NSW GOVERNMENT

Transport Access Program

Pymble Station Upgrade

Supporting Studies

Artist's impression of the proposed Pymble Station Upgrade, subject to detailed design

December 2020

TRANSPORT ACCESS PROGRAM

Pymble Station Upgrade
Noise and Vibration Impact Assessment

Prepared for:

Transport for NSW
Level 5, Tower A, Zenith Centre
821 Pacific Highway
Chatswood NSW 2067

SLR Ref: 630.30060-R02
Version No: -v1.0
November 2020

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Tenancy 202 Submarine School, Sub Base Platypus, 120 High Street
North Sydney NSW 2060 Australia

T: +61 2 9427 8100
E: sydney@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Transport for NSW (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.30060-R02-v1.0	26 November 2020	Joshua Ridgway	Robert Hall	Robert Hall

EXECUTIVE SUMMARY

Transport for NSW proposes to upgrade Pymble Station to meet disability access requirements (the Proposal) as outlined in the *Disability Discrimination Act 1992* (DDA Act). The Proposal would include upgrading the station access and station facilities as well as installing three lifts to the existing footbridge.

This report presents an assessment of construction and operational noise and vibration associated with the scoping design and identifies feasible and reasonable noise and vibration mitigation and management measures to be incorporated in the detailed design and construction planning stage of the Proposal. This assessment forms part of the input to the Review of Environmental Factors (REF).

Construction noise impacts

Construction work associated with the Proposal would be undertaken during standard daytime construction hours (7am to 6pm Monday to Friday and 8am to 1pm Saturday) where reasonable and feasible. However, some work would need to be undertaken during scheduled Sydney Trains track work periods and/or out-of-hours work periods.

Moderate daytime construction noise management level (NML) exceedances are predicted at surrounding residential receivers on both sides of the rail corridor for most of the Proposal's construction activities. Some work activities involving noise intensive equipment (such as vegetation removal and demolition) result in high daytime NML exceedances of up to 19 dB at the nearest residential receivers. These impacts would generally be limited to residential receivers located adjacent to Pymble Station on Grandview Street and Pacific Highway which have direct line of sight to the proposed work. Non-residential receivers immediately adjacent to the proposed work is predicted to have daytime NML exceedances of up to 21 dB during vegetation removal. Receivers which are located further away from the proposed work would have much lower NML exceedances or no predicted noise or vibration impact.

During out-of-hours work periods and scheduled Sydney Trains track work periods, when work is required to be performed during evening and night-time periods, exceedances of the night-time NMLs of up to 28 dBA are predicted for the nearest residential receivers surrounding the Proposal. The high magnitude of impacts at the closest receivers is a result of the highly noise intensive equipment proposed within the construction scenarios, their close proximity to the work and the low night-time NMLs in this location. It is, however, anticipated that night-time work would typically be limited to scheduled Sydney Trains track work periods and would therefore be limited to a relatively short portion of the construction program.

Of the potentially most affected receivers, six residential buildings are predicted to be 'highly noise affected', as defined by the *Interim Construction Noise Guideline* (ICNG), during the worst-case work scenarios (vegetation removal and demolition). These impacts are predominantly driven by the proposed use of highly noise intensive equipment items and parts of the work area which is close to the receivers. For instance, the wood chipper and chainsaw in the vegetation removal scenario and the grinder and saw in the demolition scenario may be operated across a range of the work areas. This results in a number of sensitive receivers in close proximity to the equipment at times during the work. It is noted that these high magnitude impacts would likely be limited to short periods where the proposed work is occurring closest to each receiver.

EXECUTIVE SUMMARY

Management of potential impacts from small to medium vibration-producing construction plant is not anticipated to be required. However, should larger equipment be required then management measures should be implemented to reduce potential impacts. Similarly, if vibration intensive equipment is required to be used in the vicinity of the station building, vibration levels should be confirmed and mitigation measures implemented as required.

Specific and additional mitigation and management measures for construction noise and vibration are outlined in this report.

Operational noise impacts

This assessment presents the applicable noise criteria for industrial noise sources associated with the Proposal.

At this stage of the design specific lift and substation systems have not been selected, which means it is too early to assess compliance with the applicable noise criteria. However, given this type of noise source generally has relatively low noise emissions, it is anticipated that the lift and substation system designs could be relatively easily mitigated if required during the detailed phase of the Proposal through the selection of appropriate equipment. While noise emissions from PA systems are generally louder than the other operational noise sources, they can typically be designed to minimise any impacts through the equipment selection, location, directionality and volume.

Cumulative noise impacts from all station noise sources should be assessed in the detailed design stage when selecting specific equipment locations and models for the lift facilities, PA systems and padmount substation.

CONTENTS

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

GLOSSARY

Item	Description / Definition
CNS	Construction Noise Strategy
CNVS	Construction Noise and Vibration Strategy
DEC	Department of Environment and Conservation (now OEH / EPA)
DECC	Department of Environment and Climate Change (now OEH / EPA)
DECCW	Department of Environment, Climate Change and Water (now OEH / EPA)
REF	Review of Environmental Factors
EPA	Environment Protection Authority
ICNG	Interim Construction Noise Guideline
INP	Industrial Noise Policy
NPfI	Noise Policy for Industry
NML	Noise Management Level
NSW	New South Wales
RBL	Rating Background Level
RNP	Road Noise Policy
SLR	SLR Consulting Australia Pty Ltd
SWL	Sound Power Level

1 Introduction

Transport for NSW is proposing to upgrade Pymble Station (the Proposal) to meet accessibility requirements outlined in the *Disability Discrimination Act 1992* (DD Act).

The Proposal is part of the Transport Access Program (TAP) which is an NSW Government initiative to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure. The Proposal would provide safe and equitable access to the surrounding pedestrian network at Pymble Station and would also improve customer facilities and amenity.

1.1 Report objectives

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Transport for NSW to prepare a construction and operational noise and vibration assessment for the proposed station upgrade at Pymble.

The aims of this assessment are to:

- summarise the construction and operational noise and vibration assessment of the scoping design for the Proposal
- identify feasible and reasonable noise and vibration mitigation and management measures to be incorporated in the detailed design and construction planning stage of the Proposal.

This assessment forms part of the input to the Review of Environmental Factors (REF).

1.2 Relevant guidelines

The noise and vibration guidelines for construction and operations are based on publications managed by the NSW Environment Protection Authority (EPA). The EPA guidelines applicable to this assessment include:

- operational noise – *Noise Policy for Industry* (NPfI, EPA 2017)
- construction noise – *Interim Construction Noise Guideline* (DECC 2009)
- construction and operational vibration (human comfort) – *Assessing Vibration – a technical guideline* (DEC 2006)
- road traffic noise on public roads – NSW *Road Noise Policy* (RNP), NSW EPA 2011).

The following additional guidelines are also referenced in this study:

- construction noise and vibration mitigation - *Construction Noise and Vibration Strategy* (CNVS, version 4.2, Transport for NSW, 2019) and its November 2019 addendum to Tables 8 and 9.

1.3 Terminology

Specific acoustic terminology is used within this assessment. An explanation of common acoustic terms is included as **Appendix A**.

2 Proposal description

2.1 Proposal overview

The Proposal involves an upgrade of Pymble Station as part of the Transport Access Program which aims to improve accessibility and amenity for customers.

The Proposal would include the following elements.

- three new lifts connecting the existing footbridge to the Grandview Street station entrance, the Pacific Highway station entrance and the station platform
- upgrades to the Grandview Street station entrance including a widened footpath to allow for a new lift landing with a canopy
- modifications to the existing taxi rank and no parking zone to accommodate the widened footpath on Grandview Street
- two new accessible parking spaces and one accessible kiss and ride space at the Pacific Highway station entrance car park
- upgrades to the Pacific Highway station entrance including:
  - a three stop lift connecting the car park / accessible parking, the bus stop at street level and the footbridge
  - a new accessible path to the lift landing with a new canopy at car park level
  - a new lift landing at street level with footpath upgrades
  - a new widened stair entrance with canopy upgrades.
- upgrades to the existing footbridge including canopy extensions and anti-throw screens, and the conversion of the vacant kiosk to allow for a new lift and lift landing
- canopy extension at platform level from the lift to the boarding assistance zone
- a new family accessible toilet and unisex ambulant toilet within the station building
- upgrade work to the existing stairs including replacement of treads and handrails
- improvements to station lighting and CCTV to improve safety and security
- improvements to customer information and communication systems including wayfinding modifications, public address (PA) system upgrade and new hearing induction loops
- modifications to the rail corridor fencing at the Grandview Street and Pacific Highway station entrances
- electrical upgrades for the new infrastructure, including a new padmount substation
- localised platform regrading and the replacement of tactiles.

The general layout of key elements for the Proposal is shown in **Figure 1**.

