer loader (½ tonne) *(vibration source)*	104	76 (+5dB penalty – tonal reversing alarm)
Excavator with rock breaker *(vibration source)*	116	88 (+5dB penalty)
Excavator, 8T with bucket *(vibration source)*	105	77
Vibratory roller *(vibration source)*	108	80
Asphalt Paver *(vibration source)*	108	80
Asphalt Rotomill (scabbler)	111	83
Concrete Pump	110	82
Cement Mixer	109	81
Concrete Placing Boom	105	77
Concrete Vibrator	104	76
Jump Form	102	74
Generator, 4 stroke portable petrol	103	75
Generator, diesel	113	85
Air compressor	107	79
Compactor *(vibration source)*	113	85
Angle grinder	101	73
Concrete Saw, handheld	115	87 (+5dB penalty)
Demolition saw	119	91 (+5dB penalty)
Circular saw	112	84 (+5dB penalty)
Jack Hammer *(vibration source)*	121	93 (+5dB penalty)
Hammer / percussive drill *(vibration source)*	112	84 (+5dB penalty)
Mulcher	117	89
Electric drill	91	63
Electric hand tools	102	74
Welder	105	77
Tower crane	105	77
Mobile crane	106	78
Skip Fill	117	89
Bored Piling Rig	110	82
Scissor lift	98	70

Table 11: Typical mid-point sound power and pressure levels of plant typical to proposed construction. These sound level values do not include the 5 dB penalty noted for some types of work. The 5 dB penalty is added to the predicted sound level at the receiver.

Vibration and ground-borne noise impacts are likely to be highest if jackhammers or other vibratory tools are used.

Where practical, the contractor should aim to implement alternative low noise and vibration methods.

6.3.2 Sensitive receivers

Nearest sensitive receivers to the Project Site that will be potentially affected by noise and vibration are surrounding residential, industrial, commercial and recreation areas as presented in Section 2, as well as existing on-site classrooms.

Table 12 outlines the most critical receivers surrounding the sites for each type of impact.

Receiver	Impact	Location	Typical Worst-Case Distance from construction site (m)
Residential	Airborne + Vibration	North / North East	80m
Commercial	Airborne	West and South	30m
Existing Classrooms	Airborne	North West	20m

Table 12: Noise sensitive receivers and approximate distance to project construction works site for NNPS

6.3.3 Construction Noise Assessment 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 Section 6.2.
- Project specific Noise Management Levels at each sensitive receiver location as outlined in Section 5.2.1.
- Noise level predictions are calculated using the noise data provided in Table 11. Where multiple plant types exist (such as trucks) typical worst-case levels are applied.
- Noise level predictions consider:
    - Distance attenuation (nearest position on site to receiver)
    - Shielding
    - Ground and building reflections
- The noise level predictions are based on assumptions that represent the worst-case scenario.
- L_{Aeq} noise levels are predicted for the operations of the nearest works area on the site to each of the nearest sensitive receiver location.
- Predictions consider the typical worst-case distances in Table 12.
- The predictions consider individual tasks and associated equipment from the nearest construction site boundary.

- The predictions assume continuous operation of equipment / plant over the 15-minute assessment period to provide a worst-case assessment, unless otherwise stated.

6.3.4 Assessment Results

Construction Noise

Table 13 presents the results for the construction noise assessment at surrounding receivers based on typical plant and equipment outlined in Section 6.3.1 operating within the boundary of the construction works site.

The following predictions assume:

- Activity source sound power level assumes noise at any individual receiver is dominated by the noisiest item of equipment at any one time.
- Outside to inside attenuation of classrooms is assumed to be 10 dB (with windows open). A further reduction of 10dB can be assumed for windows closed.
- Standard daytime hours of work

Activity	Activity Source Level (SWL)	Receiver	NML (dBA)	Predicted Noise Levels (dBA)	Exceedance (dBA)	Comments
Site Establishment	113	East Residential	51	67	16	Primary contributors to predicted exceedance are generator, crane and loaders Use petrol generator rather than diesel. Plan truck access routes and times to minimise impacts.
	113	Commercial - NBISC	75	75	0	
	113	Existing Classrooms	55	79	24	
Concreting (Paths/substructure)	113	East Residential	51	67	16	Primary contributors to predicted exceedance are crane truck, diesel generator and concrete pump. Implement localised hoarding around concrete pump and truck loading bays which will reduce noise by up to 10 dB(A).
	113	Commercial - NBISC	75	75	0	
	113	Existing Classrooms	55	79	24	
External works / landscaping	117	East Residential	51	71	20	Primary contributors to predicted exceedance are Mulcher Implement localised hoarding around Mulcher.
	117	Commercial - NBISC	75	79	n/a	
	117	Existing Classrooms	55	83	28	
Demobilisation	111	East Residential	51	65	14	Primary contributors to predicted exceedance are front end loader and trucks
	111	Commercial - NBISC	75	73	n/a	
	111	Existing Classrooms	55	77	22	

Table 13: Predicted equipment/plant noise levels at the nearest surrounding community receiver locations for work at NNPS – Levels predicted to exceed the NMLs are in red

Construction Noise Mitigation

The following will be implemented where reasonable and feasible as best practice, particularly where NMLs are exceeded.:

- **Construction Noise and Vibration Management Plan (CNVMP)** - The engaged Contractor shall prepare a comprehensive CNVMP based on their proposed plant, equipment and construction methodology, including noise mitigation measures that can be reasonably and feasibly implemented prior to the commencement of any works.
- Specify noise controls applicable to each construction activity as outlined in Table 13.
- **Noise barriers or screening** via local hoarding around the worksite is recommended for all external works. This can reduce noise levels by 5 to 10 dB. When works are moving around the site, including mobile cranes, jackhammers, and concrete saws, local "noise curtains" such as EchoBarrier or Flexshield will assist with reducing noise near the source.
- **Scheduling**
    - Noisy activities to less sensitive times of the day for each nominated receiver (i.e. daytime hours).
    - Including Respite Periods where activities are found to exceed the 75 dB(A) Highly Affected Noise Level at receivers, such as 3 hours on and 1 hour off.
- **Noise and vibration monitoring** to verify noise predictions and confirm actual noise impact (Section 6.6)
- **Alternative construction methodology and equipment -** Adopt quieter methodologies. For example:
    - use concrete sawing and removal of sections as opposed to jackhammering.
    - If generators are required for the site set-up, petrol generators or biodiesel / solar hybrid generators should be used instead of conventional diesel.
    - Electric tools are to be selected instead of petrol or pneumatic tools where possible.
- **Communication and complaints management** (see Section 6.6.3)
- Further noise and vibration controls are discussed in detail in the following sections.

6.3.5 Construction Traffic Noise

As identified throughout Section 8, noise from construction-related works at the site is expected to be a primary contributor to noise impacts on nearby noise-sensitive receivers.

Construction-related general road traffic is a temporary noise source but one which requires assessment and management, particularly for heavy vehicles accessing the site.

Truck arrivals to, and departures from, site should be scheduled to occur outside the busiest traffic periods, but where possible should also avoid noise-sensitive time periods.

Separately from the noise impacts quantified in Section 8, potential noise impacts from general construction traffic needs to be considered.

The temporary additional traffic increase due to construction will be minimal, totalling far less than 50% additional vehicles to the existing traffic. The increases in road traffic due to construction will result in below the 2 dB increase considered to be noticeable from the RNP.

However, it is also important to recognise that heavy vehicles associated with construction can generate maximum noise levels which are higher than general car traffic, and can lead to greater disturbance than cars.

Access routes should be limited to main roads and avoid local residential streets. Engine braking should be avoided, speed limits strictly observed, and heavy braking and accelerating avoided.

These noise avoidance driver behaviours may need to be enforced through observation and monitoring, and all contractors and subcontractors are to be made aware of the need for noise-considerate driver behaviour when travelling to and from the work site.

Noise from construction traffic should be dealt with by appropriate management measures that minimise noise impact. This includes:

- Staging and managing arrival of trucks to avoid queueing and idling on public streets;
- Arriving at and departing from the site via designated routes that avoid or minimise the use of local roads;
- Minimising reversing to minimise the use of movement alarms (“reversing beepers”) and / or incorporating quacker alarms;
- Minimise the use of engine braking and to avoid noise actions such as slamming doors, loud radios, shouting or the use of truck horns for signalling.

Minimising construction traffic noise will be further addressed in the Construction Traffic Management Plan.

6.3.6 Summary of Noise Assessment Findings and Discussion of Noise Controls During Construction

Based on the results from the high-level assessment based on the indicative works, we make the following comments:

- Construction works noise impacts will be greatest at residential receivers adjacent to the school to the east. Noise from various plant and equipment operating individually are generally predicted to be above the NMLs due to the proximity to the nearest affected receivers but generally within the "Highly Noise Affected" noise levels. The worst-case noise impacts are for excavators with hammers with noise levels predicted to be above the NMLs by up to 28 dB (to classrooms with windows open, and 18 dB with windows closed).
- Where NMLs are exceeded, mitigation measures to be considered and incorporated where reasonable and feasible would include:
    - Schedule noisy activities to less sensitive times of the day for each nominated receiver (i.e. daytime hours).
    - Hoarding that may already be included as part of the site works can reduce noise levels by 5 to 10 dB.
    - Including Respite Periods where activities are found to exceed the 75 dB(A) Highly Affected Noise Level at receivers, such as 3 hours on and 1 hour off.
    - The predictions for noise levels above NMLs is not unusual given the heavy plant and equipment that must be used, such as excavators and hammers, and the proximity to on campus sensitive receivers (some of which are within 20m).
    - Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when NMLs cannot be met due to safety or space constraints.

