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Construction Noise & Vibration Management Plan

St Luke's Grammar School – New Senior Campus
800 Pittwater Rd & 224 Headland Rd, Dee Why, NSW

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1.0 EXECUTIVE SUMMARY

St Luke's Grammar School proposes to construct a new Senior Campus *(NSC)* at 800 Pittwater Road and 224 headland Road, Dee Why for 600 students.

The *NSC* is proposed to be situated on land zoned *B5 – Business Development* (800 Pittwater Road) and *IN1 – General Industrial* (224 Headland Road) under Warringah Local Environmental Plan (LEP) 2011.

The proposed *NSC* site is bounded by land zoned *RE1 – Public Recreation* (Stony Range Botanic Garden) to the north and north-east, industrial premises to the east, Headland Road and industrial premises to the south and south-west and Pittwater Road to the west. The nearest residential premises to the site are located on the opposite side of Stony Range Botanic Garden to the north-east, Headland Road to the south-west and the opposite side of Pittwater Road to the west and north-west, as shown on Figure 1 and Figure 2. The *NSC* will have no shared boundary with any residential lots.

The proposal seeks approval for the following:

800 Pittwater Road:

Village Centre: Welcoming the community into the building, cafe and heart of the building, natural daylight + green spaces and administration zone.

Gathering Spaces: Auditorium for 700+ students, library hubs and social + informal learning hubs.

Science and Maths Precinct: Speciality learning areas (Physics, Chemistry, Biology), general learning areas; connection to support units and seminar rooms.

Arts Precinct: Speciality learning areas (Visual Art, Kiln), general learning areas; connection to support units and seminar rooms.

Design + Technology Precinct: Speciality learning areas (Food technology, Design and technology), general learning areas; connection to support units and seminar rooms.

Humanities Precinct: General learning areas; connection to support units and seminar rooms.

Wellness Precinct: Pool with change facilities, dance studio, gymnasium and general learning areas; connection to support units.

Media Centre: Recording studio, editing studio, green screen and media presentation room.

External Areas: External hardcourts and open space.

Car Parking 91 spaced for staff, visitors or student and bicycle parking.

224 Headland Road:

Sports Precinct: 2 new basketball courts, existing half basketball court, existing change rooms and existing school clothing store.

Car Parking: 41 spaced for staff, visitors or student and bicycle parking.

The proposal above will take place over three stages, as follows:

Stage 1 – Overview –

Location 224 Headland Road –

- *Demolition of internal walls, stairs, mezzanine level, fittings and fixtures;*
- *Removal of existing car parking line marking and concrete planter boxes;*
- *Internal alterations and additions to construct two (2) full size basketball courts with dance/exercise floor;*
- *Installation of new lift at southern end of building to provide access to school uniform store;*
- *New external works including new concrete pavers footpath, new line marking for 41 car spaces including two (2) accessible spaces; and*
- *New landscaping.*

Stage 2 – Overview –

Location 800 Pittwater Road –

- *Demolition and removal of existing tenancy fitouts (I-MED and Fitness First) including demolition of existing Fitness First swimming pool;*
- *Demolition of part of the existing basement car parking along with northern car park access ramp;*
- *Reconfiguration of basement car park to provide a total of 73 spaces (including 2 accessible spaces);*
- *New internal fitout of northern portion of 800 Pittwater Road as Senior School campus for St Luke's Grammar School comprising: o Ground Floor (Level 1): School Entry, administration and staff offices, café; general learning areas, multi-purpose area, and new Wellness Precinct including 25 metre internal swimming pool along with male and female amenities and change rooms;*
  - *First Floor (Level 2): Humanities Precinct, library and Wellness Precinct;*
  - *Second Floor (Level 3): General learning areas, Visual Arts Precinct, and Design and Technology Precinct;*
  - *Third Floor (Level 4): Roof terrace;*
  - *Fourth Floor (Level 5): Access to 224 Headland Road;*

- *Construction of new vertical circulation (lift and stairs) between 800 Pittwater Road and 224 Headland Road;*
- *New roof to part of the building including sawtooth elements;*
- *New landscaping of northern portion of site including new sports court;*
- *New acoustic wall to Pittwater Road;*
- *Reconfiguration of southern on-grade car park to provide drop-off / pick-up area for students (equivalent to 7 spaces) along with 51 car parking spaces (including 1 accessible spaces);*
- *New electrical substation adjacent to southern boundary; and*
- *New access pathways from Pittwater Road and Harbord Road to Officeworks Entry.*

Stage 3 – Overview –

Location 800 Pittwater Road –

- *Demolition and removal of existing tenancy fitout within Units 2 and 4;*
- *Demolition and removal of temporary fitout within Stage 2;*
- *Reconfiguration of southern portion of basement parking including relocation of car park entry to southern side of building. There will be a total of 76 spaces (including 2 accessible spaces) located in the basement;*
- *Construction of new southern extension to building (four (4) storeys equivalent);*
- *Internal fitout of 800 Pittwater Road as Senior School campus for St Luke's Grammar School comprising:*
  - *Ground Floor (Level 1): Administration area and staff rooms, Auditorium, Chapel, Village Centre, Café, Theatre and Performing Arts Precinct, Wellness Precinct and staff and student amenities;*
  - *First Floor (Level 2): Library; Humanities Precinct; Media Centre; Wellness Precinct, Roof Terrace above curved 'former Canteen' and staff and student amenities;*
  - *Second Floor (Level 3): Visual Arts Precinct, Maths Precinct, Science Precinct, Design and Technology Precinct, Roof Terrace above southern extension and staff and student amenities;*
  - *Third Floor (Level 4): No change from Stage 2;*
  - *Fourth Floor (Level 5): No change from Stage 2;*
- *New sawtooth roof to southern portion of building;*
- *Landscaping to southern portion of site;*
- *Extension of acoustic wall along full length of site;*

- *New pedestrian entry and stairs from Harbord Road;*
- *Removal of the existing pylon sign and new signage for the school; and*
- *Reconfiguration of driveway entry and forecourt to provide pick-up and drop-off area, bus turning and 15 spaces.*

The construction will include the internal (minimal external) demolition of the existing buildings where required, excavation of the site (external areas only – landscaping and car park grading) and the construction of the new *NSC*. The proposed hours of construction are during standard working hours Monday to Friday (7 am to 6 pm), 7 am to 5 pm on Saturdays, with no work on Sundays.

The proposal is a State Significant Development (SSD) and has been issued by the NSW Department of Planning and Environment with the Secretary's Environmental Assessment Requirements (SEARs) – *SSD 10291*. The SEARs require an assessment against the NSW Environment Protection Authority's (EPA) *Interim Construction Noise Guideline 2009* and *Assessing Vibration: a technical guideline 2006.*

This construction noise and vibration management plan has been prepared in accordance with the Australian Standard AS2436:2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"*. Construction noise and vibration management levels have been derived from the Environment Protection Authority's *Interim Construction Noise Guideline 2009* and *Assessing Vibration: a technical guideline 2006* and are used for a quantitative assessment at the nearest affected residential, educational, industrial and passive recreation receiver locations.

The major noise sources associated with the project are mobile plant and machinery to be used during the excavation and bulk earth works including rock hammering (if required) and the transport of raw materials to and from site in trucks.

There is potential, at least on some occasions, for noise emission from construction works to exceed the noise management level at some receivers during various stages of the works.

All feasible and reasonable methods to reduce noise emissions and minimise the noise impact on neighbouring properties have been provided in Section 6 of this report. These include, limiting construction activity to within the prescribed hours, selecting quiet equipment, incorporating periods of respite, maintaining community consultation relations, managing noise complaints and conducting ground-borne vibration monitoring (if necessary).

Provided the recommendations in Section 6 of this report are implemented and adhered to, the level of noise and vibration from the construction works will be minimised in accordance with Australian Standard AS2436:2010 and the NSW Environment Protection Authority's *Interim Construction Noise Guideline 2009* and *Assessing Vibration: a technical guideline 2006*.

2.0 CONSULTING BRIEF

Day Design Pty Ltd has been engaged by Midson Group on behalf of The Anglican Schools Corporation to assess the environmental noise impact of the construction of the proposed St Luke's Grammar School new Senior Campus at 800 Pittwater Road and 224 Headland Road, Dee Why, NSW.

This commission involves the following:

Scope of Work:

- Inspect the site and environs
- Measure the background noise levels at critical locations and times
- Establish acceptable noise level criterion
- Quantify noise emissions from the demolition, excavation and construction works
- Calculate the level of noise emission, taking into account distance attenuation
- Prepare a site plan identifying the development and nearby noise sensitive locations
- Provide recommendations for noise control (if necessary)
- Prepare a Construction Noise and Vibration Management Plan.

3.0 PROJECT DESCRIPTION

3.1 Site Description

The *NSC* is proposed to be situated on land zoned *B5 – Business Development* (800 Pittwater Road) and *IN1 – General Industrial* (224 Headland Road) under Warringah Local Environmental Plan (LEP) 2011.

The proposed *NSC* site is bounded by land zoned *RE1 – Public Recreation* (Stony Range Botanic Garden) to the north and north-east, industrial premises to the east, Headland Road and industrial premises to the south and south-west and Pittwater Road to the west. The nearest residential premises to the site are located on the opposite side of Stony Range Botanic Garden to the north-east, Headland Road to the south-west and the opposite side of Pittwater Road to the west and north-west, as shown on Figure 1 and Figure 2. The *NSC* will have no shared boundary with any residential lots.

The nearest noise sensitive receptors to the proposed *NSC*, in various directions, are shown on Figure 2, and as follows in Table 1.

Table 1 Noise Sensitive Receptors

Receptor and Type	Address	Direction from site
R1 – Passive Recreation	Stony Range Botanic Garden	North
R2 – Residential	10 Tango Avenue	North - East
R3 – Industrial	222 Headland Road	East
R4 – Residential	213 Headland Road	South - East
R5 – Industrial	226 Headland Road	South
R6 – Industrial	275 Harbord Road	South - West
R7 – Residential	589 Pittwater Road	West

Each receptor location has been selected to represent the adjacent premises (where applicable), eg R7 is representative of all residential receptors to the west of the *NSC*; R6 is representative of all industrial receptors to the south-west of the *NSC*.