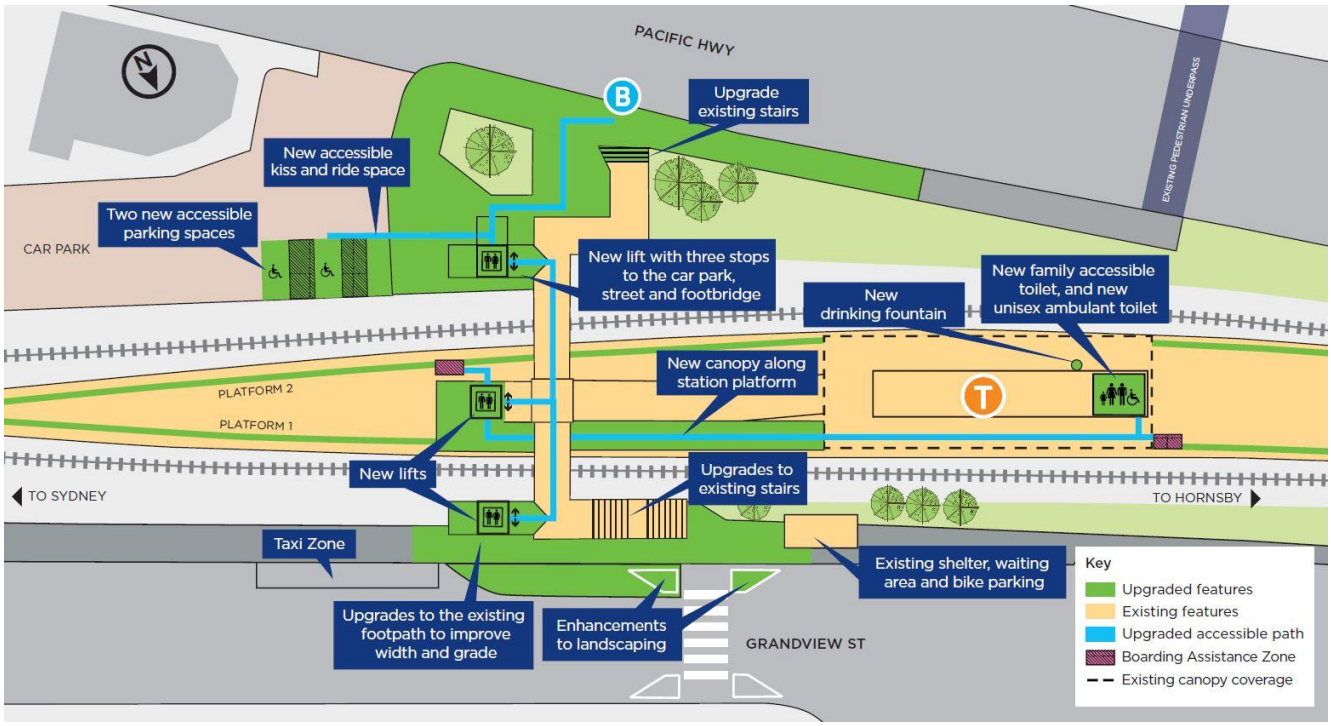


Figure 1 Key elements of the Proposal (indicative only, subject to detailed design)

2.2 Identification of sensitive receivers

The Proposal work is located as shown in **Figure 2**. Also shown are surrounding sensitive receivers, the Noise Catchment Areas (NCA.01 and NCA.02) and the noise monitoring locations L.01 and L.02.

Table 1 provides a summary of the noise catchment areas shown as NCA.01 and NCA.02 in **Figure 2**.

Table 1 Representative noise sensitive receivers

NCA	Boundary description	Sensitive receiver descriptions
NCA.01	Receivers located on the northern side of the rail corridor.	Nearest receivers are the front row of mixed commercial and medical centre, along with residential receivers to the east and beyond to the north. Closest receivers located approximately 25 m north of the Pymble Station platform.
NCA.02	Receivers located on the southern side of the rail corridor.	Mostly residential buildings beyond Pacific Highway with a mixed block of commercial, medical (Pymble Medical and Dental Centre) and educational (Capra Coaching) located immediately south of the station, between the rail corridor and Pacific Highway. Closest receivers located approximately 20 m south of the Pymble Station platform.

Figure 2 Site location and sensitive receivers

3 Existing acoustic environment

3.1 Continuous unattended monitoring

3.1.1 Noise monitoring procedure

Noise monitoring locations (refer to **Figure 2**) were selected based on an inspection of the potentially affected areas, giving consideration to other noise sources which may influence the recordings, security issues for the noise monitoring device and gaining permission for access to the location from the resident or landowner. Monitoring was undertaken from 27 August 2020 to 11 September 2020. Instrument calibration was checked before and after the measurement survey, with the variation in calibrated levels not exceeding the acceptable variation of ±0.5 dB (AS 1055).

The results of the noise monitoring have been processed to exclude periods of adverse wind and/or rain to establish representative noise levels at the locations.

3.1.2 Noise monitoring results

A summary of the unattended continuous noise monitoring is provided in **Table 2**. A full graphical representation of the unattended noise monitoring results is provided in **Appendix B**.

Table 2 Unattended noise logger results

Location	Equipment used	Address	Period[1]	Measurement parameter (dBA)			
				L90	LAeq	LA10	LA1
L.01	Svantek 957 (serial number 20668)	55 Grandview Street	Daytime (7am-6pm)	51	60	62	70
			Evening (6pm-10pm)	48	58	59	69
			Night-time (10pm-7am)	37	56	55	67
L.02	Svantek 957 (serial number 23241)	1 Livingstone Avenue	Daytime (7am-6pm)	62	76	78	85
			Evening (6pm-10pm)	59	74	77	83
			Night-time (10pm-7am)	44	72	74	82

Note 1: NPfI Governing Periods - Day: 7am to 6pm Monday to Saturday, 8am to 6pm Sundays & Public Holidays, Evening: 6pm to 10pm, Night: 10pm to 7am Monday to Saturday, 10pm to 8am Sundays & Public Holidays.

3.2 Operator attended measurements

3.2.1 Noise measurement procedure

The operator-attended noise measurements were undertaken on 27 August 2020 at L.01 and 2 September 2020 at L.02 using a calibrated Brüel and Kjær 2250L, Sound Level Meter Serial No: 3004636. The acoustic instrumentation employed throughout the noise monitoring survey was designed to comply with the requirements of *AS IEC 61672.1-2004: Electroacoustics - Sound level meters - Specifications* as a type 1 precision sound level meter and has an accuracy suitable for both field and laboratory use. Both the meter and calibrator carry current NATA calibration certificates.

3.2.2 Noise measurement results

A summary of the operator-attended ambient noise survey is shown in **Table 3**.

Table 3 Operator attended ambient noise survey

Measurement Location	Measured noise levels (dBA)			Observations (dBA)
	LA90	LAeq	LAmax	
L01 - 55 Grandview Street, Pymble 2:57pm 27/08/2020	51	57	70	Light-vehicle passby Grandview Street: 50-64 Traffic on Pacific Hwy: cars 50-58, trucks up to 64 Aircraft: up to 63 Train passby: 60-70 Birds: up to 57
L02 – 1 Livingstone Avenue, Pymble 1:37 pm 2/09/2020	63	76	93	Light-vehicle passby Pacific Hwy: 70-83 Idling traffic at lights: 56-66 Heavy-vehicle passby: up to 89 Distant traffic 56-66 Loud car passby: 85,. Motorbike passby: 86, 93 Trains not audible except during breaks in road traffic

Daytime ambient noise levels at L.01 and L.02 were observed to be dominated by traffic movements along Pacific Highway. Train movements were clearly audible at L.01 and were audible during breaks in traffic at L.02.

4 Construction noise assessment

4.1 Noise and vibration guidelines

4.1.1 Construction noise metrics

The three primary noise metrics used to describe construction noise emissions:

- **$L_{A1(1minute)}$** – the "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, assessment may be conducted using the L_{Amax} or maximum noise level
- **$L_{Aeq(15minute)}$** – the "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts
- **L_{A90}** – the "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction Noise Management Levels (NMLs) are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

4.1.2 NSW Interim Construction Noise Guideline

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

The ICNG requires proposal specific Noise Management Levels (NMLs) to be established for noise affected receivers. In the event construction noise levels are predicted to be above the NMLs, feasible and reasonable work practices are investigated to minimise noise emissions.

4.1.2.1 Residential receivers

The ICNG provides an approach for determining $L_{Aeq(15minute)}$ NMLs at residential receivers adjacent to the work by applying the measured $L_{AF90(15minute)}$ rating background noise levels (RBL), as described in **Table 4**.

Table 4 ICNG - determination of NMLs for residential receivers

Time of day	NML $L_{Aeq(15minute)}$	How to apply
Standard hours Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	RBL[1] + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring 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	RBL[1] + 5 dBA	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 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1: The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW *Noise Policy for Industry*.

4.1.2.2 Sleep disturbance

For the purposes of this assessment, the following night-time sleep disturbance noise goal has been used:

- night-time RBL +15 dBA "screening criterion"

4.1.2.3 Commercial receivers

The ICNG explains that due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories:

- industrial premises: external $L_{Aeq(15minute)}$ 75 dBA
- offices, retail outlets: external $L_{Aeq(15minute)}$ 70 dBA
- other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.

The external noise levels are assessed at the most-affected occupied point of the premises.

4.1.2.4 Other sensitive land uses

The ICNG's quantitative assessment method provides NMLs for other sensitive land uses, such as educational institutes, medical facilities, etc. These land uses are considered potentially sensitive to construction noise only when the properties are in use. The ICNG also references *AS2107:2016 – Recommended design sound levels and reverberation times for building interiors* for criteria of other sensitive receiver types that are not listed in the guideline. Neither the ICNG or AS 2107 provide criteria for childcare centres so the Association of Australian Acoustical Consultants *Guideline for Child Care Centre Acoustic Assessment* (GCCCAA) has also been referenced to adopt a noise management level for such receivers. The NMLs for the other sensitive receivers identified in the Proposal area are reproduced in **Table 5**.

Table 5 NMLs – other sensitive land uses

Use	Period	NML derived from	Noise Management Level $L_{Aeq(15minute)}$ (dBA)	
			Internal	External
Commercial	Daytime	ICNG	-	70
Childcare centre	Daytime	GCCCAA	40	50[1]
Educational	Daytime	ICNG	45	55[1]
Hotel	Daytime, evening and night-time	AS2107	45	55[1]
Public building (eg town hall)	Daytime	AS2107	45	55[1]
Place of worship	Daytime and evening	ICNG	45	55[1]
Medical facilities	Daytime	ICNG	45	65[2]
Active recreation area	Daytime and evening	ICNG	-	65
Passive recreation area	Daytime and evening	ICNG	-	60

Note 1: Receiver conservatively assumed to have openable windows and a 10 dB outside to inside facade performance.

Note 2: ICNG internal goal + 20 dB as fixed window glazing and air conditioning is assumed. A minimum outside-to-inside attenuation of 20 dB is assumed

As the noise management level for multiple other sensitive occupancy types nominated in the ICNG is an internal level, the corresponding external noise level (which the assessments are based upon) has been determined on the assumption that a 10 dB noise reduction from outside to inside is applicable. This is generally considered to be a typical assumption for a 'windows open' scenario. For medical facilities, a 20 dB noise reduction is assumed on the basis of fixed windows and air-conditioning.