It is important to recognise that the actual noise levels generated during the construction works are likely to vary considerably depending on many factors including:

- Number of items of plant and equipment operating simultaneously.
- Location of equipment on the site – relative to the noise-sensitive receivers.
- Shielding of noise provided by structures and hoardings on and around the site.
- Reflections provided by existing structures on and around the site.
- Meteorological conditions.

When construction and excavation works are likely to exceed stated criteria at nearest sensitive receivers, particularly when works occur in the areas closer to the nominated receiver, all feasible and reasonable noise control measures are to be considered.
If, during construction works, an item of equipment exceeds either the NML at any location or the maximum recommended equipment noise levels, the following noise control measures, together with construction best practices presented in Section 6.5 shall be considered to minimise the noise impacts on the neighbourhood:

- Consider implementing equipment-specific temporary screening for noisy equipment, or other noise control measures recommended in Appendix E of AS2436. This is most likely to apply to noisier items such as jackhammers.
- For large work areas, solid screening or hoarding as part of the worksite perimeters would be beneficial.
- Locate specific activities such as carpentry areas (use of circular saws etc) to internal spaces or where shielding is provided by existing structures or temporary screening.
- Managing the arrival of trucks and heavy vehicles on site at any given time (through scheduling deliveries at different times).
- Unnecessary idling of vehicles and equipment is to be avoided.
- Traffic routes are to be prepared to minimise the noise impact on the community (such as entry and exit point at different locations on the site and access via separate roads where practical).
- When loading and unloading trucks, adopt best practice noise management strategies to avoid materials being dropped from a height.
- Adopt quieter methodologies. For example, where possible, use concrete sawing and removal of sections as opposed to jackhammering.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc), not specifically identified in this assessment, incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when Noise Management Levels cannot be met due to safety or space constraints.
It is recommended that a comprehensive CEMP is prepared further to this assessment. The engaged Contractor would be required to prepare a comprehensive CEMP based on their proposed plant, equipment and construction methodology, prior to the commencement of any works.

6.4 Construction Vibration

When considering the vibration impact associated with construction works, the following is to be taken into account.

- The type of vibration generating equipment.
- Geotechnical characteristics of the site.
- The layout of the site, including the location of static sources of vibration.
- Techniques used in construction to minimise generated vibration levels.
- Hours of work with regard to the nature of operations in the affected buildings and the duration of the works.

6.4.1 Summary of Vibration Assessment and Discussion of Vibration Controls During Construction

A detailed vibration assessment has not been carried out at this stage, as actual vibration levels experienced will be dependent upon:

- Site and strata characteristics
- Specific construction equipment used
- Vibration requirements of sensitive equipment
- Activities that have the potential to generate ground-borne vibration during the construction works include:
    - Excavator hammer
    - Vibratory roller
    - Jackhammer
    - Piling
- Based on the scope of works and typical equipment required, there is a low potential for human perception vibration impacts on nearby NNPS and NSHS buildings and there is requirement to review works processes during detailed works planning to ensure that minor cosmetic impacts to structures are avoided. The significance of these impacts will need to be determined as part of the CEMP prepared by the Contractor.

Final details of the vibration management controls required for the works would be determined when the CEMP is prepared by the Contractor.

On campus buildings present the most stringent vibration criteria, particularly given their proximity to the Project Site. Controlling vibration at these receivers will also ensure that vibration criteria at all other receivers will also be satisfied.

The Contractor would be required to prepare a final CEMP based on their proposed plant, equipment and construction methodology.

6.5 Control elements

6.5.1 Noise

As a general rule, prevention is to 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 mitigation/minimisation. Providing treatments at the affected residences or other sensitive land uses is to be only 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 tonal reversing alarms or provide for alternative systems (such as broadband reversing alarms).
    - 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.
    - Brief Project staff and workers on the noise sensitivity of the neighbours to the site, particularly the residents nearby. The staff and workers need to be mindful of the noise from their discussions and colour of the language, particularly in sensitive periods, for example, during the pre-start times or "toolbox talk" as they gather to commence for work in the morning.
- 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.

6.5.2 Vibration

At this stage, we anticipate that the potential for construction works to result in structural and human perception vibration impacts is low.

Vibration management controls required for the works would be determined when the CEMP is prepared by the Contractor.

All practical means are to 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 excavation and construction equipment used.
- Modifications to methods of excavation and 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 is to be undertaken and the vibration management strategy amended.

6.5.3 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 are to be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

6.5.4 Additional Noise and Vibration Control Measures

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.
If, during construction, an item of equipment exceeds either the NML at any location or the maximum recommended equipment noise levels, the following noise control measures, together with construction best practices presented in Section 6.5.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Modifications to construction equipment used:
    - Avoid the use of large excavators – use the smallest size practicable;
    - Avoid the use of vibratory rollers – switch off vibration mode, or use the smallest size practicable if vibration must be employed;
    - Avoid the use of tracked vehicles on site, where practicable, particularly large tracked excavators and cranes – use vehicles with tyres.
- Modifications to methods of construction:

    - Saw cutting can be considered for rock removal rather than conventional rock hammering techniques to limit vibration when close to vibration sensitive locations.

- 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 other 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 assessment incorporates silencing/shielding equipment as required to meet the noise criteria.
- Minimise noise from workers as discussed in Section 6.5.1.

Implementation of all reasonable and feasible mitigation measures for all construction 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.

6.6 Noise and vibration monitoring

6.6.1 Noise monitoring

The Contractor is to consider implementing environmental noise monitoring at the reasonably most affected residential noise receivers from the construction works (adjacent to NNPS school at Oak Street).

6.6.2 Vibration monitoring

A vibration monitoring system is to be implemented if required. 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 VMLs appropriate action is to be taken.

6.6.3 Communication and complaints

The Contractor is to establish a communication 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 are to be specifically adopted for complaints relating to noise.

Upon receipt of a complaint the Contractor is to:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- 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 is to 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 is to then cease.
Any activity that is directed to cease due to excessive noise is not to recommence until the Project Manager is satisfied that the noise and vibration target requirements can be met and has given permission to recommence the activity.
The Site Supervisor is to ensure that a report of any incident is provided to the Project Manager.
The Contractor is to provide a 24-hour telephone contact number and this number is to be prominently displayed on the site.

6.7 Non-compliances

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

7 Discussion and Recommendations

A noise and vibration assessment report has been produced to determine potential proposed works under the Designated Development for Narrabeen North Public School (NNPS) as part of the Narrabeen Education Precinct 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:

Construction Noise

- Proposed construction hours are as follows:
    - Monday to Friday - 7:00am to 6:00pm
    - Saturday - 8:00am to 1:00pm
    - Sunday and Public Holidays – No works.
- Based on the results from the high-level assessment based on the indicative works, we make the following comments:
    - Construction works noise impacts will be greatest at existing classroom receivers adjacent to the construction sites. Noise from various plant and equipment operating individually are generally predicted to be above the NMLs due to the proximity to the nearest affected receivers but generally within the "Highly Noise Affected" noise levels. The worst-case noise impacts are for excavators with hammers with noise levels predicted to be above the NMLs by up to 28 dB (to classrooms with windows open, and 18 dB with windows closed).
- Where NMLs are exceeded, mitigation measures to be considered and incorporated where reasonable and feasible would include:
    - Schedule noisy activities to less sensitive times of the day for each nominated receiver (i.e. daytime hours).
    - Hoarding that may already be included as part of the site works can reduce noise levels by 5 to 10 dB.
    - Including Respite Periods where activities are found to exceed the 75 dB(A) Highly Affected Noise Level at receivers, such as 3 hours on and 1 hour off.
    - The predictions for noise levels above NMLs is not unusual given the heavy plant and equipment that must be used, and the proximity to on campus sensitive receivers (some of which are within 20m).
    - Implementation of all reasonable and feasible mitigation measures for all works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when NMLs cannot be met due to safety or space constraints.

Construction Vibration

- Based on the scope of works and typical equipment required, there is a low potential for human perception vibration impacts on nearby NNPS and NSHS buildings and there is requirement to review works processes during detailed works planning to ensure that minor cosmetic impacts to structures are avoided. The significance of these impacts will need to be determined as part of the CEMP prepared by the Contractor.
- The Contractor determine whether the existence of significant vibration levels justifies a more detailed investigation.