In addition to the noise sensitive receptor locations shown in Table 1, during all three stages of the development potential noise sensitive receptors will also be located within the development site itself. Additional Stage 1, 2 and 3 receptor locations located within the development site are shown in Table 2.

Table 2 Noise Sensitive Receptors – Additional Internal Receptor Locations

Receptor and Type	Address	Direction from site
Stage 1		
R8 – Industrial	All Units, 800 Pittwater Road	N/A
Stage 2		
R9 – Industrial	Units 2 and 4, 800 Pittwater Road	N/A
R10 – Educational (External)	224 Headland Road	N/A
Stage 3		
R10 – Educational (External)	224 Headland Road	N/A
R11 – Educational (External)	Units 1, 3 and 5, 800 Pittwater Road	N/A

Figure 1 - Location Plan, 800 Pittwater & 224 Headland Road, Dee Why, NSW.

Figure 2 - Site Plan, 800 Pittwater & 224 Headland Road, Dee Why, NSW.

3.2 Development Description

Each Stage of the development will occur in three phases:

***Stage 1** – (23 Weeks Total)*

- Phase 1 – Demolition of the existing structures where required:
  - Expected timeframe of 6 weeks
  - Activities include use of hand tools and dump trucks
- Phase 2 – Excavation (if required)
  - Expected timeframe of 4 weeks
  - Activities include use of excavator and dump trucks
- Phase 3 – Construction
  - Expected timeframe 13 weeks
  - Activities include use of cement trucks, cranes, gensets, and hand tools.

***Stage 2** – (65 Weeks Total)*

- Phase 1 – Demolition of the existing structures where required:
  - Expected timeframe of 13 weeks
  - Activities include use of hand tools, excavator and dump trucks
- Phase 2 – Excavation and earth moving
  - Expected timeframe of 7 weeks
  - Activities include use of excavator and dump trucks, and a rock breaker as required
- Phase 3 – Construction
  - Expected timeframe 45 weeks
  - Activities include use of cement trucks, cranes, gensets, and hand tools.

***Stage 3** – (60 Weeks Total)*

- Phase 1 – Demolition of the existing structures where required:
  - Expected timeframe of 10 weeks
  - Activities include use of hand tools, excavator and dump trucks
- Phase 2 – Excavation and earth moving
  - Expected timeframe of 5 weeks
  - Activities include use of excavator and dump trucks, and a rock breaker as required

- Phase 3 – Construction
    - Expected timeframe 45 weeks
    - Activities include use of cement trucks, cranes, gensets, and hand tools.

The proposed hours of construction works, including delivery of materials to and from the site, are as follows:

- Monday to Friday: 7 am to 6 pm;
- Saturdays: 7 am to 5 pm; and
- Sundays and public holidays: No work.

4.0 NOISE CRITERIA

4.1 Measured Ambient Noise Level

In order to assess the severity of a possible environmental noise problem in a residential area it is necessary to measure the ambient background noise level at the times and locations of worst possible annoyance. The lower the background noise level, the more perceptible the intrusive noise becomes and the more potentially annoying.

The ambient L_{90} background noise level is a statistical measure of the sound pressure level that is exceeded for 90% of the measuring period (typically 15 minutes).

The Rating Background Level (RBL) is defined by the NSW EPA as the median value of the (lower) tenth percentile of L_{90} ambient background noise levels for the day, evening or night time periods, measured over a number of days during the proposed days and times of operation.

The places of worst possible annoyance are the residential dwellings. These locations are shown in the Site Plan on Figure 2 as 'R2', 'R4' and 'R7'. The times of worst possible annoyance will be during the day when the *NSC* is under construction.

Ambient noise levels were previously measured in the backyard of 20 Quirk Street, shown as Location 'A' on Figure 1, from Tuesday 10 April to Tuesday 17 April, 2018. Ambient noise level were also recently measured in the front yard of 209 Headland Road, shown as Location 'B' on Figure 1, and in the north-western corner of 800 Pittwater Road, shown as Location 'C' on Figure 1, from Tuesday 28 May to Wednesday 5 June, 2019.

The day time ambient noise levels are presented in the attached Appendix B1, B2 and B3, and also below in Table 3.

Table 3 Ambient Noise Levels – Dee Why, NSW

Noise Measurement Location	Time Period	L_{90} Rating Background Level
Location 'A' *(10/4 to 17/4/18)* - Backyard, 20 Quirk St	Day (7 am to 6 pm)	**42 dBA**
Location 'B' *(28/5 to 5/6/2019)* - Front yard, 209 Headland Rd	Day (7 am to 6 pm)	**51 dBA**
Location 'C' *(28/5 to 5/6/2019)* - NW Corner, 800 Pittwater Rd	Day (7 am to 6 pm)	**59 dBA**

Meteorological conditions during the testing from Tuesday 10 April to Tuesday 17 April, 2018 typically consisted of clear skies. Temperatures ranged from 15 to 31°C. Atmospheric conditions were ideal for noise monitoring. Noise measurements were therefore considered reliable and typical for the receptor area.

Meteorological conditions during the testing from Tuesday 28 May to Wednesday 5 June, 2019 typically consisted of clear skies with some rain. Rain affected data has been removed from the assessment period. Temperatures ranged from 8 to 18°C. Atmospheric conditions were ideal for noise monitoring. Noise measurements were therefore considered reliable and typical for the receptor areas.

4.2 NSW Department of Planning & Environment

The NSW Department of Planning and Environment issued the Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS) for St Luke's Grammar School new Senior Campus at 800 Pittwater Road and 224 Headland Road, Dee Why, NSW (*SSD 10291*). As part of the SEARs, the following requirements relating to acoustics must be satisfied:

'12. Noise and Vibration

Identify and provide a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation, construction. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.

Relevant Policies and Guidelines:

- *Interim Construction Noise Guideline (DECC);*
- *Assessing Vibration: A Technical Guideline 2006.'*

4.3 Australian Standard AS2436

The Australian Standard AS2436:2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* provides guidance on noise control in respect to construction, demolition and maintenance sites. The Standard also provides guidance for the preparation of noise and vibration management plans.

Section 1.5 'Regulatory Requirements' of the Standard states:

"Legislation associated with the control of noise and vibration on and from construction, demolition and maintenance sites in Australia is generally the responsibility of the relevant State or Territory government, local council or a designated statutory authority."

Consequently the Standard does not provide specific noise criterion rather sets out practical methods for determining the potential for noise and vibration impact on the community from construction, demolition and maintenance sites.

A qualitative method is described in Section 3.3 of the standard, which is designed to avoid the need for complex noise predictions by following a series of questions relating to, for example, whether the noise is likely to be loud, have annoying characteristics or affect sleep.

In the event that any of these outcomes are likely, a more detailed and quantitative approach should be adopted.

In relation to carrying out detailed noise impact assessments, Section 4 'General' of the standard states:

"Regulatory authorities may have relevant polices and/or guidelines for the control of noise and vibration on construction sites. These should also be referred to when developing noise and vibration management plans for such projects."

In NSW this is the NSW Environment Protection Authority's *Interim Construction Noise Guideline 2009* as outlined in Section 4.4.

The Standard further states, in Section 4.6.1, that if noisy processes cannot be avoided, then the amount of noise reaching the receiver should be minimised and goes on to provide advice and recommendations to reduce noise and vibration impacts as far as reasonably practicable.

This report has been prepared in accordance with the guidance provided in AS2436:2010.

4.4 EPA Construction Noise Guideline

The NSW Environment Protection Authority published the *Interim Construction Noise Guideline* in July 2009. While some noise from construction sites is inevitable, the aim of the Guideline is to protect the majority of residences and other sensitive land uses from noise pollution most of the time.

The Guideline presents two ways of assessing construction noise impacts; the quantitative method and the qualitative method.

The quantitative method is generally suited to longer term construction projects and involves predicting noise levels from the construction phase and comparing them with noise management levels given in the guideline.

The qualitative method for assessing construction noise is a simplified way to identify the cause of potential noise impacts and may be used for short-term works, such as repair and maintenance projects of short duration.

In this instance, the quantitative method is the most appropriate and has been used in this assessment. Details of the quantitative method are given in Section 4 of the Guideline.

Normal construction hours are defined by the EPA as follows:

- 7.00 am to 6.00 pm Monday to Friday;
- 8.00 am to 1.00 pm Saturday; and
- No work on Sunday or Public Holiday.

Table 2 in Section 4 of the Guideline sets out noise management levels at affected residences and how they are to be applied during normal construction hours. The noise management level is derived from the rating background level (RBL) plus 10 dB in accordance with the Guideline. This level is considered to be the 'noise affected level' which represents the point above which there may be some community reaction to noise.

The 'highly noise affected' level of 75 dBA represents the point above which there may be strong community reaction to noise. This level is provided in the Guideline and is not based on the RBL. Restrictions to the hours of construction may apply to activities that generate noise at residences above the 'highly noise affected' noise management level.

Based on the RBLs at all sensitive residential receiver locations in the daytime, the recommended noise management level during all aspects of the construction program are summarised in Table 4.

Table 4 L_{eq} Noise Management Levels from Construction Activities

Receptor Location	Noise Management Level	How to Apply
'R2'	**52 dBA** **(42 + 10)**	The noise affected level represents the point above which there may be some community reaction to noise. ▪ Where the predicted or measured $L_{Aeq\ (15\ min)}$ noise level 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.
'R4'	**61 dBA** **(51 + 10)**	
'R7'	**69 dBA** **(59 + 10)**	
All Residential Receptors	**Highly noise affected** **75 dBA**	The highly noise affected level represents the point above which there may be strong community reaction to noise. ▪ Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences); 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

*Section 6, 'work practices' of The *Interim Construction Noise Guideline*, states: *"there are no prescribed noise controls for construction works. Instead, all feasible and reasonable work practices should be implemented to minimise noise impacts. This approach gives construction site managers and construction workers the greatest flexibility to manage noise"*.

Definitions of the terms feasible and reasonable are given in Section 1.4 of the Guideline.