4.2 Noise assessment criteria

Adopting the measured background noise levels in **Table 2** and assumptions for other sensitive receivers shown in **Table 6**, the NMLs derived for the Proposal are outlined in **Table 6**.

Table 6 NMLs for construction

Receiver type	NCA	RBL (dBA)			Standard construction (RBL+10dBA)	Out of Hours (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15)
		Day	Eve.	Night	Daytime period	Daytime period	Evening period	Night-time period	
Residential (L01)	NCA01	51	48	37	61	56	53	42	52
Residential (L02)	NCA02	62	59	44	72	67	64	49	59
Commercial	All	n/a	n/a	n/a	70	70	n/a	n/a	n/a
Other Sensitive (Childcare Centre)		n/a	n/a	n/a	50	50	n/a	n/a	n/a
Other Sensitive (Place of Worship)		n/a	n/a	n/a	55	55	55	n/a	n/a
Other Sensitive (Educational)		n/a	n/a	n/a	55	55	n/a	n/a	n/a
Other Sensitive (Medical Centre)		n/a	n/a	n/a	65	65	n/a	n/a	n/a
Other Sensitive (Hotel)		n/a	n/a	n/a	55	55	55	55	n/a
Other Sensitive (Public Building)		n/a	n/a	n/a	55	55	n/a	n/a	n/a
Other Sensitive (Outdoor Passive Recreation)		n/a	n/a	n/a	60	60	60	n/a	n/a
Other Sensitive (Outdoor Active Recreation)		n/a	n/a	n/a	65	65	65	n/a	n/a

Note 1: Out of Hours construction hours – Daytime hours are: Saturday 7am to 8am and 1pm to 6pm, Sunday/public holiday 8am to 6pm. Evening hours are: 6pm to 10pm. Night-time hours are: Monday to Friday 10pm to 7am, Saturday 10pm to 8am, Sunday/public holiday 10pm to 7am.

4.3 Ground-borne noise assessment criteria

Construction work can cause ground-borne noise impacts in nearby buildings when vibration generating equipment is in use. Vibration can be transmitted through the ground and into the structure of nearby buildings, which can then create audible noise impacts inside the building. The ICNG and CNVS provide evening and night-time ground-borne noise NMLs for residences to protect the amenity and sleep of affected residents. The ground-borne noise NMLs are:

- Evening $L_{Aeq(15minute)}$ 40 dBA
- Night-time $L_{Aeq(15minute)}$ 35 dBA.

For commercial receivers, the CNVS does not provide guidance in relation to acceptable ground-borne noise levels. An internal NML of 60 dBA has been used for these receivers, which is consistent with other similar infrastructure projects.

The NMLs only apply where internal ground-borne noise levels are higher than noise transmitted through the air. This situation can occur where buildings near to construction works have high performing facades which attenuate the airborne component, or where sensitive internal areas do not have facades which face the construction works. Should buildings susceptible to ground-borne noise be identified in the project area this should be assessed during preparation of the Construction Noise and Vibration Management Plan (CNVMP).

4.4 Vibration assessment criteria

The effects of vibration in buildings can be divided into three main categories – those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be affected.

4.4.1 Human comfort vibration

The EPA's *Assessing Vibration: a technical guideline* provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV) rather than a continuous vibration level. The VDV is dependent upon the level and duration of the short-term vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the document for vibration of an intermittent nature (ie construction work where more than three distinct vibration events occur) are presented in **Table 7**.

Table 7 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$) (*Assessing Vibration: a technical guideline)*

Building types	Assessment period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (eg hospital operating theatres, precision laboratories)	Day or Night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night-time	0.40	0.80

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods, and is dependent on the level of vibration as well as the duration.

4.4.2 Effects on building contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. For most receivers, the controlling vibration criterion will be the human comfort criterion, and it is therefore not normally required to set separate criteria in relation to the effect of construction vibration on most building contents.

Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives

4.4.3 Structural damage vibration

Structural damage vibration limits are based on Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* and British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*. These standards provide frequency-dependent vibration limits related to cosmetic damage, noting that cosmetic damage is very minor in nature, is readily repairable and does not affect the structural integrity of the building. The recommended vibration limits from BS 7385 for transient vibration for minimal risk of cosmetic damage to residential and industrial buildings is shown in **Table 8**.

Table 8 Transient vibration guide values for minimal risk of cosmetic damage (BS 7385)

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

4.4.4 Minimum working distances

As a guide, minimum working distances for the proposed items of vibration intensive plant are provided in the CNVS and are reproduced below in **Table 9**.

Table 9 Recommended minimum working distances for vibration intensive plant

Plant item	Rating/description	Minimum working distance[1]	
		Cosmetic damage (BS 7385)	Human response (NSW EPA Vibration Guideline)
Vibratory roller	< 50 kN (Typically 1-2t)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4t)	6 m	20 m
	< 200 kN (Typically 4-6t)	12 m	40 m
	< 300 kN (Typically 7-13t)	15 m	100 m
	> 300 kN (Typically 13-18t)	20 m	100 m
	> 300 kN (Typically > 18t)	25 m	100 m
Small hydraulic hammer	300 kg - 5 to 12t excavator	2 m	7 m
Medium hydraulic hammer	900 kg - 12 to 18t excavator	7 m	23 m
Large hydraulic hammer	1600 kg - 18 to 34t excavator	22 m	73 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure
Bored piling	< 800 mm	2 m	n/a

Note 1: More stringent conditions may apply to heritage or other sensitive structures, Refer **Section 4.10.4**.

The minimum working distances presented in **Table 9** are quoted for both cosmetic damage (refer to BS 7385:2 *Evaluation and Measurement for Vibration in Buildings Part 2: Guide to Damage Levels from Ground-borne Vibration*, 1993) and human comfort (refer to NSW EPA *Assessing Vibration: a technical guideline*, 2006).

The minimum working distances for building damage should be complied with at all times. The distances are noted as being indicative and would vary depending on the particular item of plant and local geotechnical conditions. They apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive work is required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed.

4.5 Construction timing

4.5.1 Staging

Subject to approval, construction is expected to commence in early 2021 and take around 24 months to complete. The construction methodology would be further developed during the detailed design of the Proposal by the nominated Contractor in consultation with Transport for NSW.

The proposed construction activities for the Proposal are identified in **Section 4.6**. The construction staging outlined in this assessment is indicative and is based on the current scoping design and may change once the detailed design methodology is finalised. The staging is also dependent on the Contractor's preferred methodology, program, and sequencing of work.

4.5.2 Construction hours

Where possible, work required for the Proposal would be undertaken during standard (NSW) Environment Protection Authority (EPA) construction hours, which are as follows:

- 7am to 6pm Monday to Friday
- 8am to 1pm Saturdays
- no work on Sundays or public holidays.

Work may need to occur outside standard hours and would include night work and work during scheduled Sydney Trains track work periods, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed and trains are not operating.

Out of hours work is required in some cases to minimise disruptions to customers, pedestrians, motorists and nearby sensitive receivers; and to ensure the safety of railway workers and operational assets. It is estimated that approximately six scheduled Sydney Trains track work periods may be required to facilitate the following:

- services relocation
- site establishment and demolition work
- installation of construction hoardings
- electrical, power supply and communication upgrades
- excavation, piling, forming and concrete pouring of lift pits / foundations
- installation of lift structures
- demolition of the existing kiosk on the footbridge and the installation of the new landing
- platform regrading / resurfacing and platform excavations for services
- modifications to the station building.

Out of hours work may also be scheduled outside scheduled Sydney Trains track work periods. Approval from Transport for NSW would be required for any out of hours work and the affected community would be notified as outlined in the CNVS.

4.6 Construction work scenarios

In order to assess the potential noise and vibration impacts during construction, a number of scenarios comprising typical plant and equipment have been developed. These are summarised in **Table 10**.

Piling work is associated with several work activities. For the purpose of this assessment, it is assumed that piling work would be performed using bored piling. If the construction contractor elects to use an alternative piling method, the noise and vibration levels generated by the use of this plant may be different to those presented in this assessment and should be reviewed during detailed design.

Table 10 Indicative construction scenarios

Plant item			Chainsaw[1]	Chipper	Concrete Mixer Truck	Concrete Pump	Concrete Saw[1]	Concrete Vibrator	Elevated Working Platform	Excavator	Flatbed Truck	Forklift	Generator / Light Tower	Grinder / Demolition Saw[1]	Hand Tools	Hi-Rail Plant (Hiab / Flatbed)	Jackhammer[1]	Mobile Crane	Piling - Bored	Roller – Vibratory[1]	Truck
Sound Power Level (LAeq)[1]			114	116	103	106	118	102	97	99	100	101	98	105	94	102	113	100	111	109	108
Assumed on-time in 15 minute period (minutes)			5	15	7.5	7.5	5	15	3	7.5	3	15	15	5	15	7.5	5	7.5	7.5	15	3
SWL Max (LAmax)			116	120	112	109	122	105	102	105	106	106	98	108	100	110	115	107	118	115	112
ID	**Scenario**	**Activity**																			
1a	Site establishment	Establishment of site compounds and work areas							X			X	X		X			X			X
1b		Vegetation removal	X	X					X						X						X
2a	Power supply work	Removal of existing power infrastructure							X				X		X			X			X
2b		Earthwork and installation of new power infrastructure and underground cables			X	X		X	X	X			X		X				X	X	X

Plant item			Chainsaw[1]	Chipper	Concrete Mixer Truck	Concrete Pump	Concrete Saw[1]	Concrete Vibrator	Elevated Working Platform	Excavator	Flatbed Truck	Forklift	Generator / Light Tower	Grinder / Demolition Saw[1]	Hand Tools	Hi-Rail Plant (Hiab / Flatbed)	Jackhammer[1]	Mobile Crane	Piling - Bored	Roller – Vibratory[1]	Truck
Sound Power Level (LAeq)[1]			114	116	103	106	118	102	97	99	100	101	98	105	94	102	113	100	111	109	108
Assumed on-time in 15 minute period (minutes)			5	15	7.5	7.5	5	15	3	7.5	3	15	15	5	15	7.5	5	7.5	7.5	15	3
SWL Max (LAmax)			116	120	112	109	122	105	102	105	106	106	98	108	100	110	115	107	118	115	112
ID	**Scenario**	**Activity**																			
3a	Main work	Demolition of existing railings, kiosk and components, etc, where required					X		X					X	X						X
3b		Excavation and piling work								X			X		X	X	X		X	X	X
3c		Concrete work			X	X		X					X			X					
3d		Installation of lifts, services, and fit-out							X		X	X	X		X	X		X			X
3e		Platform resurfacing					X		X				X	X		X	X	X		X	
3f		Platform canopies work							X	X	X	X	X		X	X	X	X			X
3g		Station building modifications							X				X		X						X
3H		Laydown areas									X		X			X		X			
4a	Site demobilisation	Commissioning and demobilisation										X	X		X			X			X

Note 1: Incorporates the ICNG 'annoyance penalty'

4.7 Predicted noise impacts

In order to quantify noise emissions from the proposed construction work, a 3D computer noise model has been used to predict the $L_{Aeq(15minute)}$ and $L_{A1(1minute)}$ noise levels at the nearest receivers.