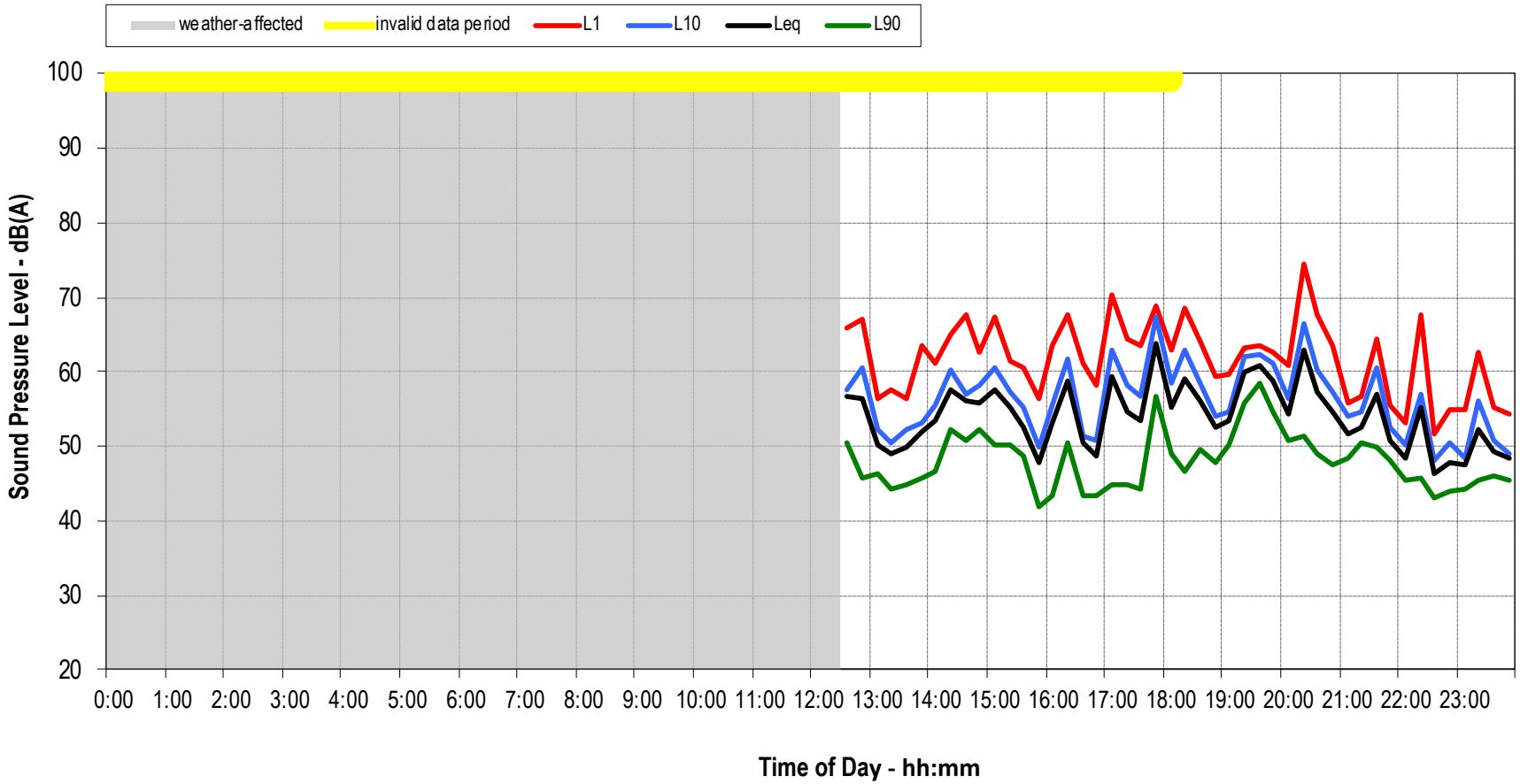
Construction Environmental Management Plan

- A CEMP shall be prepared further to this assessment by the engaged Contractor.

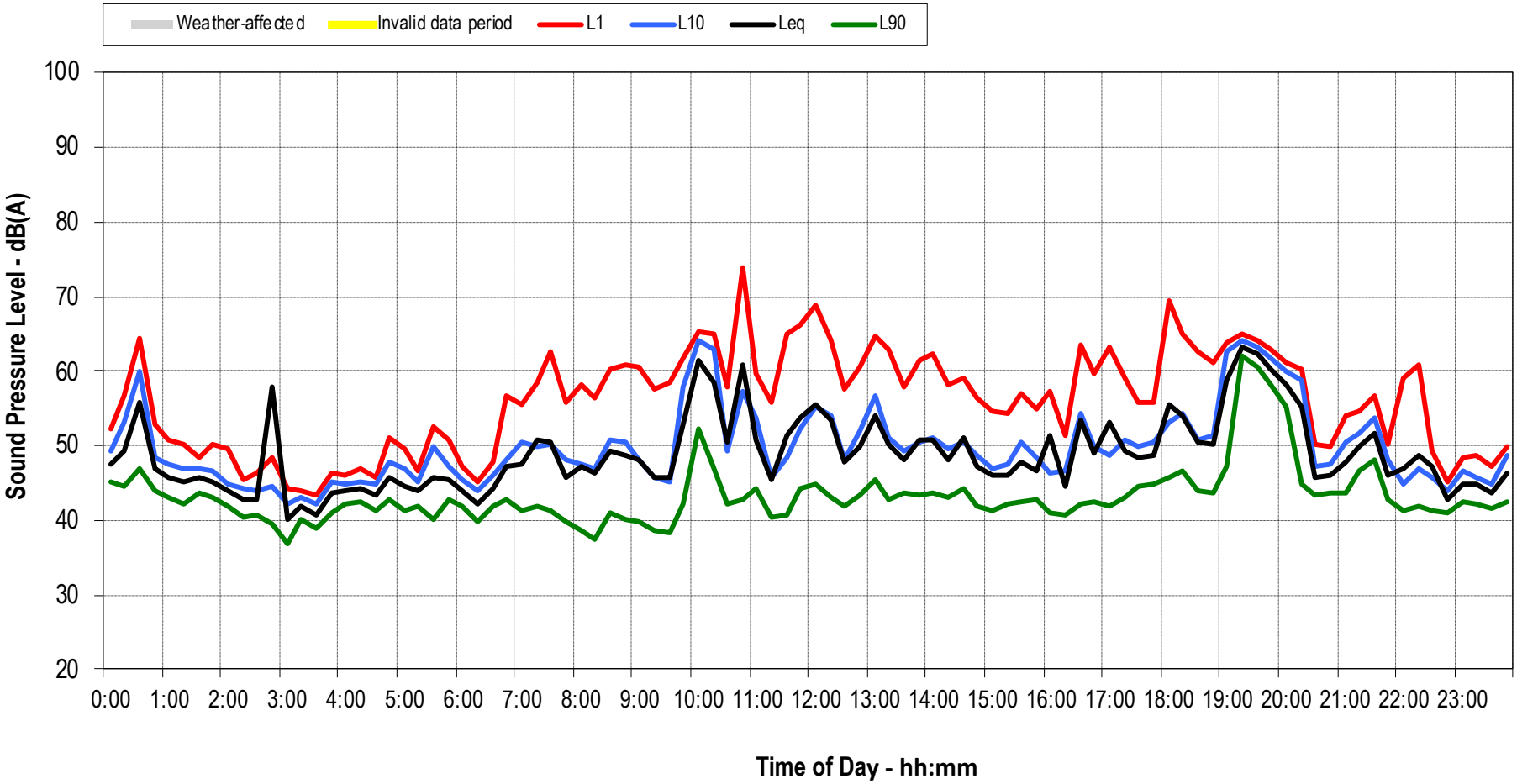
Appendix A – Ambient Noise Monitoring Data

Period 1

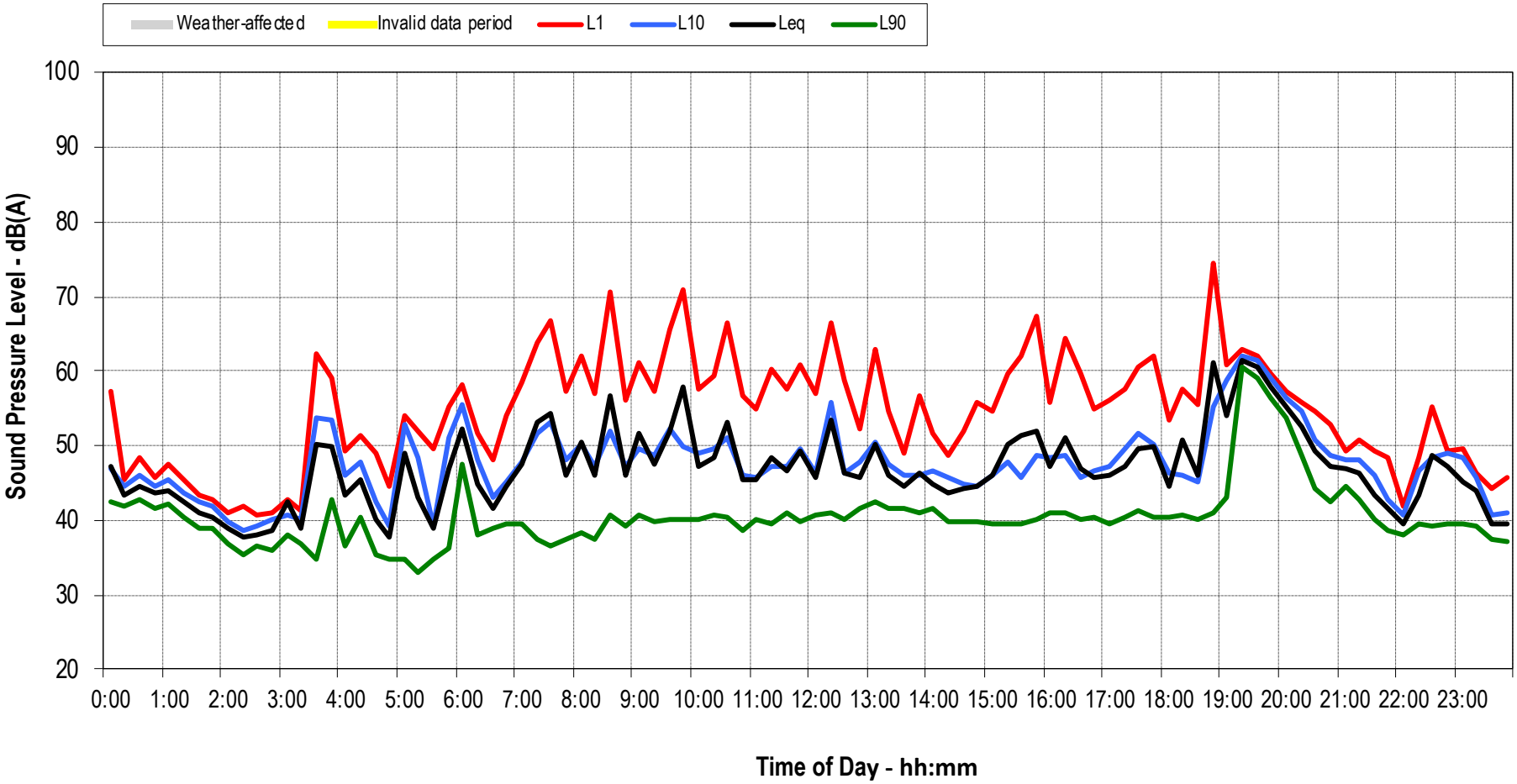
Narrabeen Education Precinct - Friday 08 April 2022