Section 4.1.2 of the guideline sets out noise management levels at the nearby affected educational receivers. It states that *'internal noise levels are to be assessed at the centre of the occupied room'*, however, *'where internal noise levels cannot be measured, external noise levels may be used. A conservative estimate of the difference between internal and external noise levels is 10 dB for buildings other than residences'*, as follows:

- Classrooms at schools and other educational institutions: external $L_{Aeq,\ 15\ minute}$ (45 + 10 =) 55 dBA.

During construction, the proponent should regularly update the occupants of the schools regarding noise levels and hours of work.

Table 3 in Section 4.1.2 of the guideline sets out noise management levels at the nearby affected passive recreation area. It states that 'the external noise levels should be assessed at the most affected point within 50 m of the area boundary', as follows:

- passive recreation areas: external $L_{Aeq,\ 15\ minute}$ 60 dBA.

Section 4.1.3 of the guideline sets out noise management levels at the nearby affected industrial premises. It states that 'the external noise levels should be assessed at the most-affected occupied point of the premises', as follows:

- industrial premises: external $L_{Aeq,\ 15\ minute}$ 75 dBA.

During construction, the proponent should regularly update the occupant of the industrial premises regarding noise levels and hours of work.

4.5 EPA Vibration Guideline

The NSW EPA published the *Assessing Vibration: a technical guideline* in February 2006. This guideline is based on the British Standard BS6472:1992 *"Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)."*

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. The guideline considers vibration from construction activities as Intermittent Vibration. Table 2.4 of the guideline sets out limits for Vibration Dose Values to assess intermittent vibration and is replicated below in Table 5 for residential, educational and industrial receptor locations.

Table 5 Vibration Dose Values (VDV) from Construction Activities

Receptor Location	Daytime	
	Preferred value ($m/s^{1.75}$)	Maximum value ($m/s^{1.75}$)
All residences	0.20	0.40
Schools, educational institutions	0.40	0.80
Workshops	0.80	1.60

The British Standard BS7385-2:1993 *"Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration"* provides guide values for transient vibration relating to cosmetic damage, replicated below in Table 6 for residential, educational and industrial buildings.

Table 6 Transient Vibration Guide Values for Cosmetic Damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Residential and light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Industrial buildings	50 mm/s at 4 Hz and above	

In our opinion, an overall peak particle velocity of **15 mm/s** at the boundaries of residential / educational receptors and **50 mm/s** at the boundaries of industrial receptors will comply with the recommended values in Table 6, and are acceptable criteria for intermittent vibration to prevent cosmetic damage to the adjacent residential, educational and industrial buildings.

4.6 Project Specific Noise Criteria

In our opinion, the most relevant noise and vibration management levels for this development are those outlined in Sections 4.4 and 4.5 of this report, and summarised as follows:

- Noise management level of **52 dBA** ($L_{eq,\,15\ minute}$) for residential receptors 'R2';
- Noise management level of **61 dBA** ($L_{eq,\,15\ minute}$) for residential receptors 'R4';
- Noise management level of **69 dBA** ($L_{eq,\,15\ minute}$) for residential receptors 'R7';
- Noise management level of **60 dBA** $L_{eq,\,15\ minute}$ for all passive recreation receptors;
- Noise management level of **55 dBA** ($L_{eq,\,15\ minute}$) for all educational receptor;
- Noise management level of **75 dBA** $L_{eq,\,15\ minute}$ for all industrial receptors;
- A Vibration Dose Value (VDV) between **0.2 – 0.4 $m/s^{1.75}$** for human annoyance in residential buildings; and
- A Vibration Dose Value (VDV) between **0.4 – 0.8 $m/s^{1.75}$** for human annoyance in schools or educational institutions;
- A Vibration Dose Value (VDV) between **0.8 – 1.6 $m/s^{1.75}$** for human annoyance in industrial buildings;
- A Peak Particle Velocity no greater than **15 mm/s** to prevent cosmetic damage to residential buildings and educational institutions; and
- A Peak Particle Velocity no greater than **50 mm/s** to prevent cosmetic damage to industrial buildings.

5.0 NOISE EMISSION

The main sources of noise on the site during the three phases of demolition, excavation and construction will be from heavy machinery such as excavators, dump trucks, cranes, cement mixers, rock breakers, etc.

Unless otherwise noted, the predicted noise levels in the following Sections assume that all equipment and plant listed are operating at the same time within the same general area along the nearest or furthest boundaries. This constitutes a worst-case scenario, however, due to the nature of the works, it is more likely that equipment will be dispersed over a wider area of the construction site and will not be continuously operating simultaneously. Typically, therefore, lower average noise levels can be expected.

A schedule of the sound power levels for the main demolition, excavation and construction equipment was extracted from the Day Design database of Sound Power Levels and the Australian Standard AS2436:1981 *"Guide to Noise Control on Construction, Maintenance and Demolition Sites".*

Knowing the sound power level of a noise source, the sound pressure level (as measured with a sound level meter) can be calculated at a remote location using suitable formulae to account for distance losses, barrier effects, etc.

Calculations consider distance attenuation, acoustic shielding provided by existing buildings (where applicable) and sound transmission loss (where applicable). The range of levels are based on the closest potential distance and furthest potential distance at which each item of plant may operate from each respective residential, educational, industrial or passive recreation location. The calculated noise levels at nearby residential, educational, industrial or passive recreation receptors are presented in the following sections.

5.1 Stage 1 – Construction Noise Emissions

5.1.1 Phase 1 – Demolition Works

The demolition and removal of the existing building elements is estimated to take 6 weeks and will involve the use of hand tools and regular truck movements transporting waste materials from the site. The equipment likely to be used and their corresponding sound power levels are presented below in Table 7.

Table 7 Stage 1 – Typical Demolition Plant and Equipment – Sound Power Levels

Description	Sound Power Level, dBA
Truck	107
Compressor	101
Generator	99
Hand Tools	102
Jackhammer	112
Bobcat	106

Note: All sound power levels are based on previous noise measurements at various sites

The calculated noise levels at nearby residential, industrial and passive recreation receptors are presented below in Table 8 as a worst case scenario.

Table 8 Stage 1 - Calculated Receptor Sound Pressure Levels from Demolition Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	53 – 60
R2 – 10 Tango Avenue	54 – 57
R3 – 222 Headland Road	69 – 82
R4 – 213 Headland Road	57 – 70
R5 – 226 Headland Road	64 – 73
R6 - 275 Harbord Road	63 – 70
R7 – 589 Pittwater Road	57 – 61
R8 – All Units, 800 Pittwater Road	64 – 73

5.1.2 Phase 2 – Excavation Works (if required)

The excavation works, if required, are estimated to take 4 weeks and will involve the use of excavators and regular truck movements transporting waste materials from the site. The equipment likely to be used and their corresponding sound power levels are presented below in Table 9.

Table 9 Stage 1 - Typical Excavation Works Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Excavator – Hitachi 330	107
Truck	107
Compressor	101
Generator	99

Note: All sound power levels are based on previous noise measurements at various sites

The calculated noise levels at nearby residential, industrial and passive recreation receptors are presented below in Table 10 as a worst case scenario.

Table 10 Stage 1 - Calculated Receptor Sound Pressure Levels from Excavation Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	54 – 61
R2 – 10 Tango Avenue	55 – 58
R3 – 222 Headland Road	70 – 83
R4 – 213 Headland Road	58 – 71
R5 – 226 Headland Road	64 – 72
R6 – 275 Harbord Road	61 – 70
R7 – 589 Pittwater Road	56 – 61
R8 – All Units, 800 Pittwater Road	64 – 72

5.1.3 Phase 3 – Construction

The construction of Stage 1 of the *NSC* is estimated to take 13 weeks and will involve the use of heavy vehicles, power tools and portable mechanical plant such as generators and compressors. The equipment likely to be used and their corresponding sound power levels are presented below in Table 11.

Table 11 Stage 1 - Typical Construction Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Cement Truck	109
Crane	104
Generator	99
Compressor	101
Power Saw	105
Nail Gun	95
Grinder	101
Bobcat	106

Note: All sound power levels are based on previous noise measurements at various sites

During the construction phase, work will be more dispersed across the site as the scale of work, compared to the previous phase, is less intensive. The calculated noise levels at nearby residential, industrial and passive recreation receptors are presented below in Table 12 as a worst case scenario.

Table 12 Stage 1 - Calculated Receptor Sound Pressure Levels from Construction Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	55 – 62
R2 – 10 Tango Avenue	56 – 59
R3 – 222 Headland Road	71 – 84
R4 – 213 Headland Road	59 – 72
R5 – 226 Headland Road	66 – 74
R6 – 275 Harbord Road	62 – 72
R7 – 589 Pittwater Road	57 – 63
R8 – All Units, 800 Pittwater Road	66 – 74

5.1.4 Stage 1 - Noise Emission Summary

From the calculated noise levels in Sections 5.1.1 to 5.1.3, the level of noise exceedance is presented below in Table 13.

Table 13 Stage 1 - Calculated $L_{eq\ 15\ minute}$ Noise Levels (Without Noise Controls)

Description	Calculated Noise Levels (dBA)						
	R1	R2	R3	R4	R5	R6	R7
Phase 1 – Demolition Works							
Demolition Works	53 - 60	54 - 57	69 - 82	57 - 70	64 - 73	63 - 70	57 - 61
Noise Management Level	60	52	75	61	75	75	69
Exceedance	0 dB	**Up to 4 dB**	**Up to 7 dB**	**Up to 9 dB**	0 dB	0 dB	0 dB
Phase 2 – Excavation Works							
Excavation Works	54 - 61	55 - 58	70 - 83	58 - 71	64 - 72	61 - 70	56 - 61
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 1 dB**	**Up to 6 dB**	**Up to 8 dB**	**Up to 10 dB**	0 dB	0 dB	0 dB
Phase 3 – Construction							
Construction Works	55 - 62	56 - 59	71 - 84	59 - 72	66 - 74	62 - 72	57 - 63
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 2 dB**	**Up to 7 dB**	**Up to 9 dB**	**Up to 11 dB**	0 dB	0 dB	0 dB

It can be seen from Table 13 above, that the predicted levels of noise from construction activities will at times be in excess of the noise management levels at residential receptor locations ‘R2’ and ‘R4’, at the passive recreation receptor location ‘R1’ and the industrial receptor ‘R3’.

To minimise the noise impact from the construction activities we recommend that the noise controls and the management plan detailed in Section 6 of this report be implemented.