The predictions include the source noise levels of the anticipated equipment, the location of the nearest sensitive receivers, the number of plant items likely to be operating at any given time, the distance between the equipment and the receivers, and shielding or reflections provided by topography and/or buildings.

The resultant daytime, daytime Out of Hours, evening and night-time worst-case $L_{Aeq(15minute)}$ and $L_{A1(1minute)}$ noise level predictions for residential receivers and non-residential receivers are presented in **Table 11** and **Table 12** respectively. The results are presented as a summary of the worst-case impacts for each work scenario when the work is located at the nearest position within the work area to each receiver.

In practice, the noise levels will vary due to the fact that plant will move around the worksite and will not all be operating concurrently. As such, noise levels are likely to be lower than the worst-case noise levels presented for notable periods of time during the work.

The ICNG states that where construction work is planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed work.

Table 11 Predicted noise levels at residential receivers

Ref	Work activity	Worst case construction Period	NCA	Type	Noise level – LAeq(15minute) (dBA)												Noise level – LA1(60second) (dBA) (sleep disturbance)		
					Worst-case predicted	RBL			NML				NML Exceedance				Worst-case predicted	Screening criteria (RBL+15 dBA)	Exceedance
						Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
Site establishment																			
1A	Establishment of site compounds and work areas	Night-time	NCA01	RES	68	51	48	37	61	56	53	42	7	12	15	26	77	52	25
			NCA02	RES	70	62	59	44	72	67	64	49	0	3	6	21	79	59	20
1B	Vegetation removal	Standard Daytime	NCA01	RES	80	51	48	37	61	56	53	42	19	-	-	-	-	-	-
			NCA02	RES	81	62	59	44	72	67	64	49	9	-	-	-	-	-	-
Power supply work																			
2A	Removal of existing power infrastructure	Night-time	NCA01	RES	56	51	48	37	61	56	53	42	0	0	3	14	66	52	14
			NCA02	RES	60	62	59	44	72	67	64	49	0	0	0	11	70	59	11
2B	Earthwork and installation of new power infrastructure and underground cables	Night-time	NCA01	RES	63	51	48	37	61	56	53	42	2	7	10	21	69	52	17
			NCA02	RES	67	62	59	44	72	67	64	49	0	0	3	18	73	59	14
Main work																			
3A	Demolition of existing railings, kiosk and components, etc, where required	Night-time	NCA01	RES	64	51	48	37	61	56	53	42	3	8	11	22	72	52	20
			NCA02	RES	77	62	59	44	72	67	64	49	5	10	13	28	85	59	26
3B	Excavation and piling work	Night-time	NCA01	RES	62	51	48	37	61	56	53	42	1	6	9	20	68	52	16
			NCA02	RES	72	62	59	44	72	67	64	49	0	5	8	23	78	59	19
3C	Concrete work	Night-time	NCA01	RES	58	51	48	37	61	56	53	42	0	2	5	16	62	52	10
			NCA02	RES	71	62	59	44	72	67	64	49	0	4	7	22	75	59	16
3D	Installation of lifts, services, and fit-out	Night-time	NCA01	RES	57	51	48	37	61	56	53	42	0	1	4	15	65	52	13
			NCA02	RES	68	62	59	44	72	67	64	49	0	1	4	19	76	59	17
3E	Platform resurfacing	Night-time	NCA01	RES	65	51	48	37	61	56	53	42	4	9	12	23	72	52	20
			NCA02	RES	73	62	59	44	72	67	64	49	1	6	9	24	80	59	21
3F	Platform canopies work	Night-time	NCA01	RES	61	51	48	37	61	56	53	42	0	5	8	19	65	52	13
			NCA02	RES	69	62	59	44	72	67	64	49	0	2	5	20	73	59	14
3G	Station building modifications	Night-time	NCA01	RES	52	51	48	37	61	56	53	42	0	0	0	10	64	52	12
			NCA02	RES	63	62	59	44	72	67	64	49	0	0	0	14	75	59	16
3H	Laydown areas	Night-time	NCA01	RES	66	51	48	37	61	56	53	42	5	10	13	24	72	52	20
			NCA02	RES	62	62	59	44	72	67	64	49	0	0	0	13	68	59	9
Site demobilisation																			
4A	Commissioning and demobilisation	Night-time	NCA01	RES	68	51	48	37	61	56	53	42	7	12	15	26	77	52	25
			NCA02	RES	70	62	59	44	72	67	64	49	0	3	6	21	79	59	20

Note 1: Worst-case predicted noise levels greater than 75 dBA are highlighted in red and indicates highly affected receiver noise levels as defined in the ICNG.
Note 2: Predicted exceedances of the sleep disturbance screening criteria are highlighted in brown.

Table 12 Predicted noise levels at non-residential receivers

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
Site establishment											
1A	Establishment of site compounds and work areas	Night-time	NCA01	COM	X	X			76	70	6
			NCA01	OED	X	X			34	55	-
			NCA01	OME	X	X			60	65	-
			NCA01	OPW	X	X	X		37	55	-
			NCA01	OCC	X	X			46	50	-
			NCA01	OHO	X	X	X	X	51	55	-
			NCA01	OPB	X	X			44	55	-
			NCA01	OOA	X	X	X		48	65	-
			NCA01	OOP	X	X	X		45	60	-
			NCA02	COM	X	X			81	70	11
			NCA02	OED	X	X			54	55	-
			NCA02	OME	X	X			63	65	-
			NCA02	OPW	X	X	X		60	55	5
			NCA02	OCC	X	X			31	50	-
			NCA02	OOA	X	X	X		39	65	-
1B	Vegetation removal	Standard Daytime	NCA01	COM	X	n/a – no work			86	70	16
			NCA01	OED	X				46	55	-
			NCA01	OME	X				85	65	20
			NCA01	OPW	X				50	55	-
			NCA01	OCC	X				62	50	12
			NCA01	OHO	X				69	55	14
			NCA01	OPB	X				57	55	2
			NCA01	OOA	X				61	65	-
			NCA01	OOP	X				57	60	-
			NCA02	COM	X				91	70	21
			NCA02	OED	X				70	55	15
			NCA02	OME	X				83	65	18
			NCA02	OPW	X				72	55	17
			NCA02	OCC	X				45	50	-
			NCA02	OOA	X				53	65	-

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
Power supply work											
2A	Removal of existing power infrastructure	Night-time	NCA01	COM	X	X			72	70	2
			NCA01	OED	X	X			25	55	-
			NCA01	OME	X	X			54	65	-
			NCA01	OPW	X	X	X		25	55	-
			NCA01	OCC	X	X			40	50	-
			NCA01	OHO	X	X	X	X	49	55	-
			NCA01	OPB	X	X			37	55	-
			NCA01	OOA	X	X	X		36	65	-
			NCA01	OOP	X	X	X		35	60	-
			NCA02	COM	X	X			65	70	-
			NCA02	OED	X	X			52	55	-
			NCA02	OME	X	X			58	65	-
			NCA02	OPW	X	X	X		52	55	-
			NCA02	OCC	X	X			23	50	-
			NCA02	OOA	X	X	X		30	65	-
2B	Earthwork and installation of new power infrastructure and underground cables	Night-time	NCA01	COM	X	X			79	70	9
			NCA01	OED	X	X			32	55	-
			NCA01	OME	X	X			61	65	-
			NCA01	OPW	X	X	X		32	55	-
			NCA01	OCC	X	X			47	50	-
			NCA01	OHO	X	X	X	X	56	55	1
			NCA01	OPB	X	X			44	55	-
			NCA01	OOA	X	X	X		43	65	-
			NCA01	OOP	X	X	X		42	60	-
			NCA02	COM	X	X			72	70	2
			NCA02	OED	X	X			59	55	4
			NCA02	OME	X	X			65	65	-
			NCA02	OPW	X	X	X		59	55	4
			NCA02	OCC	X	X			30	50	-
			NCA02	OOA	X	X	X		37	65	-