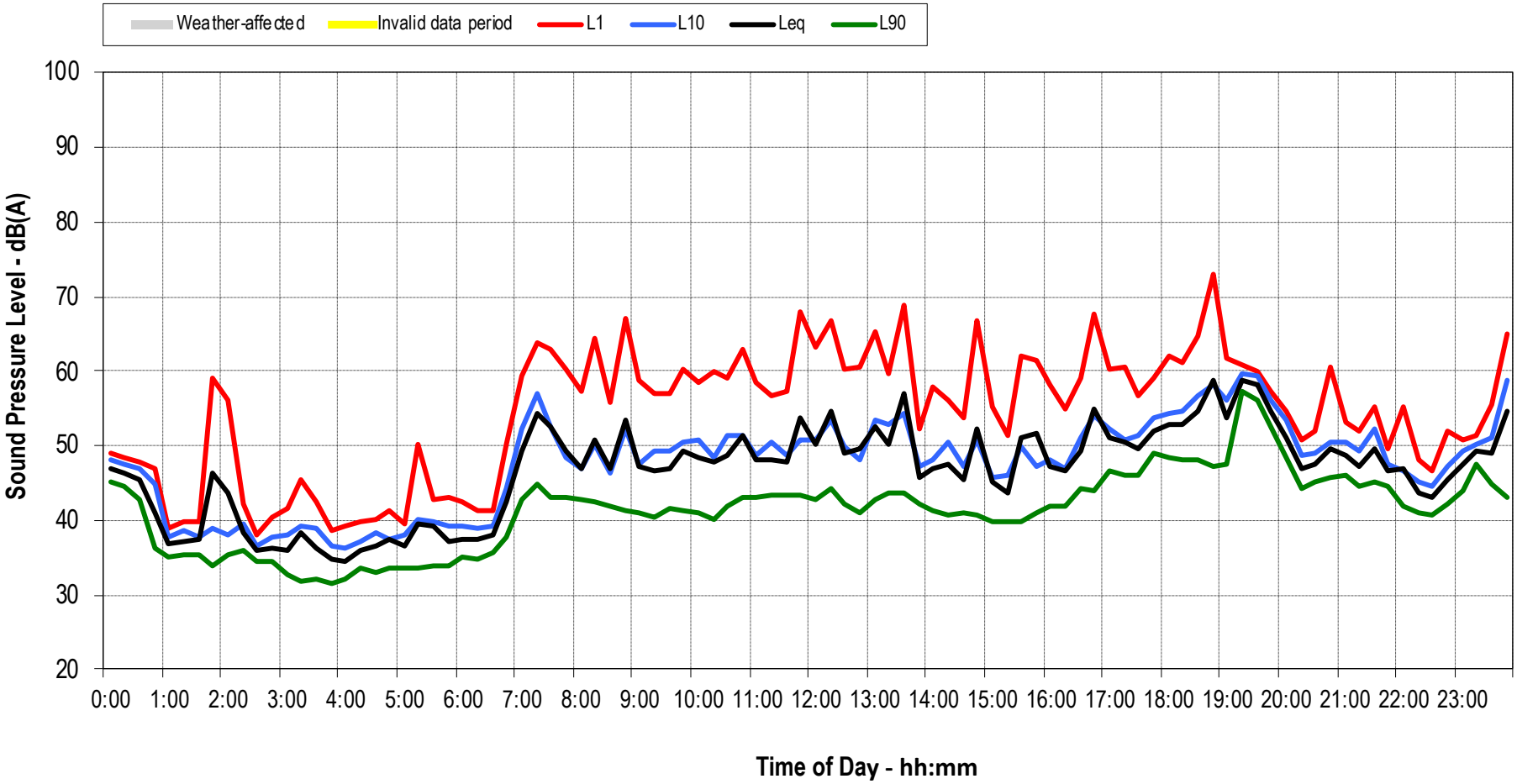
Narrabeen Education Precinct - Saturday 09 April 2022



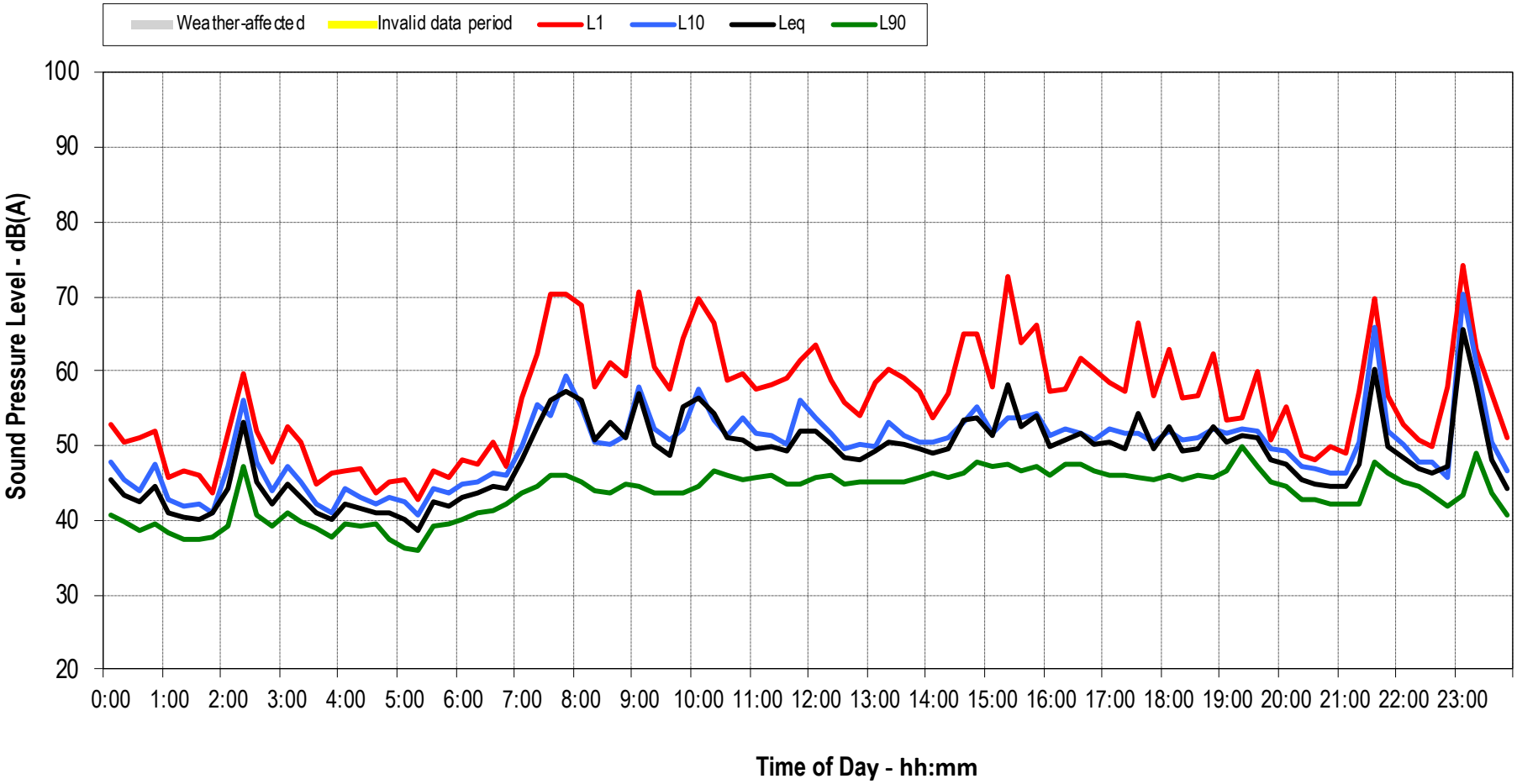
Narrabeen Education Precinct - Sunday 10 April 2022