From the calculated noise levels in Sections 5.1.1 to 5.1.3, the level of noise exceedance at the development site receptor locations is presented in Table 14.

Table 14 Stage 1 - Calculated $L_{eq\ 15\ minute}$ Noise Levels (Without Noise Controls) – Internal Receptor Locations

Description	Calculated Noise Levels (dBA) R8
Phase 1 – Demolition Works	
Demolition Works	64 – 73
Noise Management Level	75
Exceedance	0 dB
Phase 2 – Excavation Works	
Excavation Works	64 – 72
Noise Management Level	75
Exceedance	0 dB
Phase 3 – Construction	
Construction Works	66 – 74
Noise Management Level	75
Exceedance	0 dB

It can be seen from Table 14 above, that the predicted levels of noise from construction activities complies with the noise management levels at the industrial receptor 'R8'.

5.2 Stage 2 – Construction Noise Emissions

5.2.1 Phase 1 – Demolition Works

The demolition and removal of the existing building elements is estimated to take 13 weeks and will involve the use of excavators (external), rock hammers to break concrete (external), hand tools and regular truck movements transporting waste materials from the site. The equipment likely to be used and their corresponding sound power levels are presented below in Table 15.

Table 15 Stage 2- Typical Demolition Plant and Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Excavator – Hitachi 330	107
Truck	107
Compressor	101
Generator	99
Hydraulic Rock Breaker	118
Hand Tools	102
Jackhammer	112
Bobcat	106

Note: All sound power levels are based on previous noise measurements at various sites

Given the intensity of work involved with concrete breaking, it is unlikely that this activity will take place at the same time as any other activity. Therefore we have assessed the noise impact of the concrete breaking individually. The calculated noise levels at nearby residential, educational, industrial and passive recreation receptors are presented below in Table 16 as a worst case scenario.

Table 16 Stage 2 - Calculated Receptor Sound Pressure Levels from Demolition Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	60 – 66
R2 – 10 Tango Avenue	54 – 58
R3 – 222 Headland Road	60 – 66
R4 – 213 Headland Road	49 – 50
R5 – 226 Headland Road	60 – 63
R6 – 275 Harbord Road	59 – 65
R7 – 589 Pittwater Road	57 – 68
R9 – Units 2 & 4, 800 Pittwater Road	62 – 74
R10 – 224 Headland Road	55 – 73

Table 16 Stage 2 - Calculated Receptor Sound Pressure Levels from Demolition Works – Cont.

Concrete Breaking	
R1 – Stony Range Botanic Garden	69 – 74
R2 – 10 Tango Avenue	62 – 66
R3 – 222 Headland Road	69 – 74
R4 – 213 Headland Road	57 – 58
R5 – 226 Headland Road	69 – 71
R6 – 275 Harbord Road	67 – 74
R7 – 589 Pittwater Road	66 – 76
R9 – Units 2 & 4, 800 Pittwater Road	70 – 82
R10 – 224 Headland Road	64 – 81

5.2.2 Phase 2 – Excavation and Bulk Earth Works

The excavation and bulk earth works are estimated to take 7 weeks and will involve the use of excavators, rock hammers/saws (if required), and regular truck movements transporting waste materials from the site. The equipment likely to be used and their corresponding sound power levels are presented below in Table 17.

Table 17 Stage 2 - Typical Excavation Works Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Excavator – Hitachi 330	107
Truck	107
Compressor	101
Generator	99
Hydraulic Rock Breaker	118

Note: All sound power levels are based on previous noise measurements at various sites

Given the intensity of work involved with rock breaking (if required), it is unlikely that this activity will take place at the same time as any other activity. Therefore we have assessed the noise impact of rock breaking individually. The calculated noise levels at nearby residential, educational, industrial and passive recreation receptors are presented in Table 18 as a worst case scenario.

Table 18 Stage 2 - Calculated Receptor Sound Pressure Levels from Excavation Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	62 – 67
R2 – 10 Tango Avenue	55 – 59
R3 – 222 Headland Road	62 – 67
R4 – 213 Headland Road	50 – 51
R5 – 226 Headland Road	62 – 64
R6 – 275 Harbord Road	60 – 67
R7 – 589 Pittwater Road	59 – 69
R9 – Units 2 & 4, 800 Pittwater Road	63 – 75
R10 – 224 Headland Road	57 – 74
Rock Breaking	
R1 – Stony Range Botanic Garden	69 – 74
R2 – 10 Tango Avenue	62 – 66
R3 – 222 Headland Road	69 – 74
R4 – 213 Headland Road	57 – 58
R5 – 226 Headland Road	69 – 71
R6 – 275 Harbord Road	67 – 74
R7 – 589 Pittwater Road	66 – 76
R9 – Units 2 & 4, 800 Pittwater Road	70 – 82
R10 – 224 Headland Road	64 – 81

5.2.3 Phase 3 – Construction

The construction of Stage 2 of the *NSC* is estimated to take 45 weeks and will involve the use of heavy vehicles, power tools and portable mechanical plant such as generators and compressors. The equipment likely to be used and their corresponding sound power levels are presented below in Table 19.

Table 19 Stage 2 - Typical Construction Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Cement Truck	109
Crane	104
Generator	99
Compressor	101
Power Saw	105
Nail Gun	95
Grinder	101
Bobcat	106

Note: All sound power levels are based on previous noise measurements at various sites

During the construction phase, work will be more dispersed across the site as the scale of work, compared to the previous phase, is less intensive. The calculated noise levels at nearby residential, educational, industrial and passive recreation receptors are presented below in Table 20 as a worst case scenario.

Table 20 Stage 2 - Calculated Receptor Sound Pressure Levels from Construction Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	62 – 68
R2 – 10 Tango Avenue	56 – 60
R3 – 222 Headland Road	62 – 68
R4 – 213 Headland Road	51 – 52
R5 – 226 Headland Road	63 – 66
R6 – 275 Harbord Road	62 – 68
R7 – 589 Pittwater Road	61 – 71
R9 – Units 2 & 4, 800 Pittwater Road	65 – 77
R10 – 224 Headland Road	57 – 76

5.2.4 Stage 2 - Noise Emission Summary

From the calculated noise levels in Sections 5.2.1 to 5.2.3, the level of noise exceedance is presented below in Table 21.

Table 21 Stage 2 - Calculated $L_{eq\ 15\ minute}$ Noise Levels (Without Noise Controls)

Description	Calculated Noise Levels (dBA)						
	R1	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Phase 1 – Demolition Works							
Demolition Works	60 - 66	54 - 58	60 - 66	49 - 50	60 - 63	59 - 65	57 - 68
Concrete Breaking	69 - 74	62 - 66	69 - 74	57 - 58	69 - 71	67 - 74	66 - 76
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 14 dB**	**Up to 14 dB**	0 dB	0 dB	0 dB	0 dB	**Up to 7 dB**
Phase 2 – Excavation Works							
Excavation Works	62 - 67	55 - 59	62 - 67	50 - 51	62 - 64	60 - 67	59 - 69
Rock Breaking	69 - 74	62 - 66	69 - 74	57 - 58	69 - 71	67 - 74	66 - 76
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 14 dB**	**Up to 14 dB**	0 dB	0 dB	0 dB	0 dB	**Up to 7 dB**
Phase 3 – Construction							
Construction Works	62 - 68	56 - 60	62 - 68	51 - 52	63 - 66	62 - 68	61 - 71
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 8 dB**	**Up to 8 dB**	0 dB	0 dB	0 dB	0 dB	**Up to 2 dB**

It can be seen from Table 21 above, that the predicted levels of noise from construction activities will at times be in excess of the noise management levels at residential receptor locations 'R2' and 'R7' and at the passive recreation receptor location 'R1'.

From the calculated noise levels in Sections 5.2.1 to 5.2.3, the level of noise exceedance at the development site receptor locations is presented in Table 22.

Table 22 Stage 2 - Calculated $L_{eq\ 15\ minute}$ Noise Levels (Without Noise Controls) – Internal Receptor Locations

Description	Calculated Noise Levels (dBA)	
	R9	R10
Phase 1 – Demolition Works		
Demolition Works	62 - 74	55 - 73
Concrete Breaking	70 - 82	64 - 81
Noise Management Level	75	55
Exceedance	**Up to 7 dB**	**Up to 26 dB**
Phase 2 – Excavation Works		
Excavation Works	63 - 75	57 - 74
Rock Breaking	70 - 82	64 - 81
Noise Management Level	75	55
Exceedance	**Up to 7 dB**	**Up to 26 dB**
Phase 3 – Construction		
Construction Works	65 - 77	57 - 76
Noise Management Level	75	55
Exceedance	**Up to 2 dB**	**Up to 21 dB**

It can be seen from Table 22 above, that the predicted levels of noise from construction activities will at times be in excess of the noise management levels at industrial receptor location 'R9' and the educational receptor location 'R10'.

To minimise the noise impact from the construction activities we recommend that the noise controls and management plan detailed in Section 6 of this report be implemented.

Rock hammering is not considered cumulatively as it is unknown at this stage whether it will be required, and if so where it may be required. To include it in the cumulative noise predictions would over-state the predicted impact. However, as a precaution, it is recommended in the noise management controls (Section 6.2) that in the event that rock hammering is required near to residential receptors, it is conducted in the absence of any other plant operations to avoid a cumulative noise impact.

5.3 Stage 3 – Construction Noise Emissions

5.3.1 Phase 1 – Demolition Works

The demolition and removal of the existing building elements is estimated to take 10 weeks and will involve the use of excavators (external), rock hammers to break concrete (external), hand tools and regular truck movements transporting waste materials from the site. The equipment likely to be used and their corresponding sound power levels are presented below in Table 23.

Table 23 Stage 3 - Typical Demolition Plant and Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Excavator – Hitachi 330	107
Truck	107
Compressor	101
Generator	99
Hydraulic Rock Breaker	118
Hand Tools	102
Jackhammer	112
Bobcat	106

Note: All sound power levels are based on previous noise measurements at various sites

Given the intensity of work involved with concrete breaking, it is unlikely that this activity will take place at the same time as any other activity. Therefore we have assessed the noise impact of the concrete breaking individually. The calculated noise levels at nearby residential, educational, industrial and passive recreation receptors are presented below in Table 24 as a worst case scenario.