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
Main work											
3A	Demolition of existing railings, kiosk and components, etc, where required	Night-time	NCA01	COM	X	X			81	70	11
			NCA01	OED	X	X			41	55	-
			NCA01	OME	X	X			65	65	-
			NCA01	OPW	X	X	X		41	55	-
			NCA01	OCC	X	X			53	50	3
			NCA01	OHO	X	X	X	X	59	55	4
			NCA01	OPB	X	X			52	55	-
			NCA01	OOA	X	X	X		55	65	-
			NCA01	OOP	X	X	X		53	60	-
			NCA02	COM	X	X			79	70	9
			NCA02	OED	X	X			60	55	5
			NCA02	OME	X	X			66	65	1
			NCA02	OPW	X	X	X		67	55	12
			NCA02	OCC	X	X			40	50	-
			NCA02	OOA	X	X	X		47	65	-
3B	Excavation and piling work	Night-time	NCA01	COM	X	X			79	70	9
			NCA01	OED	X	X			34	55	-
			NCA01	OME	X	X			61	65	-
			NCA01	OPW	X	X	X		36	55	-
			NCA01	OCC	X	X			47	50	-
			NCA01	OHO	X	X	X	X	56	55	1
			NCA01	OPB	X	X			47	55	-
			NCA01	OOA	X	X	X		45	65	-
			NCA01	OOP	X	X	X		43	60	-
			NCA02	COM	X	X			77	70	7
			NCA02	OED	X	X			58	55	3
			NCA02	OME	X	X			64	65	-
			NCA02	OPW	X	X	X		64	55	9
			NCA02	OCC	X	X			33	50	-
			NCA02	OOA	X	X	X		39	65	-

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
3C	Concrete work	Night-time	NCA01	COM	X	X			78	70	8
			NCA01	OED	X	X			32	55	-
			NCA01	OME	X	X			58	65	-
			NCA01	OPW	X	X	X		32	55	-
			NCA01	OCC	X	X			44	50	-
			NCA01	OHO	X	X	X	X	53	55	-
			NCA01	OPB	X	X			46	55	-
			NCA01	OOA	X	X	X		49	65	-
			NCA01	OOP	X	X	X		46	60	-
			NCA02	COM	X	X			75	70	5
			NCA02	OED	X	X			54	55	-
			NCA02	OME	X	X			60	65	-
			NCA02	OPW	X	X	X		62	55	7
			NCA02	OCC	X	X			30	50	-
			NCA02	OOA	X	X	X		40	65	-
3D	Installation of lifts, services, and fit-out	Night-time	NCA01	COM	X	X			74	70	4
			NCA01	OED	X	X			35	55	-
			NCA01	OME	X	X			57	65	-
			NCA01	OPW	X	X	X		35	55	-
			NCA01	OCC	X	X			46	50	-
			NCA01	OHO	X	X	X	X	52	55	-
			NCA01	OPB	X	X			44	55	-
			NCA01	OOA	X	X	X		43	65	-
			NCA01	OOP	X	X	X		42	60	-
			NCA02	COM	X	X			72	70	2
			NCA02	OED	X	X			53	55	-
			NCA02	OME	X	X			59	65	-
			NCA02	OPW	X	X	X		61	55	6
			NCA02	OCC	X	X			33	50	-
			NCA02	OOA	X	X	X		40	65	-

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
3E	Platform resurfacing	Night-time	NCA01	COM	X	X			79	70	9
			NCA01	OED	X	X			37	55	-
			NCA01	OME	X	X			69	65	4
			NCA01	OPW	X	X	X		39	55	-
			NCA01	OCC	X	X			49	50	-
			NCA01	OHO	X	X	X	X	60	55	-
			NCA01	OPB	X	X			53	55	-
			NCA01	OOA	X	X	X		57	65	-
			NCA01	OOP	X	X	X		54	60	-
			NCA02	COM	X	X			78	70	8
			NCA02	OED	X	X			59	55	4
			NCA02	OME	X	X			67	65	2
			NCA02	OPW	X	X	X		68	55	13
			NCA02	OCC	X	X			39	50	-
			NCA02	OOA	X	X	X		38	65	-
3F	Platform canopies work	Night-time	NCA01	COM	X	X			75	70	5
			NCA01	OED	X	X			33	55	-
			NCA01	OME	X	X			65	65	-
			NCA01	OPW	X	X	X		35	55	-
			NCA01	OCC	X	X			45	50	-
			NCA01	OHO	X	X	X	X	56	55	1
			NCA01	OPB	X	X			49	55	-
			NCA01	OOA	X	X	X		53	65	-
			NCA01	OOP	X	X	X		50	60	-
			NCA02	COM	X	X			74	70	4
			NCA02	OED	X	X			55	55	-
			NCA02	OME	X	X			63	65	-
			NCA02	OPW	X	X	X		64	55	9
			NCA02	OCC	X	X			35	50	-
			NCA02	OOA	X	X	X		34	65	-

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
3G	Station building modifications	Night-time	NCA01	COM	X	X			67	70	-
			NCA01	OED	X	X			27	55	-
			NCA01	OME	X	X			59	65	-
			NCA01	OPW	X	X	X		27	55	-
			NCA01	OCC	X	X			36	50	-
			NCA01	OHO	X	X	X	X	53	55	-
			NCA01	OPB	X	X			43	55	-
			NCA01	OOA	X	X	X		36	65	-
			NCA01	OOP	X	X	X		35	60	-
			NCA02	COM	X	X			61	70	-
			NCA02	OED	X	X			48	55	-
			NCA02	OME	X	X			54	65	-
			NCA02	OPW	X	X	X		55	55	-
			NCA02	OCC	X	X			27	50	-
			NCA02	OOA	X	X	X		38	65	-
3H	Laydown areas	Night-time	NCA01	COM	X	X			61	70	-
			NCA01	OED	X	X			32	55	-
			NCA01	OME	X	X			53	65	-
			NCA01	OPW	X	X	X		35	55	-
			NCA01	OCC	X	X			44	50	-
			NCA01	OHO	X	X	X	X	48	55	-
			NCA01	OPB	X	X			42	55	-
			NCA01	OOA	X	X	X		40	65	-
			NCA01	OOP	X	X	X		38	60	-
			NCA02	COM	X	X			79	70	9
			NCA02	OED	X	X			52	55	-
			NCA02	OME	X	X			61	65	-
			NCA02	OPW	X	X	X		58	55	3
			NCA02	OCC	X	X			29	50	-
			NCA02	OOA	X	X	X		32	65	-

Ref	Work activity	Worst case construction period	NCA	Type[1]	Periods when receiver is in use				Noise level – LAeq(15minute) (dBA)	NML (dBA)	Exceedance (dB)
					Day	Day OOH	Eve	Night	Worst-case predicted		
Site demobilisation											
4A	Commissioning and demobilisation	Night-time	NCA01	COM	X	X			76	70	6
			NCA01	OED	X	X			34	55	-
			NCA01	OME	X	X			60	65	-
			NCA01	OPW	X	X	X		37	55	-
			NCA01	OCC	X	X			46	50	-
			NCA01	OHO	X	X	X	X	51	55	-
			NCA01	OPB	X	X			44	55	-
			NCA01	OOA	X	X	X		48	65	-
			NCA01	OOP	X	X	X		45	60	-
			NCA02	COM	X	X			81	70	11
			NCA02	OED	X	X			54	55	-
			NCA02	OME	X	X			63	65	-
			NCA02	OPW	X	X	X		60	55	5
			NCA02	OCC	X	X			31	50	-
			NCA02	OOA	X	X	X		39	65	-

Note 1: Receiver classification abbreviations are residential (RES), commercial (COM), other sensitive – childcare centre (OCC), other sensitive – educational facility (OED), other sensitive – medical (OME), other sensitive – hotel (OHO), other sensitive – public building eg town hall (OPB), other sensitive – place of worship (POW), other sensitive – outdoor active recreation (OOA), other sensitive – outdoor passive recreation (OOP).

4.8 Discussion

4.8.1 Site establishment

During site establishment, the most potentially affected residential receivers are predicted to exceed the daytime NMLs by up to 19 dB in NCA01 and 9 dB in NCA02 during vegetation removal. During these noise-intensive works the receivers with NML exceedances are generally limited to those with direct line of sight to the equipment and are situated within 200 metres. Impacts at Other sensitive receiver types are typically those receivers immediately adjacent to the work (ie the front row mixed commercial/other receivers adjacent to the station on both sides of the corridor). While the NML exceedances have been identified as relatively high, these impacts are highly dependent on the specific location of the high noise plant which should be considered to minimise the impacts. Options to minimise noise impacts at these receivers are discussed further in **Section 5**.

NML exceedances of this magnitude would be limited to periods when noise intensive equipment for vegetation removal work (chainsaw and wood chipper) are operating directly adjacent to the sensitive receivers. Sensitive receivers which are located further away from the proposed work areas would have lower NML exceedances. For example, the predicted noise levels at the second row of receivers from the work area typically reduce by 10 dB when compared with the front row. However, due to the noise intensive nature of the equipment, daytime NML exceedances are predicted over the adjacent area during the vegetation removal work.

Site establishment work is proposed to be undertaken during a combination of standard daytime construction hours, out-of-hours periods, and during shorter duration scheduled Sydney Trains track work periods, depending on the specific tasks being undertaken. The use of high noise equipment associated with vegetation clearing work is not anticipated to occur outside of standard daytime construction hours and is not anticipated to extend for more than a few days.

4.8.2 Power supply work

Exceedances of the daytime NMLs during the power supply work is negligible at up to 2 dB at the worst affected residential receiver. Due to reduced background noise, exceedances of the night-time NMLs up to 21 dB in NCA01 and 18 dB in NCA02 are predicted for the nearest residential receivers. These worst-case exceedances are driven by the use of the piling rig and vibratory roller.

The power supply work activities are proposed to be undertaken during a combination of standard daytime construction hours, out-of-hours periods, and during shorter duration scheduled Sydney Trains track work periods, depending on the specific tasks being undertaken. Consistent with the main work scenarios, the use of noise intensive equipment during the night-time period increases the risk of sleep disturbance at the surrounding residential receivers. Where practical it is recommended that use of noise intensive equipment is scheduled to occur in the less sensitive daytime period to reduce the magnitude of the resultant NML exceedances and sleep disturbance impacts.

4.8.3 Main work

The majority of the main work is proposed to occur during standard daytime construction hours and during out-of-hours periods occurring during scheduled Sydney Trains track work periods.