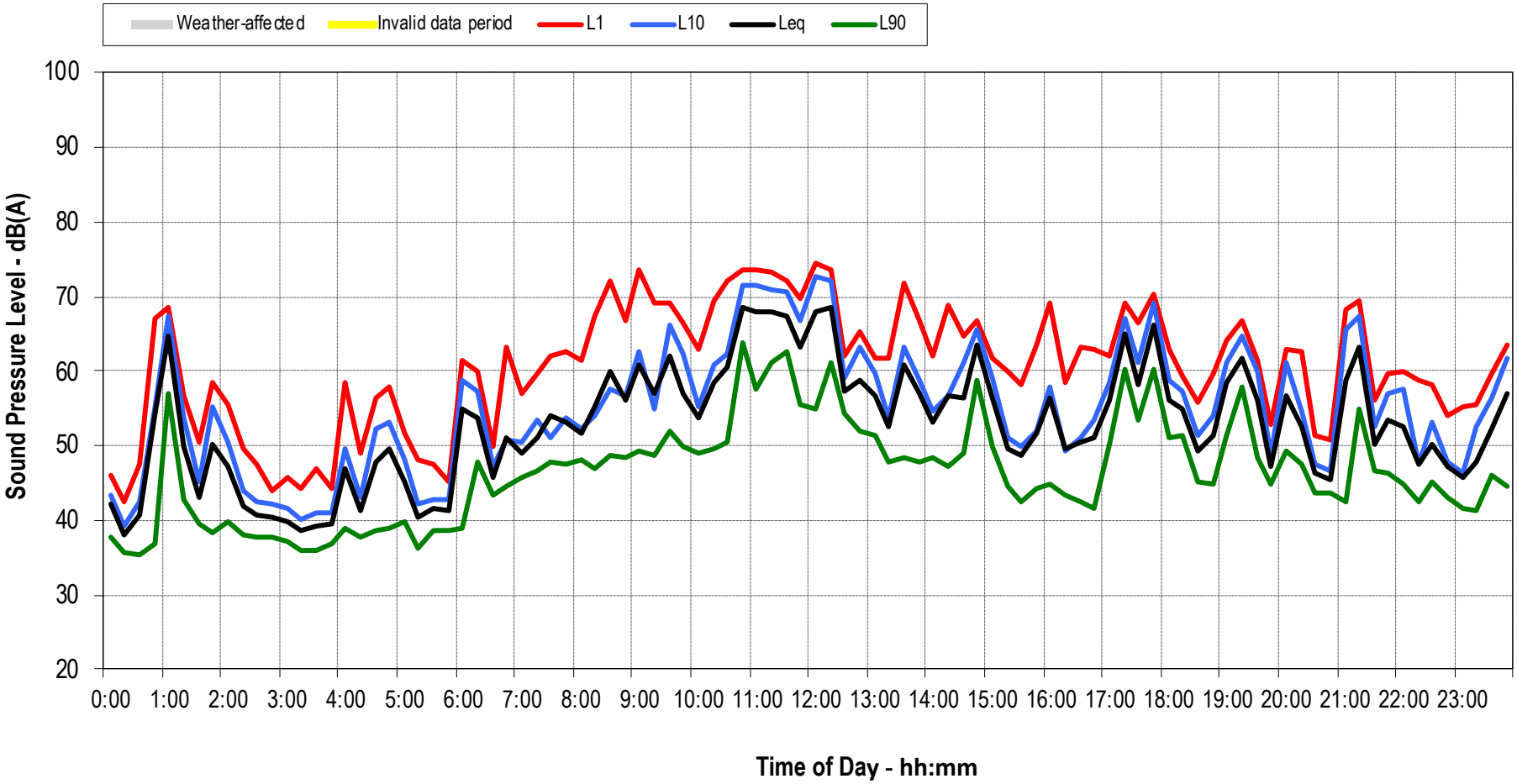
Narrabeen Education Precinct - Monday 11 April 2022



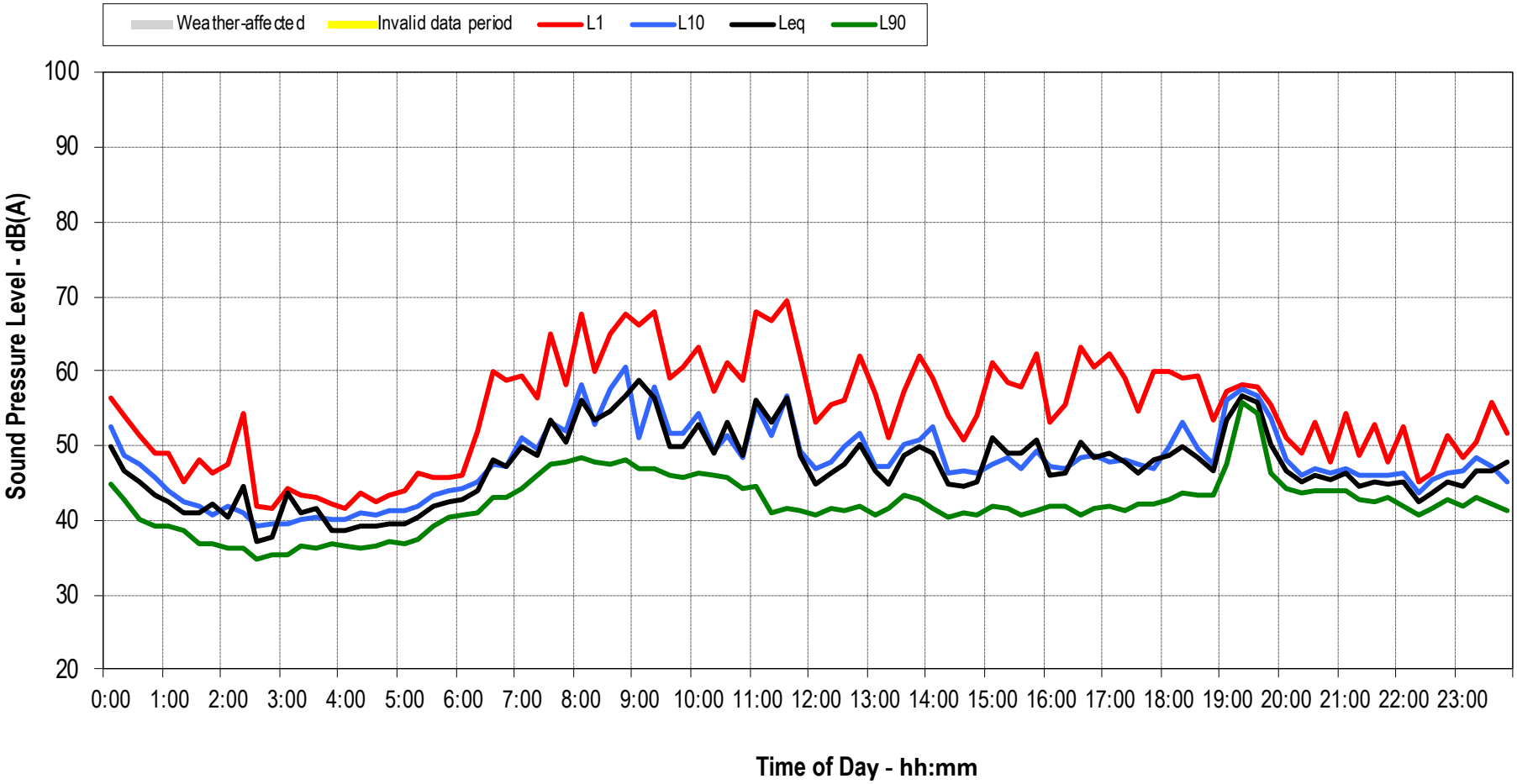
Narrabeen Education Precinct - Tuesday 12 April 2022



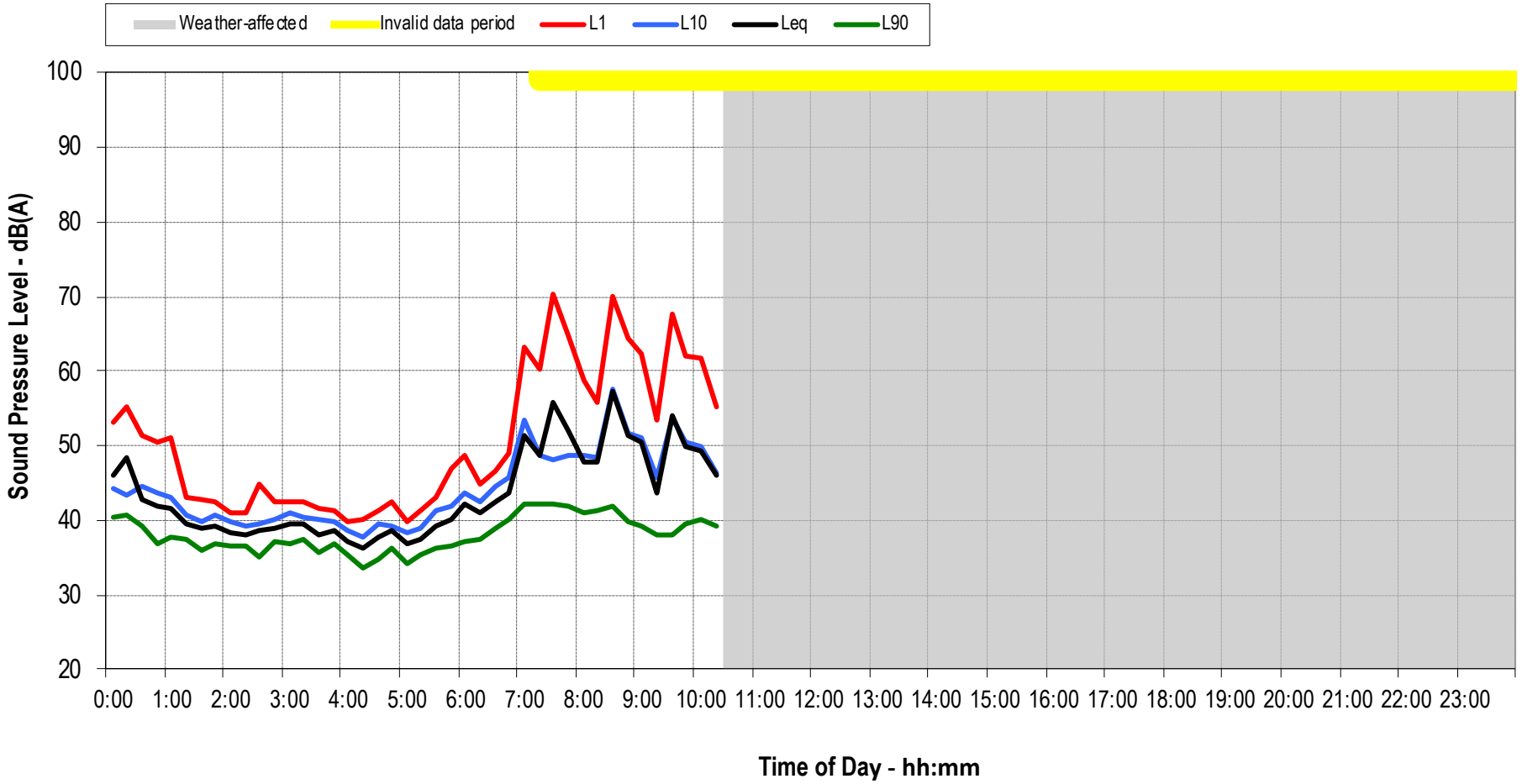
Narrabeen Education Precinct - Wednesday 13 April 2022