Table 24 Stage 3 - Calculated Receptor Sound Pressure Levels from Demolition Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	57 – 60
R2 – 10 Tango Avenue	48 – 49
R3 – 222 Headland Road	54 – 56
R4 – 213 Headland Road	50 – 52
R5 – 226 Headland Road	64 – 69
R6 – 275 Harbord Road	65 – 82
R7 – 589 Pittwater Road	62 – 69
R10 – 224 Headland Road	55 – 61
R11 – Units 1, 3 & 5 800 Pittwater Road	62 – 74

Table 24 Stage 3 - Calculated Receptor Sound Pressure Levels from Demolition Works – Cont.

Concrete Breaking	
R1 – Stony Range Botanic Garden	65 – 68
R2 – 10 Tango Avenue	56 – 57
R3 – 222 Headland Road	62 – 64
R4 – 213 Headland Road	58 – 61
R5 – 226 Headland Road	72 – 77
R6 – 275 Harbord Road	74 – 90
R7 – 589 Pittwater Road	70 – 77
R10 – 224 Headland Road	64 – 69
R11 – Units 1, 3 & 5 800 Pittwater Road	70 – 82

5.3.2 Phase 2 – Excavation and Bulk Earth Works

The excavation and bulk earth works are estimated to take 5 weeks and will involve the use of excavators, rock hammers/saws (if required), and regular truck movements transporting waste materials from the site. The equipment likely to be used and their corresponding sound power levels are presented below in Table 25.

Table 25 Stage 3 - Typical Excavation Works Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Excavator – Hitachi 330	107
Truck	107
Compressor	101
Generator	99
Hydraulic Rock Breaker	118

Note: All sound power levels are based on previous noise measurements at various sites

Given the intensity of work involved with rock breaking (if required), it is unlikely that this activity will take place at the same time as any other activity. Therefore we have assessed the noise impact of rock breaking individually. The calculated noise levels at nearby residential, educational, industrial and passive recreation receptors are presented in Table 26 as a worst case scenario.

Table 26 Stage 3 - Calculated Receptor Sound Pressure Levels from Excavation Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	58 – 61
R2 – 10 Tango Avenue	56 – 57
R3 – 222 Headland Road	62 – 64
R4 – 213 Headland Road	57 – 61
R5 – 226 Headland Road	65 – 70
R6 – 275 Harbord Road	67 – 83
R7 – 589 Pittwater Road	63 – 70
R10 – 224 Headland Road	57 – 62
R11 – Units 1, 3 & 5 800 Pittwater Road	63 – 75
Rock Breaking	
R1 – Stony Range Botanic Garden	65 – 68
R2 – 10 Tango Avenue	56 – 57
R3 – 222 Headland Road	62 – 64
R4 – 213 Headland Road	58 – 61
R5 – 226 Headland Road	72 – 77
R6 – 275 Harbord Road	74 – 90
R7 – 589 Pittwater Road	70 – 77
R10 – 224 Headland Road	64 – 69
R11 – Units 1, 3 & 5 800 Pittwater Road	70 – 82

5.3.3 Phase 3 – Construction

The construction of Stage 3 of the *NSC* is estimated to take 45 weeks and will involve the use of heavy vehicles, power tools and portable mechanical plant such as generators and compressors. The equipment likely to be used and their corresponding sound power levels are presented below in Table 27.

Table 27 Stage 3 - Typical Construction Equipment - Sound Power Levels

Description	Sound Power Level, dBA
Cement Truck	109
Crane	104
Generator	99
Compressor	101
Power Saw	105
Nail Gun	95
Grinder	101
Bobcat	106

Note: All sound power levels are based on previous noise measurements at various sites

During the construction phase, work will be more dispersed across the site as the scale of work, compared to the previous phase, is less intensive. The calculated noise levels at nearby residential, educational, industrial and passive recreation receptors are presented below in Table 28 as a worst case scenario.

Table 28 Stage 3 - Calculated Receptor Sound Pressure Levels from Construction Works

Receptor Location	Calculated Sound Pressure Levels (dBA)
R1 – Stony Range Botanic Garden	59 – 62
R2 – 10 Tango Avenue	50 – 51
R3 – 222 Headland Road	56 – 58
R4 – 213 Headland Road	52 – 54
R5 – 226 Headland Road	67 – 72
R6 – 275 Harbord Road	68 – 85
R7 – 589 Pittwater Road	65 – 72
R10 – 224 Headland Road	57 – 63
R11 – Units 1, 3 & 5 800 Pittwater Road	65 – 77

5.3.4 Stage 3 - Noise Emission Summary

From the calculated noise levels in Sections 5.3.1 to 5.3.3, the level of noise exceedance is presented below in Table 29.

Table 29 Stage 3 - Calculated $L_{eq\ 15\ minute}$ Noise Levels (Without Noise Controls)

Description	Calculated Noise Levels (dBA)						
	R1	R2	R3	R4	R5	R6	R7
Phase 1 – Demolition Works							
Demolition Works	57 - 60	48 - 49	54 - 56	50 - 52	64 - 69	65 - 82	62 - 69
Concrete Breaking	65 - 68	56 - 57	62 - 64	58 - 61	72 - 77	74 - 90	70 - 77
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 8 dB**	**Up to 5 dB**	0 dB	0 dB	**Up to 2 dB**	**Up to 15 dB**	**Up to 8 dB**
Phase 2 – Excavation Works							
Excavation Works	58 - 61	56 - 57	62 - 64	57 - 61	65 - 70	67 - 83	63 - 70
Rock Breaking	65 - 68	56 - 57	62 - 64	58 - 61	72 - 77	74 - 90	70 - 77
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 8 dB**	**Up to 5 dB**	0 dB	0 dB	**Up to 2 dB**	**Up to 15 dB**	**Up to 8 dB**
Phase 3 – Construction							
Construction Works	59 - 62	50 - 51	56 - 58	52 - 54	67 - 72	68 - 85	65 - 72
Noise Management Level	60	52	75	61	75	75	69
Exceedance	**Up to 2 dB**	0 dB	0 dB	0 dB	0 dB	**Up to 10 dB**	**Up to 3 dB**

It can be seen from Table 29 above, that the predicted levels of noise from construction activities will at times be in excess of the noise management levels at residential receptor locations ‘R2’ and ‘R7’, at the passive recreation receptor location ‘R1’ and the industrial receptor ‘R5’ and ‘R6’. There is also potential for the highly noise affected level of 75 dBA to be exceeded at ‘R7’ during any concrete or rock breaking (if required).

From the calculated noise levels in Sections 5.3.1 to 5.3.3, the level of noise exceedance at the development site receptor locations is presented in Table 30.

Table 30 Stage 3 - Calculated $L_{eq\ 15\ minute}$ Noise Levels (Without Noise Controls) – Internal Receptor Locations

Description	Calculated Noise Levels (dBA)	
	R10	R11
Phase 1 – Demolition Works		
Demolition Works	55 - 61	62 - 74
Concrete Breaking	64 - 69	70 - 82
Noise Management Level	55	55
Exceedance	**Up to 14 dB**	**Up to 27 dB**
Phase 2 – Excavation Works		
Excavation Works	57 - 62	63 - 75
Rock Breaking	64 - 69	70 - 82
Noise Management Level	55	55
Exceedance	**Up to 14 dB**	**Up to 27 dB**
Phase 3 – Construction		
Construction Works	57 - 63	65 - 77
Noise Management Level	55	55
Exceedance	**Up to 8 dB**	**Up to 22 dB**

It can be seen from Table 30 above, that the predicted levels of noise from construction activities will at times be in excess of the noise management levels at the educational receptor locations 'R10' and 'R11'.

To minimise the noise impact from the construction activities we recommend that the noise controls and management plan detailed in Section 6 of this report be implemented.

Rock hammering is not considered cumulatively as it is unknown at this stage whether it will be required, and if so where it may be required. To include it in the cumulative noise predictions would over-state the predicted impact. However, as a precaution, it is recommended in the noise management controls (Section 6.2) that in the event that rock hammering is required near to residential receptors, it is conducted in the absence of any other plant operations to avoid a cumulative noise impact.

5.4 Vibration Emission

It is difficult to accurately predict levels of ground borne vibration at remote locations as there are many variables to consider including the surrounding terrain, strata, rock density, etc.

Previous measurements of ground borne vibration from rock hammering show that vibration levels can vary significantly at different distances and receptor locations. Given the distances from neighbouring developments to any potential rock hammering on site, we recommend that if warranted compliance monitoring of ground borne vibration is carried out at the nearest residences or industrial premises, wherever these activities are required.

Recommendations are made in Section 6.3 of this report should complaints arise from nearby residences or industrial premises regarding vibration from the site.

6.0 NOISE CONTROL RECOMMENDATIONS

The predicted level of noise emission from the demolition, excavation and construction activities at the St Luke's Grammar School new Senior Campus at 800 Pittwater Road and 224 Headland Road, Dee Why, NSW, have the potential to exceed the noise management levels established in Section 4.6 of this report.

In order to minimise the noise impact from all demolition, excavation and construction activities, we recommend the following engineering and management noise controls be implemented.

6.1 Engineering and Practical Noise Controls

Australian Standard AS2436:2010, Appendix C, Table C3 provides the relative effectiveness of various forms of noise control that may be applicable and implemented on various construction sites and projects. Table C3 is replicated below in Table 31.

Table 31 Relative Effectiveness of Various Forms of Noise Control

Control by	Nominal Noise Reduction Possible, dB
Distance	Approximately 6 dB for each doubling of distance
Enclosure	Normally 5 dB to 25 dB maximum 50 dB
Silencing	Normally 5 dB to 10 dB maximum 20 dB

Distance

Where applicable, we recommend locating mechanical plant near the centre of the construction area such that it is as far as practically possible from nearby noise sensitive receptors.

Enclosure

Constructing acoustical enclosures around items of mobile plant such as generators is recommended where extended use for long periods of time is expected.

Silencing

Consideration should be given to any mobile plant already acoustically treated when assessing tenders. All plant and machinery should be selected with consideration to low noise options where practicable and available.

Care should be taken to ensure that not more than one item of plant is operating simultaneously within close proximity of any noise sensitive receptor as far as reasonably practicable, to minimise cumulative noise impacts.