In general, impacts during standard construction hours are predicted to be below NML at the majority of surrounding residential receivers. The most potentially affected residential receivers are predicted to exceed the daytime NMLs by up to 5 dB during noise intensive activity for demolition, platform resurfacing and laydown activities (note the highest impacts for laydown activities are adjacent to the in-corridor laydown area to the east of the main work). The highest predicted noise levels at non-residential receivers exceed the NML by up to 13 dB during demolition and platform resurfacing. NML exceedances of this magnitude would generally be limited to sensitive receivers with a line of sight to the proposed equipment for this work. For operational reasons, it may also be required to program some of these works out of hours at a time when these receivers are not occupied and therefore not susceptible to adverse noise impact.

Exceedance of the night-time NMLs at residential receivers are predicted up to 28 dB (demolition activity) and 24 dB (platform resurfacing and in-corridor laydown area) at the nearest residential receivers.

The high magnitude of these impacts at the most potentially affected sensitive receivers is largely the result of the highly noise intensive concrete saw, jackhammer, and vibratory roller included in the proposed main work scenarios (or hi-rail equipment and mobile crane for the laydown areas). Additionally, the night-time noise management levels are based on the notably lower background noise level during this period. The culmination of these factors results in an increased risk of sleep disturbance at many surrounding residential receivers. Where practical it is recommended that use of noise intensive equipment is scheduled to occur in the less sensitive daytime period to reduce the magnitude of the resultant NML exceedances and sleep disturbance impacts.

4.8.4 Site demobilisation

The nearest-affected residential receivers in NCA01 are predicted to exceed the daytime NMLs by up to 7 dB during the proposed site demobilisation activity. Noise levels in NCA02 are not predicted to exceed NMLs at residential receivers during the work.

The highest predicted noise levels at non-residential receivers exceed the NML by up to 11 dB at the nearest commercial receivers in NCA02.

Sensitive receivers with NML exceedances are generally limited to those with that have a line of sight to the work. Site demobilisation activities are proposed to be undertaken during a combination of standard daytime construction hours, out-of-hours periods, and during shorter duration scheduled Sydney Trains track work periods, depending on the specific tasks being undertaken.

4.8.5 Highly noise affected receivers

Receivers are considered to be highly noise affected if noise levels from construction exceed 75 dBA $L_{Aeq(15minute)}$.

With reference to **Table 11**, vegetation removal and demolition activities are predicted to result in 'highly noise affected' receivers. Due to the close vicinity of the work to receivers directly adjacent to Pymble Station, worst case construction daytime noise levels are predicted above 75 dBA $L_{Aeq(15minute)}$ in both NCAs during the operation of noise intensive equipment.

The location of receivers with potential to be highly noise affected at noise intensive times during these activities is shown in **Figure 3**.

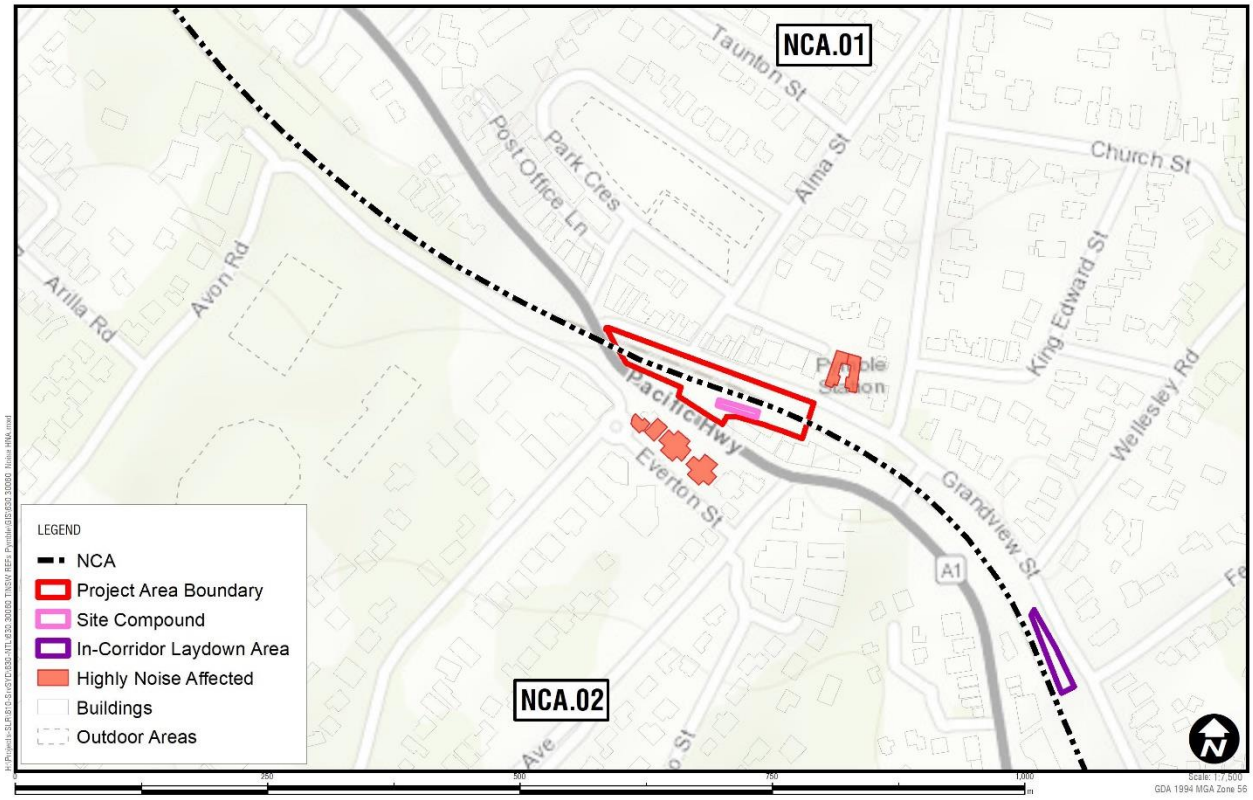


Figure 3 Highly noise affected receivers

Figure 3 shows that six residential receiver buildings are predicted to be highly noise affected during noise intensive work.

Mitigation measures recommended to minimise the impacts are outlined in **Section 5**.

4.8.6 Cumulative noise impacts

Cumulative noise impacts warrant assessment where more than one work scenario operates at the same time and in the same location such that the same receiver is impacted by noise from more than one work scenario. Generally, the proposed work is scheduled in consecutive phases and therefore cumulative noise impacts are not predicted as the assessment is controlled by noise impacts from the individual phases (as assessed).

Where construction work associated with other projects occurs at the same time as the Proposal work, this has the potential to result in marginally higher noise levels at the nearby receivers. However, noisy work from each project would typically not occur at the same time, and may affect different facades of a building, minimising the cumulative impacts.

4.9 Construction road traffic

Construction vehicles associated with the Proposal on public roads are not expected to exceed 12 heavy vehicle deliveries per day during peak construction periods (scheduled Sydney Trains track work periods) and less during non-track work periods.

The relatively small number of construction vehicles accessing the site is predicted to have an insignificant effect on existing road traffic noise levels and further consideration of noise impacts due to construction traffic is not required.

4.10 Construction vibration assessment

4.10.1 Vibration intensive equipment

Vibration intensive equipment is proposed during the main work scenarios which include the use of a vibratory roller, jackhammers and piling rigs.

For the purpose of this assessment, it is assumed that piling work would be performed using non-vibration intensive bored piling. If the construction contractor elects to use an alternative piling method, the vibration levels generated by the use of this plant may be higher than those presented in this assessment.

Vibratory rolling or jackhammering is proposed during the following scenarios:

- earthwork and installation of new power infrastructure and underground cables
- excavation and piling work
- platform resurfacing and canopies work

Vibratory rolling and jackhammering during the work at its closest is likely to be the around 15 metres from the closest commercial receivers on Grandview Street and Pacific Highway, and around 40 metres from the nearest residential receivers on Pacific Highway. For work on the platform vibration impacts to the station building should be considered.

4.10.2 Cosmetic damage assessment

For most sources of intermittent vibration during construction, the predominant vibration energy occurs at frequencies usually in the 10 Hz to 100 Hz range. On this basis, and with reference to BS 7385:2 and **Section 4.4**, a vibration damage screening level of 7.5 mm/s has been adopted for the purpose of assessing potential impacts from continuous vibration.

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

Based on the safe working distances presented in the CNVS and the use of a medium vibratory roller, indicative vibration levels at the representative receivers are shown in **Table 13**.

Table 13 Indicative vibration levels at nearby receivers

Receiver[1]	Approximate distance to works	Indicative Vibration Level (mm/s)[2]
NCA01 (COM)	15 m	7.5
NCA02 (COM)	15 m	7.5
NCA02 (RES)	40 m	1.6

Note 1: Receiver classification abbreviations are residential (RES), commercial (COM).

Note 2: Estimated from the minimum working distances specified in CNVS for a medium vibratory roller (< 50 kN, Typically 7-13 tonnes) and assumed dense rock.

The information presented in **Table 13** indicates that the separation distance from the nearest receivers is sufficient to mitigate the potential impacts for a medium sized vibratory roller.

Other items of plant (jackhammer, bored piling) are associated with a lower vibration level and are not identified any closer to the receivers than the vibratory rolling scenario. As such, it is considered that structural or cosmetic damage impacts from vibration intensive work is unlikely for the adjacent receivers.

If vibration intensive work such as large vibratory rollers or other equipment are required to be undertaken within the specified minimum working distances outlined in **Section 4.4.4**, or in close proximity to potentially vibration-sensitive structures such as the station building, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

4.10.3 Human comfort vibration assessment

In relation to human comfort (response), the safe working distances in **Section 4.4.4** relate to continuous vibration and apply to **residential** receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are permitted, as discussed in *Assessing Vibration - a technical guideline*.

Vibration at the nearest receivers is likely to be perceptible at times during the work.

For vibratory rolling, where the nearest affected receiver is located approximately 15 metres from the work area, assuming a medium vibratory roller operating continuously near the adjacent site boundary, it is anticipated that the day-time commercial VDV criterion of 0.8 $m/s^{1.75}$ will be reached within an impractical working time (under one hour). The majority of receivers surrounding the relevant work is are situated at over 100 metres from the site boundary at sufficient distance to mitigate potential vibration impacts.