Narrabeen Education Precinct - Thursday 14 April 2022

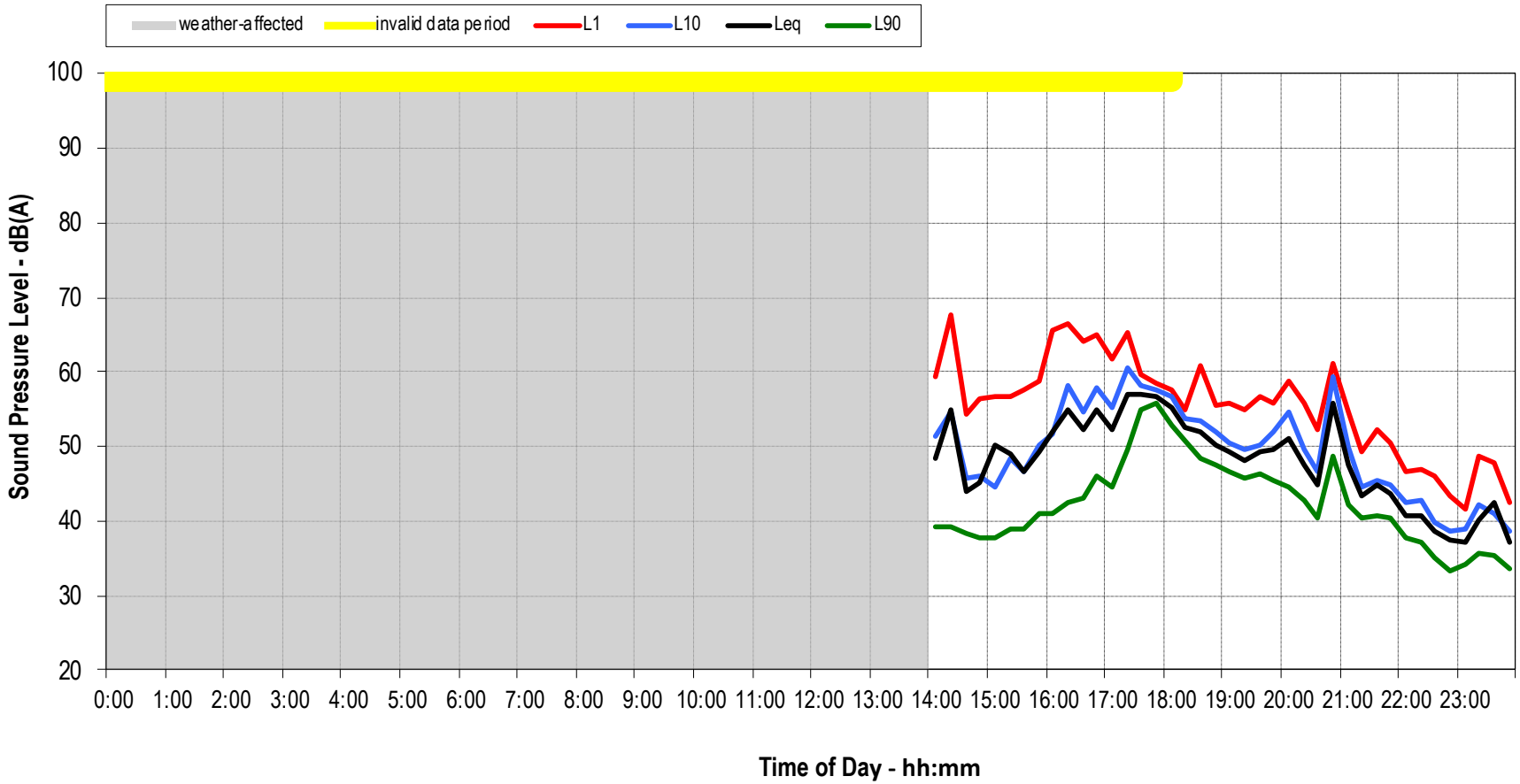


Narrabeen Education Precinct - Friday 15 April 2022

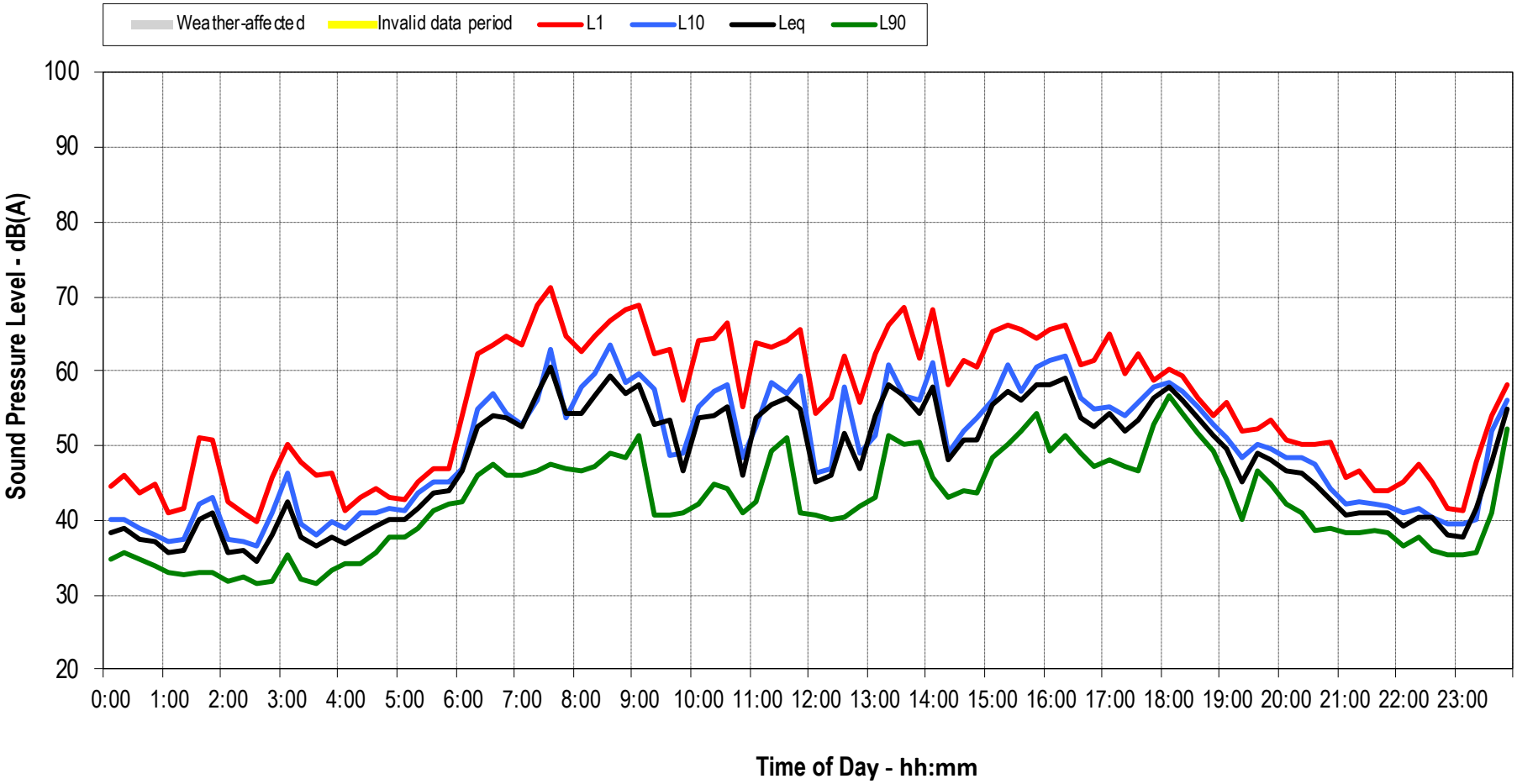


Period 2

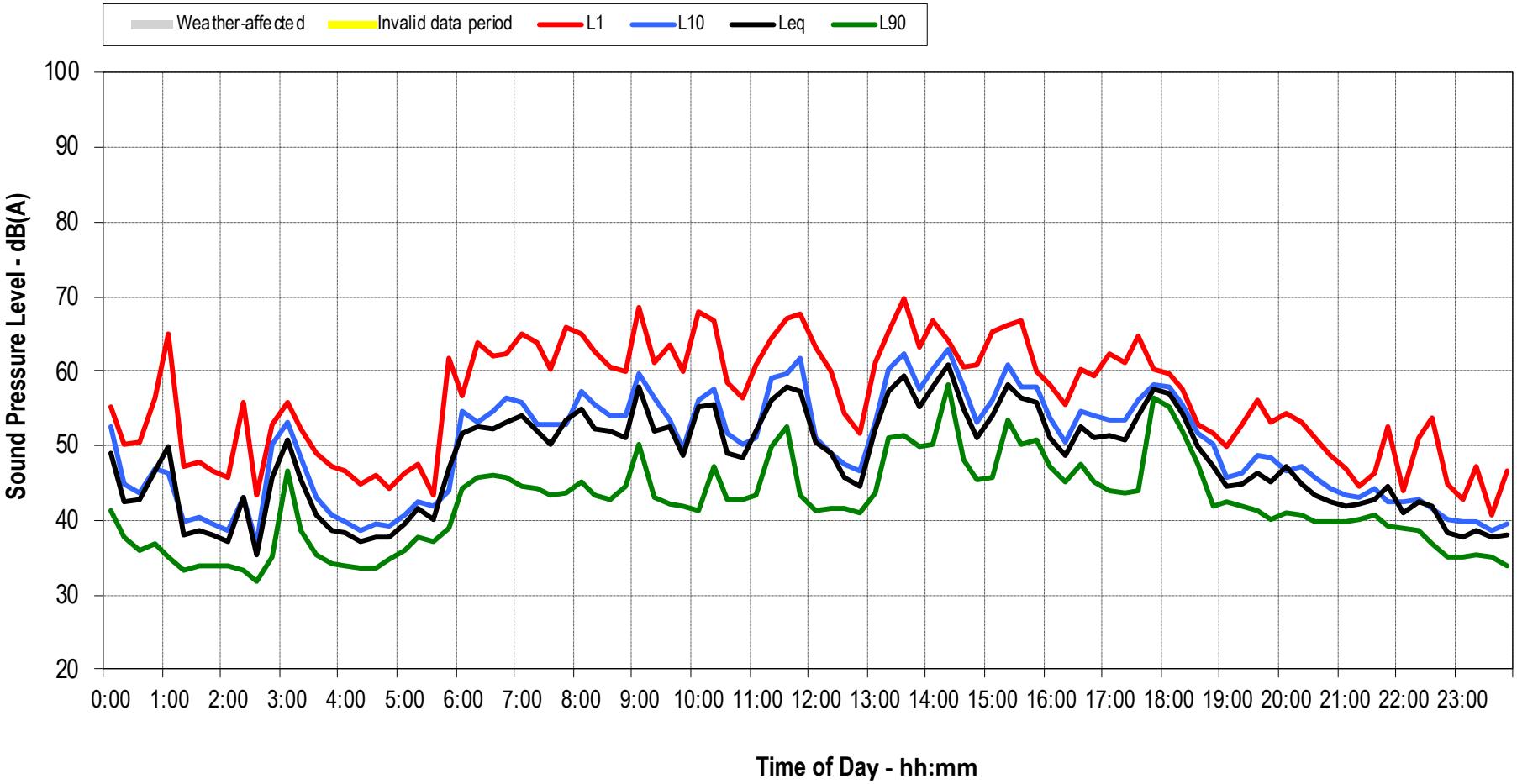