In addition to the noise controls above, we recommend that the common wall between the Stage 2 (IMED and Fitness First) and Stage 3 (Officeworks) buildings be maintained for the duration of the Stage 2 construction period. Should a justified noise complaint be received during the construction period, an investigation to determine whether the existing wall can be acoustically improved (to reduce the noise transmission) should be undertaken.

6.2 Noise Management Controls

The following noise management controls are derived from, or are in accordance with recommendations given in Australian Standard AS2436:2010 and the EPA's *Interim Construction Noise Guideline*.

Periods of Respite

We recommend that noisy construction activities such as rock hammering or jackhammering only operate for 2 to 3 hours at a time.

Ensure activities in any one location are staggered, for instance, if rock hammering or jackhammering is occurring near to a noise sensitive receptor, all other construction activities will cease in the same location so as to minimise cumulative noise impacts.

Work Practices

We recommend that workers and contractors be trained in work practices to minimise noise emission such as the following:

- Avoid dropping materials from a height.
- Avoid shouting and talking loudly outdoors.
- Avoid the use of radios outdoors that can be heard at the boundary of noise sensitive receptors.
- Turn off equipment when not being used.
- Carry out work only within the proposed hours of operation (see Section 3.2).

Heavy Vehicles and Staff Vehicles

- Keep truck drivers informed of designated vehicle routes, parking locations, acceptable delivery hours or other relevant practices (for example, minimising the use of engine brakes, and no extended periods of engine idling).
- Locate site vehicle entrances away from residences where practicable.
- Optimise the number of vehicle trips to and from the site – movements can be organised to amalgamate loads rather than using a number of vehicles with smaller loads.
- Parking areas should be located as far from residential receiver locations as practicable.
- No motor vehicles should access the site via, or park within residential areas prior to 7 am on any occasion, in order avoid sleep disturbance.

Community Relations

- A Community Liaison Officer (Project Manager or Site Manager) is to be appointed by the contractor prior to the commencement of any works.
- The Community Liaison Officer will approach all potentially affected noise sensitive receptors prior to the commencement of any works as an initial introduction and provide his or her contact details.

- The Community Liaison Officer will explain the project, duration of works, potentially noisy periods as well as determine any particularly sensitive receivers or sensitive time periods and schedule works accordingly, as far as reasonably practical.
- A contact number will be provided for any residents to call with complaints or queries.

Once works commence, communication with the community should be maintained by the Community Liaison Officer. Communication should be maintained via a range of media including, for example, continued individual contact, letter box drops or a clearly visible notice board at the site office or on construction site boundaries.

Consultation and cooperation between the contractor and the neighbours and the removal of uncertainty and rumour can help to reduce adverse reaction to noise.

Managing a Noise Complaint

The Community Liaison Officer should receive and manage noise complaints.

All complaints should be treated promptly and with courtesy.

Should a justified noise complaint not be resolved, noise monitoring may be carried out at the affected receptor location and appropriate measures be taken to reduce the noise emission as far as reasonably practicable.

Where it is not practical to stop the noise, or reduce the noise, a full explanation of the event taking place, the reason for the noise and times when it will stop should be given to the complainant.

The following guidelines are recommended in Section 6 of the *Interim Construction Noise Guideline* to manage a noise complaint:

- Provide a readily accessible contact point.
- Give complaints a fair hearing.
- Have a documented complaints process, including an escalation procedure so that if a complainant is not satisfied there is a clear path to follow.
- Call back as soon as possible to keep people informed of action to be taken to address noise problems. Call back at night-time only if requested by the complainant to avoid further disturbance.
- Provide a quick response to complaints, with complaint handling staff having both a good knowledge of the project and ready access to information.
- Implement all feasible and reasonable measures to address the source of complaint.
- Keep a register of any complaints, including details of the complaint such as date, time, person receiving complaint, complainant's contact number, person referred to, description of the complaint, work area (for larger projects), time of verbal response and timeframe for written response where appropriate.

6.3 Vibration Monitoring

We recommend that the level of vibration be measured during any rock hammering (or internal jackhammering) in the event complaints arise from any nearby noise sensitive receptors regarding vibration.

The vibration measurements can be carried out using either an attended or an unattended vibration monitor. An unattended vibration monitor should be fitted with an alarm in the form of a strobe light or siren to make the plant operator aware immediately when the vibration limit is exceeded. The vibration monitor should be set to trigger the alarm when the overall Peak Particle Velocity (PPV) exceeds **15 mm/s** at the nearest residential building or **50 mm/s** at the nearest industrial building.

Dilapidation reports should be commissioned for potentially affected residential and industrial premises prior to any works being undertaken. This may be reassessed once the extent of required work is known.

In the event that levels of ground-borne vibration exceed the recommended acceptable levels for cosmetic damage, vibration causing works should cease immediately and alternative methods, such as rock sawing, be considered.

6.4 Construction Disclaimer

Recommendations made in this report are intended to resolve acoustical problems only. We make no claims of expertise in other areas of building construction and therefore the recommended noise controls should be implements into the building design in consultation with other specialists to ensure they meet the structural, fire, thermal or other aspects of building construction.

We encourage clients to check with us before using materials or equipment that are alternative to those specified in our Acoustical Report.

7.0 CONCLUSION

Day Design was engaged by Midson Group on behalf of The Anglican Schools Corporation to prepare a Construction Noise and Vibration Management Plan for the proposed St Luke's Grammar School new Senior Campus at 800 Pittwater Road and 224 Headland Road, Dee Why, NSW.

Provided the recommendations in Section 6 of this report are implemented, the level of noise and vibration from the construction works at St Luke's Grammar School new Senior Campus at 800 Pittwater Road and 224 Headland Road, Dee Why, NSW will be minimised as far as reasonably practical in accordance with the Australian Standard AS2436:2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* and the EPA's *Interim Construction Noise Guideline 2009* and *Assessing Vibration: a technical guideline 2006*, as detailed in Section 4 of this report.

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Senior Acoustical Consultant

for and on behalf of Day Design Pty Ltd

AAAC MEMBERSHIP

Day Design Pty Ltd is a member company of the Association of Australasian Acoustical Consultants, and the work herein reported has been performed in accordance with the terms of membership.

APPENDICES

Appendix A – Instrumentation
Appendix B – Ambient Noise Surveys
AC108-1 to 4 – Glossary of Acoustical Terms

NOISE SURVEY INSTRUMENTATION

Noise level measurements and analysis in this report were made with instrumentation as follows:

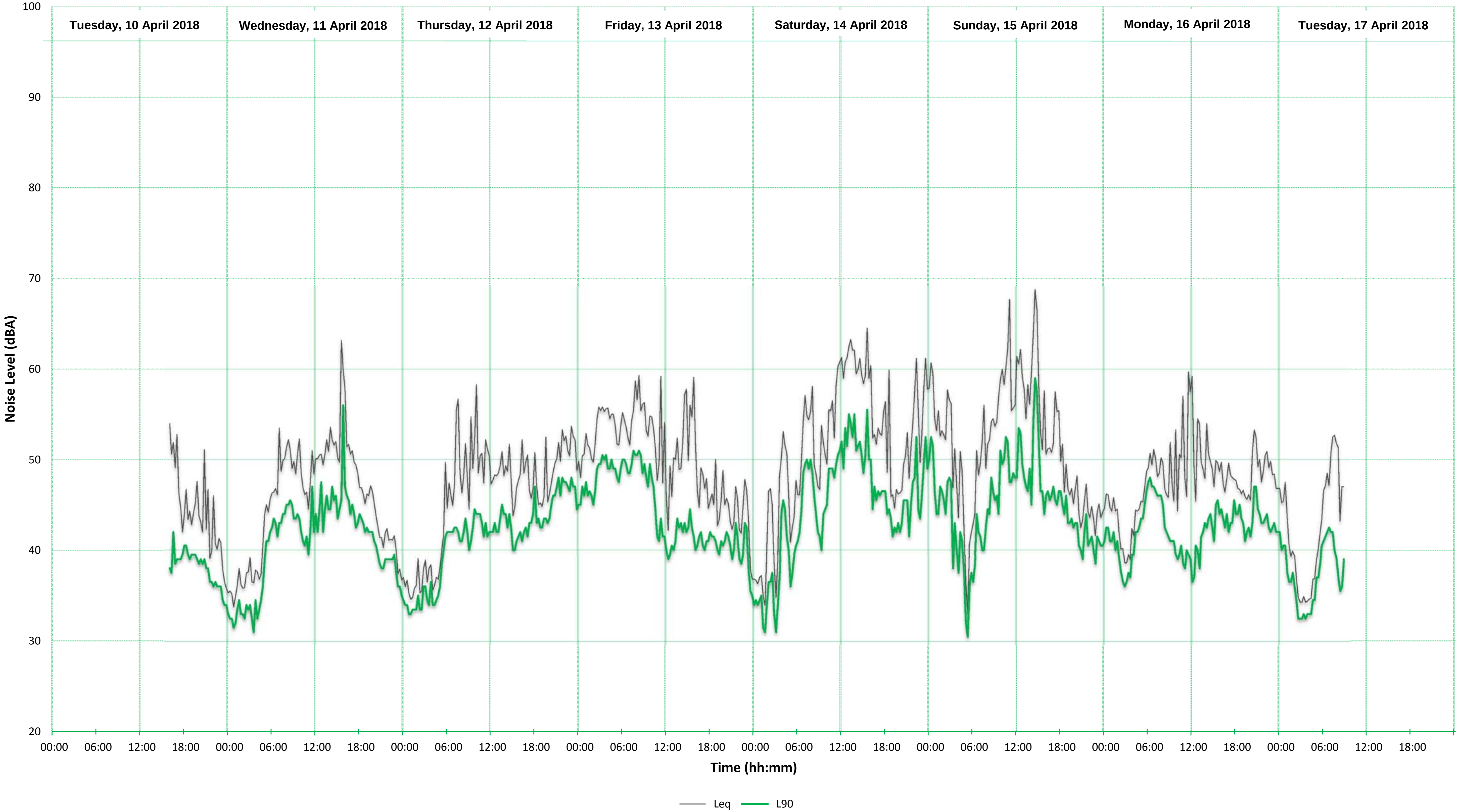
Table A1 Noise Survey Instrumentation

Description	Model No	Serial No
Infobyte Noise Logger (Type 2) Condenser Microphone 0.5" diameter	iM4 MK 250	113 113
Infobyte Noise Logger (Type 2) Condenser Microphone 0.5" diameter	iM4 MK 250	117 117
Infobyte Noise Logger (Type 2) Condenser Microphone 0.5" diameter	iM4 MK 250	118 118

An environmental noise logger is used to continuously monitor ambient noise levels and provide information on the statistical distribution of noise during an extended period of time. The Infobyte Noise Monitors iM4 #113, #117 and #118 are Type 2 precision environmental noise monitor meeting all the applicable requirements of AS1259 for an integrating-averaging sound level meter.