Where vibratory rolling is required at a location less than 50 metres from the nearest sensitive receiver it is recommended that a small vibratory roller is used where practicable.

This assessment indicates that vibration monitoring is required at the start of work to determine the site specific vibration propagation characteristics and provide information to the construction team in relation to likely allowable working durations with the vibratory roller.

4.10.4 Heritage buildings

The heritage items identified in the Ku-ring-gai Local Environmental Plan (Local Centres) 2012 are shown in **Figure 4**.

Figure 4 Ku-ring-gai Local Environmental Plan (Local Centres) 2012

Note: Map identification number *6650_COM_HER_003_010_20131213*.

At this stage in the Proposal, the following heritage listed structures have been identified within approximately 100 metres of the proposed work involving vibration-generating plant described in **Section 4.10.1**.

Table 14 Heritage listed structures within 100 metres of vibration generating work

LEP Designation	Address	Description
n/a	Pymble Station	Pymble Station is located on the Sydney Trains s170 register
I59	3-5 Alma Street	“Claverton”, dwelling house
I68	1 Livingstone Avenue	Uniting Church
I69	1116 Pacific Highway	Former police station
I70	1134 Pacific Highway	Pymble Hotel
I78	4A Park Crescent	Dwelling house

BS 7385 states that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Heritage buildings are to be considered on a case by case bases. Where a historic building or structure is deemed to be sensitive to damage from vibration (following inspection), it is recommended to reduce the vibration criteria accordingly in line with the CNVS. The more conservative DIN 4150 superficial cosmetic damage criteria of 2.5 mm/s should be considered for vibration sensitive structures. Where heritage buildings of a typical residential-type construction are not found to be structurally unsound, DIN 4150 superficial cosmetic damage criteria of 5 mm/s may be more suitable as a screening criterion.

For the proposed construction activities, the vibration intensive equipment is limited to the vibratory roller (during Earthwork and installation of new power infrastructure and underground cables, Excavation and Piling, Platform Resurfacing activities) and the pneumatic hammer / jackhammer (during the Excavation and Piling, Platform Resurfacing and Platform canopies work).

The separation distance between the proposed equipment and the majority of the above heritage items is likely to be sufficient to mitigate vibration levels such that the DIN4150 criteria is not exceeded. The exception to this is the Pymble Station buildings. As such, it is recommended that alternative lower vibration techniques to the vibratory roller (eg saw cutting, rotary drilling without impact) is preferred when in the near vicinity of this building. Jackhammer operation should be controlled to ensure contact with the building structure is avoided.

Where vibration intensive work is required to be undertaken within the specified safe working distances outlined in **Section 4.4.4**, or in close proximity to vibration sensitive heritage structures, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

In relation to the heritage structures, it is recommended to limit equipment to low vibration items (ie non-vibratory rollers) when work is required within 50 metres of any heritage structure. Note this is to be confirmed with site measurements to quantify the site-specific vibration levels. This could be undertaken prior to commencement of the work near any sensitive structures and include operator-attended monitoring.

At locations where the predicted and/or measured vibration levels are greater than the nominated screening levels, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5 Construction noise and vibration mitigation measures

The construction noise and vibration predictions indicate that the proposed construction activities are likely to exceed the construction noise management levels at locations adjacent to the construction work areas. The predicted exceedances should therefore be managed in accordance with mitigation measures as detailed within this report and Transport for NSW procedures.

A detailed construction methodology and associated management plans (including a Construction Noise and Vibration Management Plan) should be developed during the detailed design phase of the Proposal to manage impacts.

5.1 Standard mitigation measures

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG.

Reference should also be made to the Transport for NSW *Construction Noise and Vibration Strategy* (CNVS, version 4.2 and its November 2019 addendum to Tables 8 and 9) which details a number of standard mitigation measures for construction activities likely to result in adverse noise or vibration impacts associated with infrastructure projects.

Where identified in the impact assessment, particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies, noting that additional site specific measures may also be recommended.

Standard mitigation measures which may be considered appropriate for the Proposal, as taken from the CNVS, are shown in **Table 15**.

Table 15 Recommended standard noise mitigation measures

Action required	Applies to	Details
Management measures		
Implementation of any project specific mitigation measures required	Airborne noise. Ground-borne noise and vibration	In addition to the measures set out in this table, any *project specific* mitigation measures identified in the environmental assessment documentation (eg Environmental Impact Statement, Review of Environmental Factors, submissions or representations report) or approval or licence conditions must be implemented
Implement stakeholder consultation measures	Airborne noise. Ground-borne noise and vibration	Periodic Notification (monthly letterbox drop and website notification)[1] Notifications for night/weekend noisy works Website and web based surveys Project information and construction response telephone line Social media and email distribution list Community Engagement Managers

Action required	Applies to	Details
Register of Noise Sensitive Receivers	Airborne noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • address of receiver • category of receiver (eg Residential, Commercial etc.) • contact name and phone number
Site inductions	Airborne noise Ground-borne noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height; throwing of metal items; and slamming of doors. No excessive revving of plant and vehicle engines Refrain from idling vehicles Controlled release of compressed air.
Monitoring	Airborne noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Attended vibration measurements shall be undertaken at all buildings within 25 m of vibration generating activities when these activities commence to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Building condition surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage.
Construction respite period	Ground-borne noise and vibration Airborne noise	High noise and vibration generating activities[2] may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block[3].
Construction hours and scheduling	Airborne noise Ground-borne noise and vibration	Where feasible and reasonable, works should be carried out during Standard Construction Hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods.
Source controls		
Equipment selection	Airborne noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable.
Maximum noise levels	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in Appendix C (of the CNVS).

Action required	Applies to	Details
Rental plant and equipment	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Appendix C (of the CNVS).
Plan worksites and activities to minimise noise and vibration	Airborne noise Ground-borne vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers.
Path controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne noise	Stationary noise sources would be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained where necessary. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where necessary) and consideration of site topography when situating plant.

Note 1 Detailing all upcoming construction activities at least 7 days prior to commencement of relevant work.

Note 2 Includes jack and rock hammering, sheet and pile driving, rockbreaking and vibratory rolling.

Note 3 "Continuous" includes any period during which there is less than a 60 minutes respite between ceasing and recommencing any of the work.

5.2 Additional noise mitigation measures

Additional noise mitigation measures to be explored in the CNVMPs in the event of predicted exceedances of the noise goals, particularly during Out of Hours Works (OOHWs), are described in the CNVS as updated in the November 2019 addendum.

The additional mitigation measures described in the CNVS are summarised in **Table 16**, with discussion of their potential applicability to these works. The objective of these additional noise mitigation measures is to engage, inform and provide project-specific messages to the community, recognising that advanced warning of potential disruptions can assist in reducing the impact.

Table 16 Additional Management Measures Descriptions

Measure	Description	Abbreviation
Periodic Notification	A notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the Transport for NSW website. Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (eg traffic change or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for project specify the requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by Transport for NSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receivers or a nominated representative location. Monitoring can be in the form of either unattended logging (ie for vibration with an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (ie for specific periods of construction noise). The purpose of the monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required.	V
Specific Notification	Specific notification are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefing provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by Transport for NSW prior to implementation/ distribution.	SN

Measure	Description	Abbreviation
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to length periods of noise or vibration respite from an ongoing impact. The offer could comprise per-purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative Construction Methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace larger rock break with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (eg to minimise impacts to rail operations), and approval must be given by Transport for NSW through the OOHW Approval Protocol. Note: this management measure does not apply to OOHW Period 1 – Days.	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evening and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all project. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as a justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with Community Engagement Representatives.	DR

The CNVS includes definition of the level of noise impact which triggers consideration of each additional mitigation measure (reproduced in **Table 17**).

Table 17 Additional mitigation measures matrix – Airborne construction noise

Construction hours	Receiver perception	dBA above RBL	dBA above NML	Additional management measures
Standard Hours Mon-Fri (7am - 6pm) Sat (8am - 1pm) Sun/Pub Hol (Nil)	Noticeable	5 to 10	0	-
	Clearly Audible	>10 to 20	<10	-
	Moderately Intrusive	>20 to 30	>10 to 20	PN, V
	Highly Intrusive	>30	>20	PN, V
	75 dBA or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Mon-Fri (6pm - 10pm) Sat (7am - 8am & 1pm - 10pm) Sun/Pub Hol. (8am - 6pm)	Noticeable	5 to 10	<5	-
	Clearly Audible	>10 to 20	5 to 15	PN, RP[1], DR[1]
	Moderately Intrusive	>20 to 30	>15 to 25	PN, V, SN, RO, RP[1], DR[1]
	Highly Intrusive	>30	>25	PN, V, SN, RO, RP[1], DR[1]
OOHW Period 2 Mon-Sat (12am - 7am & 10pm - 12am) Sun/Pub Hol. (12am - 8am & 6pm - 12am)	Noticeable	5 to 10	<5	PN
	Clearly Audible	>10 to 20	5 to 15	PN, V, SN, RO[2], RP[1], DR[1]
	Moderately Intrusive	>20 to 30	>15 to 25	PN, V, SN, RO[2], RP[1], DR[1]
	Highly Intrusive	>30	>25	PN, V, SN, RO[2], RP[1], DR[1], AA

Note 1: Respite periods and duration reduction are not applicable when works are carried out during OOHW Perio 1 Day only (ie Saturday 6am-7am and 1pm-6pm, Sunday / Public Holidays 8am-6pm).

Note 2: Respite offer during OOHW Period 2 are only applicable for evening periods (ie, Sundays / Public Holidays 6pm-10pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

Note 3: PN = Project notification, SN = Specific notification, individual briefings, or phone call, V = Verification monitoring, DR = Duration Reduction, RP = Respite Period, RO = Project specific respite offer, AA = Alternative accommodation.

5.3 Additional vibration mitigation measures

Where the vibration management levels for building damage may be exceeded, vibration monitoring should be conducted to determine site specific minimum working distances. Alternative construction methodologies may need to be considered where it is not possible to complete the work within the building damage vibration management levels. The additional mitigation measures described in the CNVS are summarised below in **Table 18**.