Narrabeen Public School - Tuesday 26 April 2022



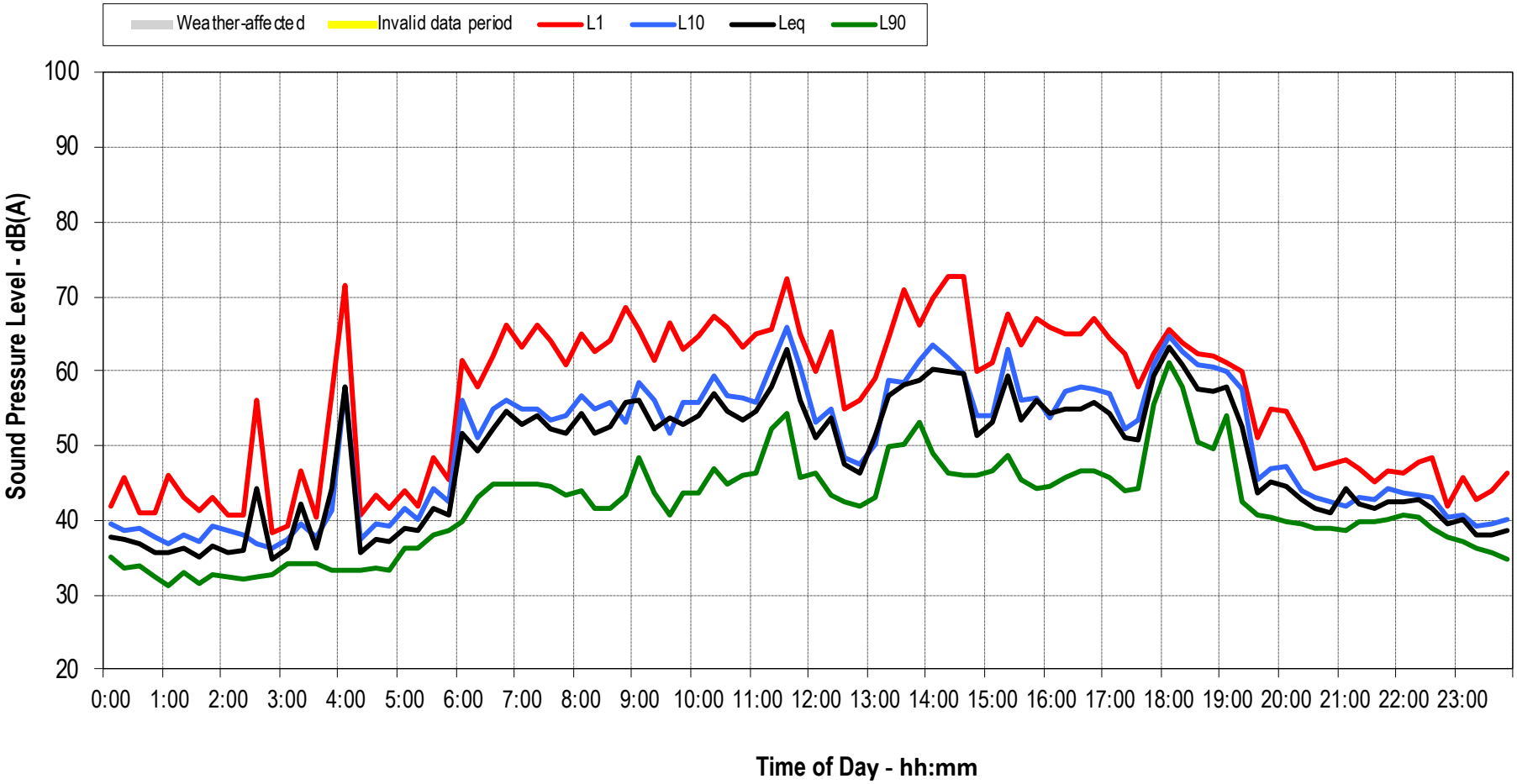
Narrabeen Public School - Wednesday 27 April 2022



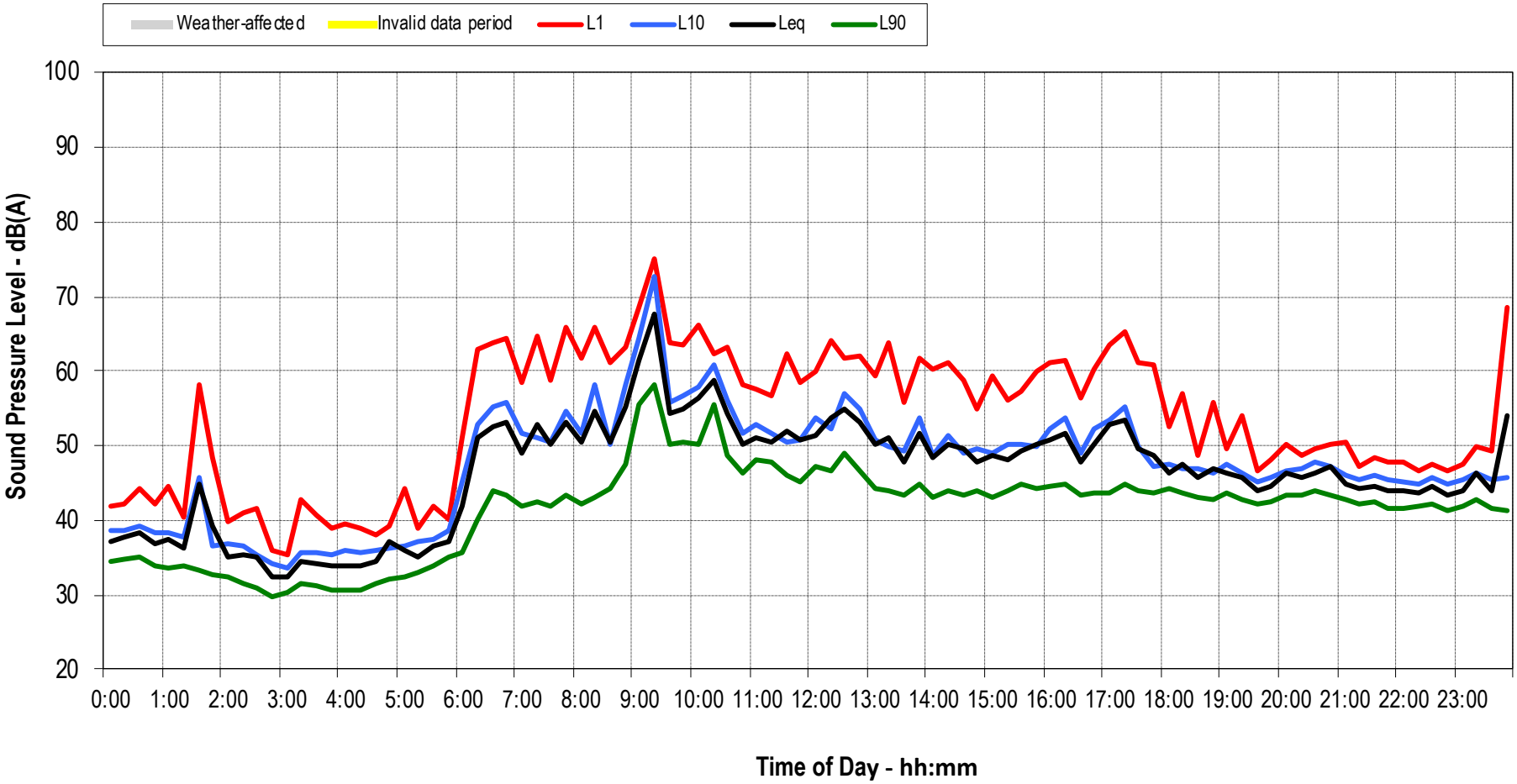
Narrabeen Public School - Thursday 28 April 2022