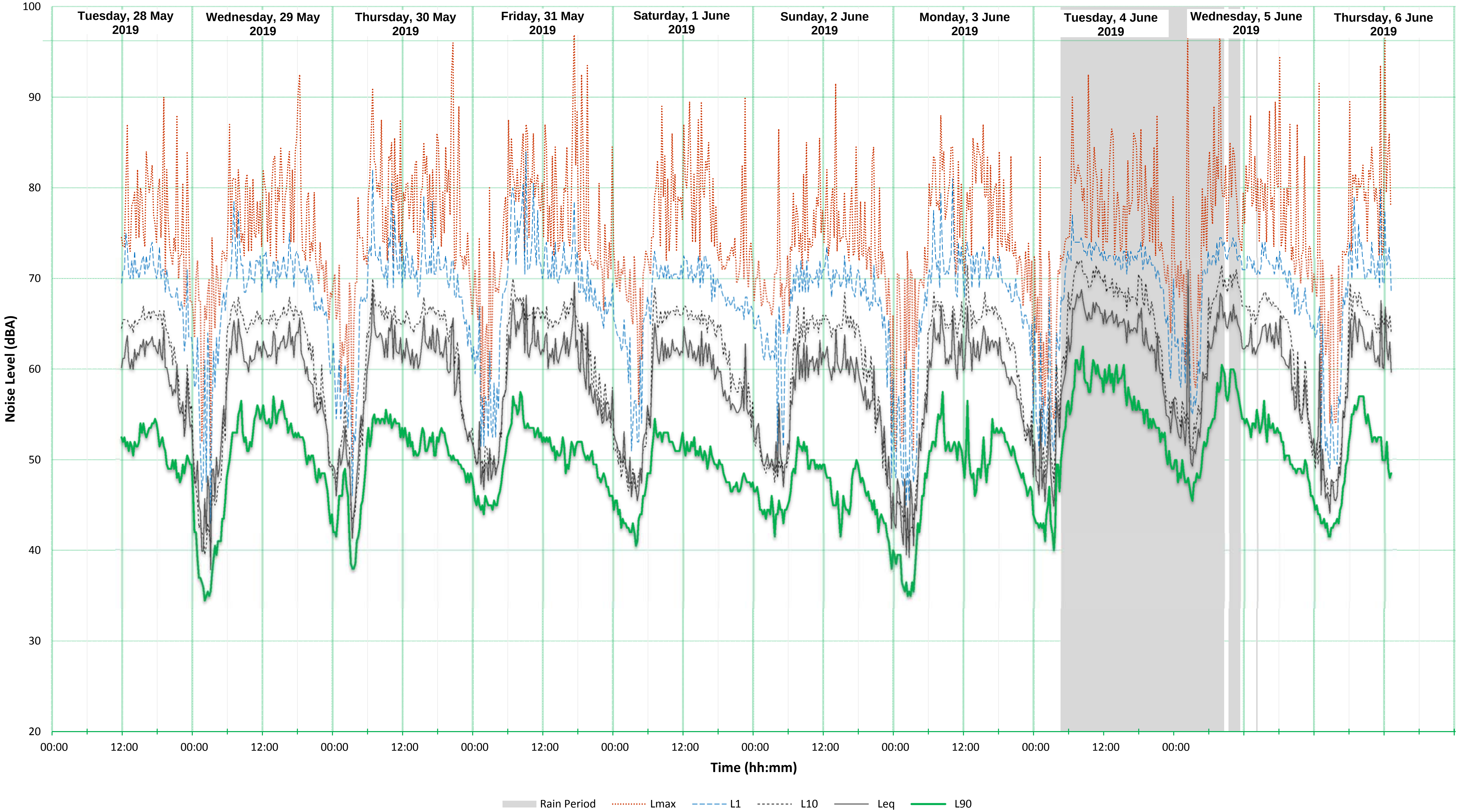
All instrument systems had been laboratory calibrated using instrumentation traceable to Australian National Standards and certified within the last two years thus conforming to Australian Standards. The measurement system was also field calibrated prior to and after noise surveys. Calibration drift was found to be less than 1 dB during unattended measurements. No adjustments for instrument drift during the measurement period were warranted.

Located at Rear yard - 20 Quick Street, Dee Why, NSW



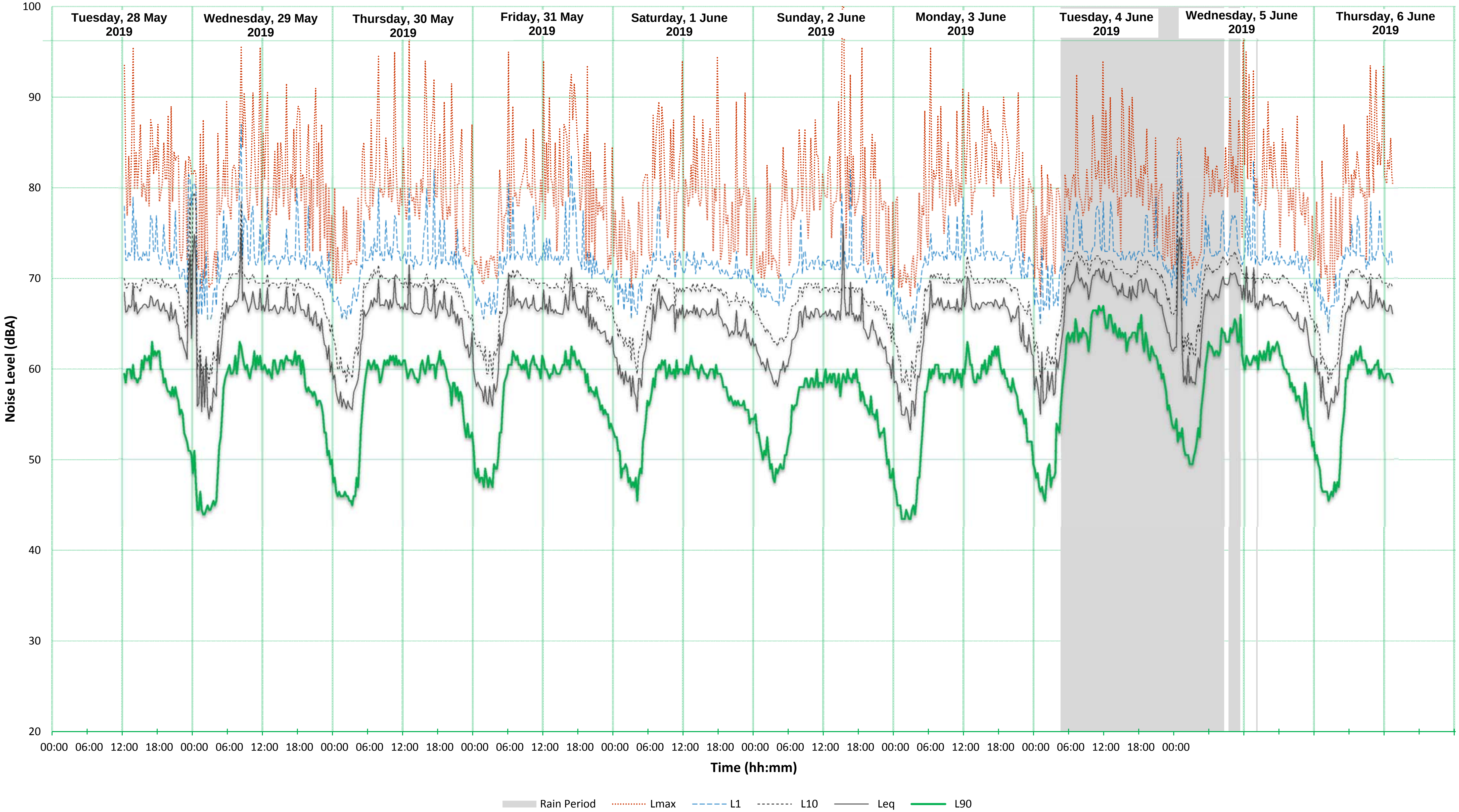
AMBIENT NOISE SURVEY

Located at 209 Headland Rd, Dee Why, NSW



AMBIENT NOISE SURVEY

Located at 800 Pittwater Rd, Dee Why, NSW



ACOUSTICAL – Pertaining to the science of sound, including the generation, propagation, effects and control of both noise and vibration.

AMBIENT NOISE – The ambient noise level at a particular location is the overall environmental noise level caused by all noise sources in the area, both near and far, including road traffic, factories, wind in the trees, birds, insects, animals, etc.

AUDIBLE – means that a sound can be heard. However, there are a wide range of audibility grades, varying from "barely audible" to "just audible", "clearly audible" and "prominent". Chapter 83 of the NSW Environment Protection Authority – Environmental Noise Control Manual (1985) states:

"noise from a particular source might be offensive if it is clearly audible, distinct from the prevailing background noise and of a volume or character that a reasonable person would be conscious of the intrusion and find it annoying or disruptive".

It follows that the word "audible" in an environmental noise context means "clearly audible".

BACKGROUND NOISE LEVEL – Silence does not exist in the natural or the built-environment, only varying degrees of noise. The Background Noise Level is the average minimum dBA level of noise measured in the absence of the noise under investigation and any other short-term noises such as those caused by cicadas, lawnmowers, etc. It is quantified by the L_{A90} or the dBA noise level that is exceeded for 90 % of the measurement period (usually 15 minutes).

- **Assessment Background Level (ABL)** is the single figure background level representing each assessment period – day, evening and night (ie three assessment background levels are determined for each 24hr period of the monitoring period). Determination of the assessment background level is by calculating the tenth percentile (the lowest tenth percent value) of the background levels (L_{A90}) for each period (refer: NSW Industrial Noise Policy, 2000).
- **Rating Background Level (RBL)** as specified by the Environment Protection Authority is the overall single figure (L_{A90}) background noise level representing an assessment period (day, evening or night) over a monitoring period of (normally) three to seven days.

  The RBL for an assessment period is the median of the daily lowest tenth percentile of L_{90} background noise levels.

  If the measured background noise level is less than 30 dBA, then the Rating Background Level (RBL) is considered to be 30 dBA.

DECIBEL – The human ear has a vast sound-sensitivity range of over a thousand billion to one. The decibel is a logarithmic unit that allows this same range to be compressed into a somewhat more comprehensible range of 0 to 120 dB. The decibel is ten times the logarithm of the ratio of a sound level to a reference sound level. See also Sound Pressure Level and Sound Power Level.

Decibel noise levels cannot be added arithmetically since they are logarithmic numbers. If one machine is generating a noise level of 50 dBA, and another similar machine is placed beside it, the level will increase to 53 dBA, not 100 dBA. Ten similar machines placed side by side increase the sound level by 10 dBA, and one hundred machines increase the sound level by 20 dBA.

dBA – The human ear is less sensitive to low frequency sound than high frequency sound. We are most sensitive to high frequency sounds, such as a child's scream. Sound level meters have an inbuilt weighting network, termed the dBA scale, that approximates the human loudness response at quiet sound levels (roughly approximates the 40 phon equal loudness contour).

However, the dBA sound level provides a poor indication of loudness for sounds that are dominated by low frequency components (below 250 Hz). If the difference between the "C" weighted and the "A" weighted sound level is 15 dB or more, then the NSW Industrial Noise Policy recommends a 5 dBA penalty be applied to the measured dBA level.

dBC – The dBC scale of a sound level meter is similar to the dBA scale defined above, except that at high sound intensity levels, the human ear frequency response is more linear. The dBC scale approximates the 100 phon equal loudness contour.

EQUIVALENT CONTINUOUS NOISE LEVEL, L_{Aeq} – Many noises, such as road traffic or construction noise, vary continually in level over a period of time. More sophisticated sound level meters have an integrating electronic device inbuilt, which average the A weighted sound pressure levels over a period of time and then display the energy average or L_{Aeq} sound level. Because the decibel scale is a logarithmic ratio the higher noise levels have far more sound energy, and therefore the L_{Aeq} level tends to indicate an average which is strongly influenced by short term, high level noise events. Many studies show that human reaction to level-varying sounds tends to relate closely to the L_{Aeq} noise level.

FREE FIELD – This is a sound field not subject to significant reflection of acoustical energy. A free field over a reflecting plane is usually outdoors with the noise source resting on hard flat ground, and not closer than 6 metres to any large flat object such as a fence or wall; or inside an anechoic chamber.

FREQUENCY – The number of oscillations or cycles of a wave motion per unit time, the SI unit being the Hertz, or one cycle per second.

IMPACT ISOLATION CLASS (IIC) – The American Society for Testing and Materials (ASTM) has specified that the IIC of a floor/ceiling system shall be determined by operating an ISO 140 Standard Tapping Machine on the floor and measuring the noise generated in the room below. The IIC is a number found by fitting a reference curve to the measured octave band levels and then deducting the sound pressure level at 500 Hz from 110 decibels. Thus the higher the IIC, the better the impact sound isolation.

IMPACT SOUND INSULATION ($L_{nT,w}$) – Australian Standard AS ISO 717.2 – 2004 has specified that the Impact Sound Insulation of a floor/ceiling system be quantified by operating an ISO 140 Standard Tapping Machine on the floor and measuring the noise generated in the room below. The Weighted Standardised Impact Sound Pressure Level ($L_{nT,w}$) is the sound pressure level at 500 Hz for a reference curve fitted to the measured octave band levels. Thus the lower $L_{nT,w}$ the better the impact sound insulation.

IMPULSE NOISE – An impulse noise is typified by a sudden rise time and a rapid sound decay, such as a hammer blow, rifle shot or balloon burst.

INTRUSIVE NOISE LEVEL, L_{Aeq} – The level of noise from a factory, place of entertainment, etc. in NSW is assessed on the basis of the average maximum noise level, or the $L_{Aeq\ (15\ min)}$. This is the energy average A weighted noise level measured over any 15 minute period.

LOUDNESS – The degree to which a sound is audible to a listener is termed the loudness. The human ear perceives a 10 dBA noise level increase as a doubling of loudness and a 20 dBA noise increase as a quadrupling of the loudness.

MAXIMUM NOISE LEVEL, L_{Amax} – The rms maximum sound pressure level measured on the "A" scale of a sound level meter during a noise survey is the L_{Amax} noise level. It may be measured using either the Fast or Slow response time of the meter. This should be stated.

NOISE RATING NUMBERS – A set of empirically developed equal loudness curves has been adopted as Australian Standard AS1469-1983. These curves allow the loudness of a noise to be described with a single NR number. The Noise Rating number is that curve which touches the highest level on the measured spectrum of the subject noise. For broadband noise such as fans and engines, the NR number often equals the dBA level minus five.

NOISE – Noise is unwanted sound. Sound is wave motion within matter, be it gaseous, liquid or solid. "Noise includes sound and vibration".

NOISE REDUCTION COEFFICIENT – See: "Sound Absorption Coefficient".

OFFENSIVE NOISE - (Reference: Dictionary of the Protection of the Environment Operations Act 1997). *"Offensive Noise means noise:*

(a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances:

- *(i) is harmful to (or likely to be harmful to) a person who is outside the premise from which it is emitted, or*
- *(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*

(b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances prescribed by the regulations."

PINK NOISE – Pink noise is a broadband noise with an equal amount of energy in each octave or third octave band width. Because of this, Pink Noise has more energy at the lower frequencies than White Noise and is used widely for Sound Transmission Loss testing.

REVERBERATION TIME, T_{60} – The time in seconds, after a sound signal has ceased, for the sound level inside a room to decay by 60 dB. The first 5 dB decay is often ignored, because of fluctuations that occur while reverberant sound conditions are being established in the room. The decay time for the next 30 dB is measured and the result doubled to determine the T_{60}. The Early Decay Time (EDT) is the slope of the decay curve in the first 10 dB normalised to 60 dB.

SOUND ABSORPTION COEFFICIENT, α – α Sound is absorbed in porous materials by the viscous conversion of sound energy to heat energy as the sound waves pass through it. Sound is similarly absorbed by the flexural bending of internally damped panels. The fraction of incident energy that is absorbed is termed the Sound Absorption Coefficient, α. An absorption coefficient of 0.9 indicates that 90 % of the incident sound energy is absorbed. The average α from 250 to 2000 Hz is termed the Noise Reduction Coefficient (NRC).

SOUND ATTENUATION – If an enclosure is placed around a machine, or a silencer is fitted to a duct, the noise emission is reduced or attenuated. An enclosure that attenuates the noise level by 30 dBA, reduces the sound energy by one thousand times.

SOUND EXPOSURE LEVEL (SEL) – The total sound energy of a single noise event condensed into a one second duration or in other words it is an L_{eq} (1 sec).

SOUND PRESSURE LEVEL, L_p – The level of sound measured on a sound level meter and expressed in decibels, dB, dBA, dBC, etc. $L_p = 20 \times \log (P/P_o)$ ... dB

where P is the rms sound pressure in Pascal and P_o is a reference sound pressure of 20 μPa. L_p varies with distance from a noise source.

SOUND POWER LEVEL, L_w – The Sound Power Level of a noise source is an absolute that does not vary with distance or with a different acoustic environment.

$L_w = L_p + 10 \log A$ ... dB, re: 1pW,
where A is the measurement noise-emission area in square metres in a free field.

SOUND TRANSMISSION CLASS (STC) – An internationally standardised method of rating the sound transmission loss of partition walls to indicate the decibels of noise reduction of a human voice from one side to the other. (Refer: Australian Standard AS1276 – 1979)

SOUND TRANSMISSION LOSS – The amount in decibels by which a random sound is reduced as it passes through a sound barrier. A method for the measurement of airborne Sound Transmission Loss of a building partition is given in Australian Standard AS1191 - 2002.

STATISTICAL EXCEEDENCE SOUND LEVELS, L_{A90}, L_{A10}, L_{A1}, etc – Noise which varies in level over a specific period of time (usually 15 minutes) may be quantified in terms of various statistical descriptors:

The L_{A90} is the dBA level exceeded for 90 % of the time. In NSW the L_{A90} is measured over periods of 15 minutes, and is used to describe the average minimum or background noise level.

The L_{A10} is the dBA level that is exceeded for 10 % of the time. In NSW the L_{A10} measured over a period of 10 to 15 minutes. It was until recently used to describe the average maximum noise level, but has largely been replaced by the L_{Aeq} for describing level-varying noise.

The L_{A1} is the dBA level that is exceeded for 1 % of the time. In NSW the L_{A1} may be used for describing short-term noise levels such as could cause sleep arousal during the night.

STEADY NOISE – Noise, which varies in level by 6 dBA or less, over the period of interest with the time-weighting set to “Fast”, is considered to be “steady”. (Refer AS 1055.1 1997)

WEIGHTED SOUND REDUCTION INDEX, R_w – This is a single number rating of the airborne sound insulation of a wall, partition or ceiling. The sound reduction is normally measured over a frequency range of 100 to 3,150 Hertz and averaged in accordance with ISO standard weighting curves (Refer AS/NZS 1276.1:1999).

Internal partition wall R_w + C ratings are frequency weighted to simulate insulation from human voice noise. The R_w + C is always similar in value to the STC rating value. External walls, doors and windows may be $R_w + C_{tr}$ rated to simulate insulation from road traffic noise. This is normally a lower number than the STC rating value.

WHITE NOISE – White noise is broadband random noise whose spectral density is constant across its entire frequency range. The sound power is the same for equal bandwidths from low to high frequencies. Because the higher frequency octave bands cover a wider spectrum, white noise has more energy at the higher frequencies and sounds like a hiss.