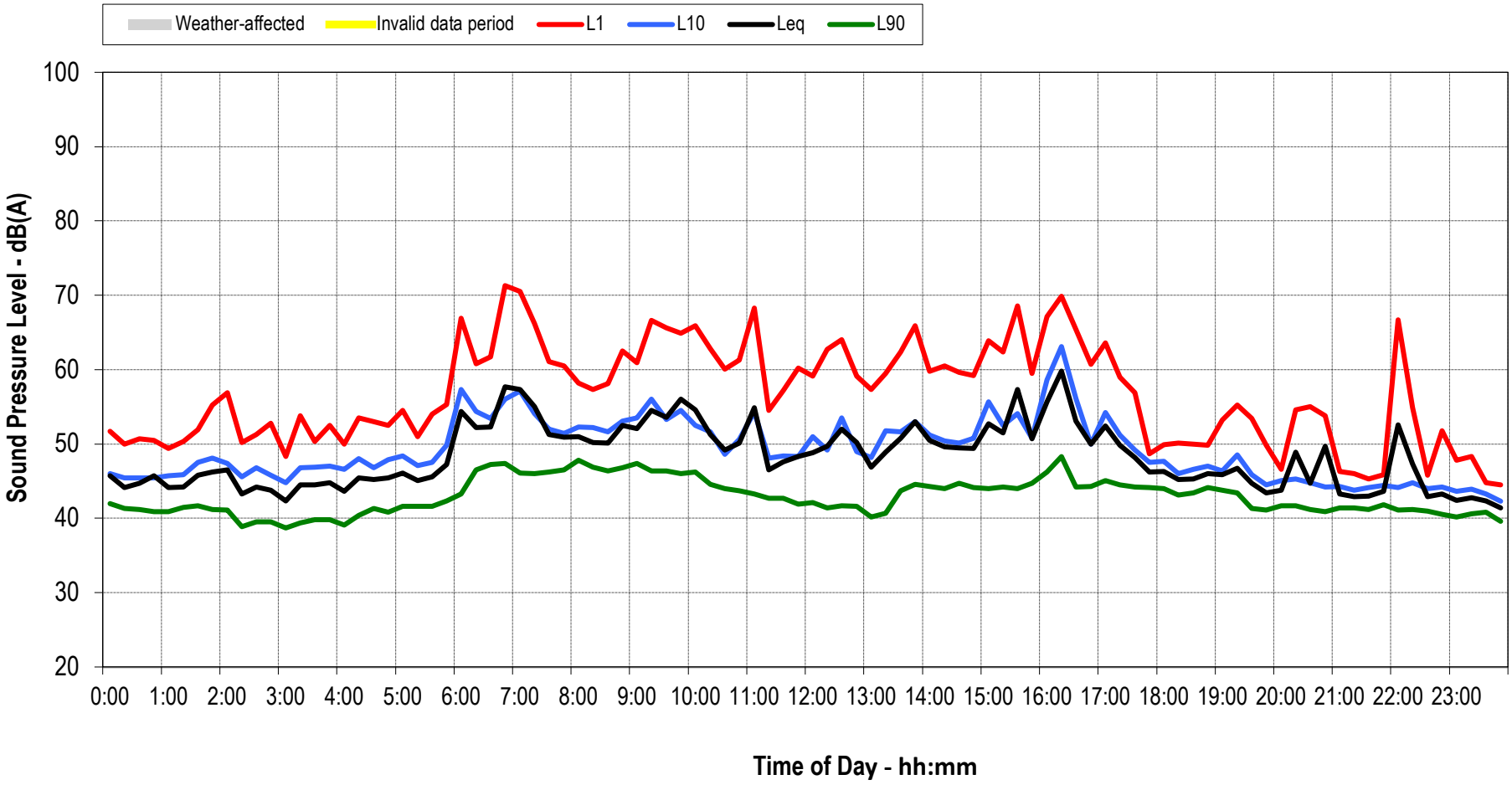
Narrabeen Public School - Friday 29 April 2022



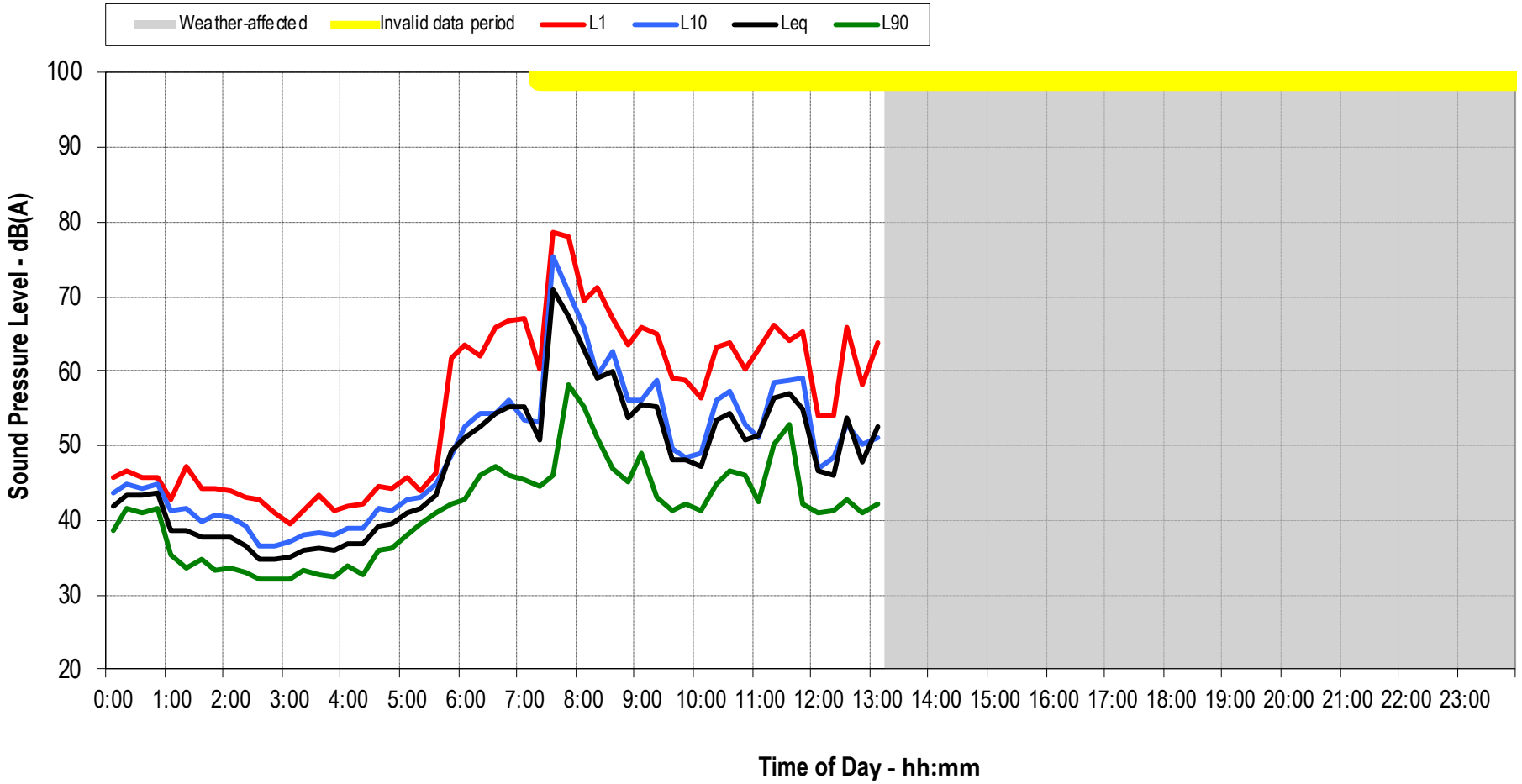
Narrabeen Public School - Saturday 30 April 2022



Narrabeen Public School - Sunday 01 May 2022



Narrabeen Public School - Monday 02 May 2022



Appendix B : 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[2]. 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 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

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

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[3], 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.

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