Table 18 Additional mitigation measures matrix – Construction vibration

Construction hours	Receiver Perception	Vibration Management Level	Additional Management Measures
Standard Hours Mon-Fri (7am - 6pm) Sat (8am - 1pm) Sun/Pub Hol (Nil)	Human disturbance	Exceeds HVML	PN, V, RO
	Building damage	Exceeds DVML	V, AC
OOHW Period 1 Mon-Fri (6pm - 10pm) Sat (7am - 8am) & (1pm - 10pm) Sun/Pub Hol. (8am - 6pm)	Human disturbance	Exceeds HVML	PN, V, SN, RO, RP, DR
	Building damage	Exceeds DVML	V, AC
OOHW Period 2 Mon-Fri (10pm - 7am) Sat (10pm - 8am) Sun/Pub Hol. (6pm - 7am)	Human disturbance	Exceeds HVML	PN, V, SN, RO, AA, RP, DR
	Building damage	Exceeds DVML	V, AC

Notes: PN = Project notification SN = Specific notification, individual briefings, or phone call, V = Verification monitoring, AA = Alternative accommodation, DR = Duration Reduction, RO = Project specific respite offer, RP = Respite Period, AC = Alternative construction methodology.

5.4 Summary of additional mitigation

Based on the predicted noise levels in **Section 4.7**, additional mitigation measures as per the requirements shown in **Table 17** have been determined for work during the proposed construction hours. The extent of additional mitigation measures are representative of the worst-case construction activities with the daytime and night-time (OOHW period 2) affected receiver areas shown in **Figure 5** and **Figure 6** respectively.

Respite offers and respite periods may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified, it may be beneficial to increase the work duration, number of evenings or nights worked so that the project can be progressed and completed in a shorter timeframe. The approach to respite periods would be confirmed during preparation of the CNVMP and in consultation with the community.

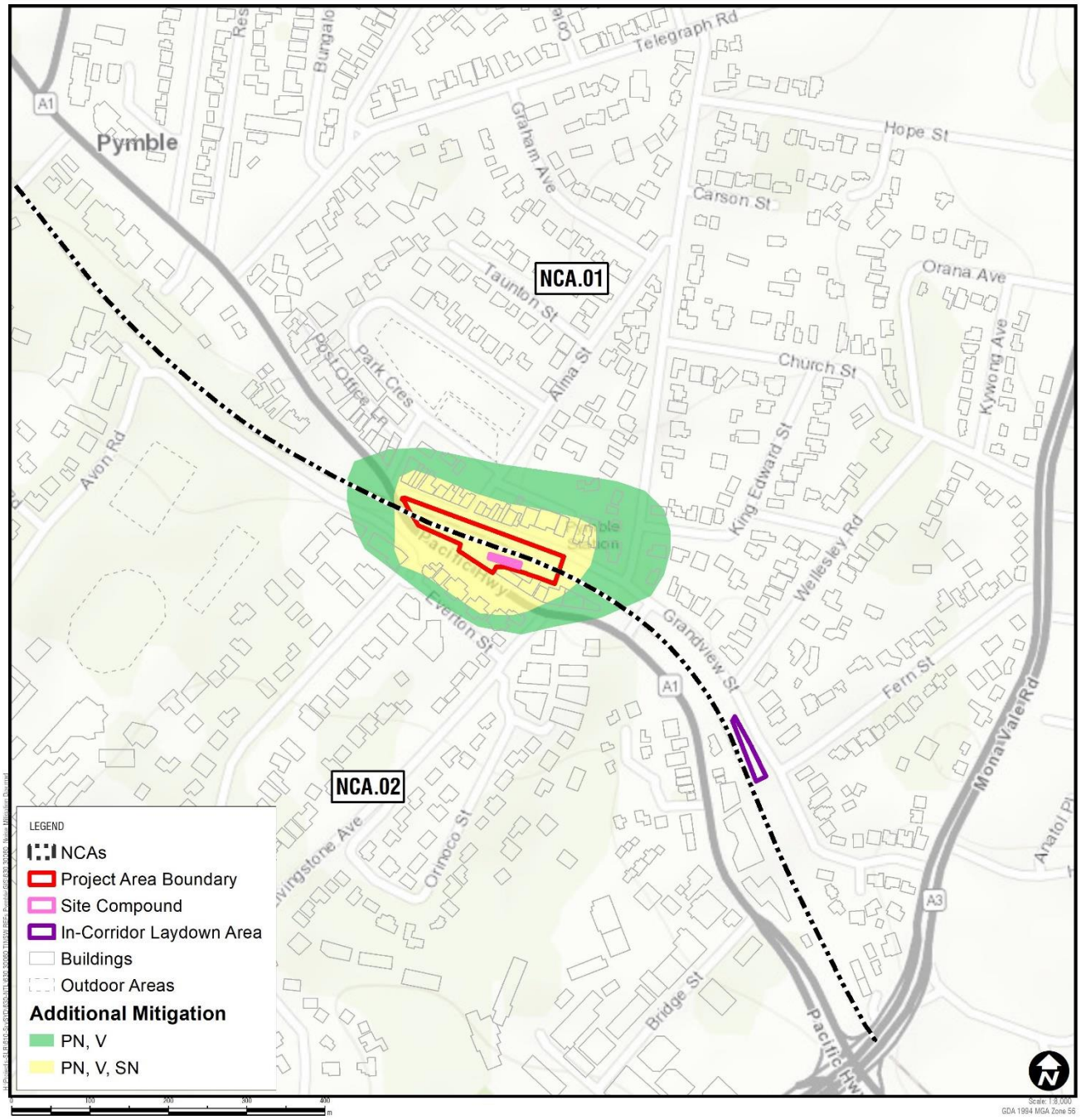


Figure 5 Additional mitigation summary - Standard daytime construction hours

Notes: PN = Project notification SN = Specific notification, individual briefings, or phone call, V = Verification monitoring

Additional mitigation measures are required for daytime work at residential receivers surrounding Pymble Station. These mitigation requirements are a result of construction activities with high noise plant such as a chainsaw, chipper, concrete saw, jackhammer, or vibratory roller.

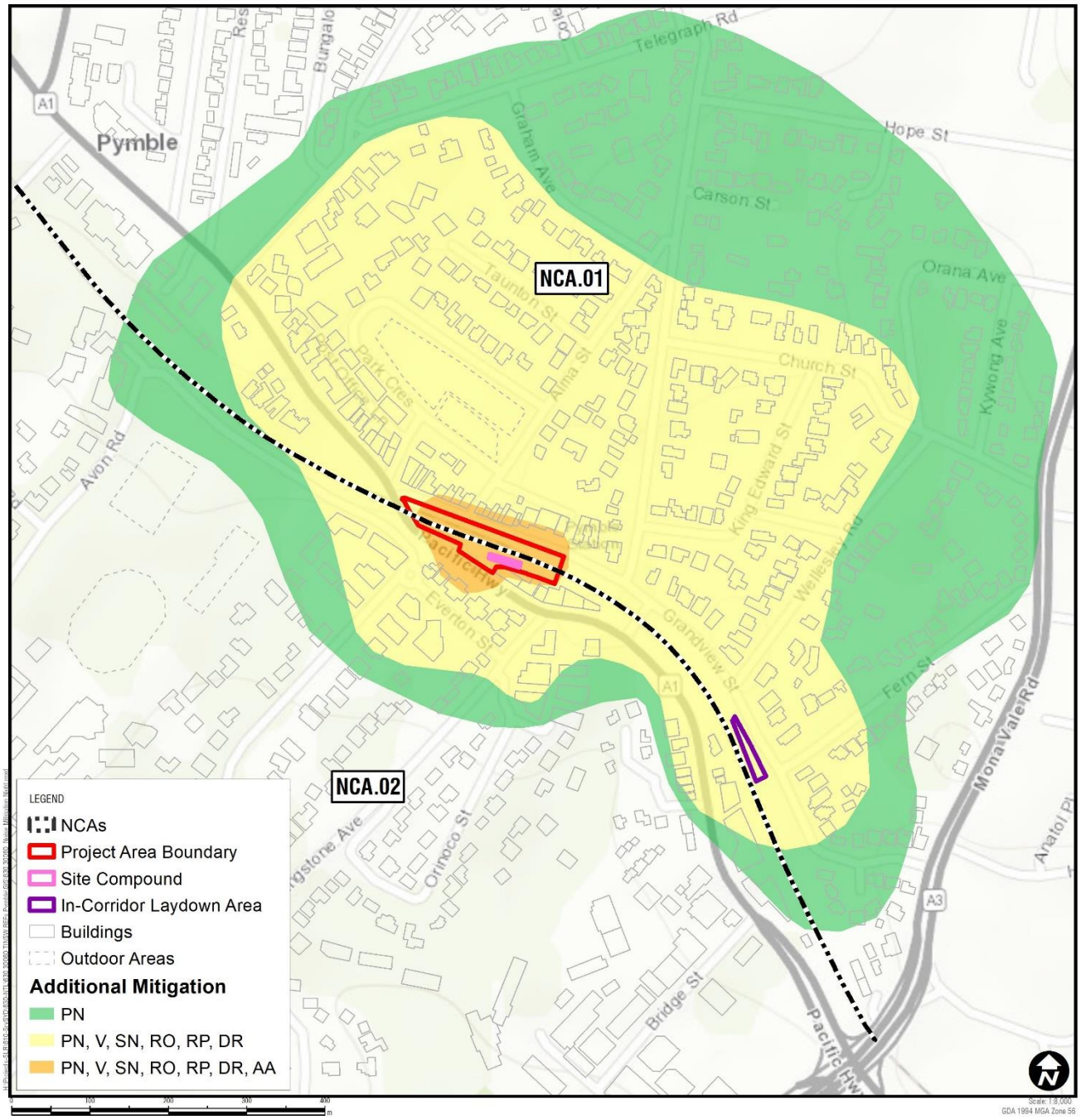


Figure 6 Additional mitigation summary - Out of hours period 2 work

Notes: PN = Project notification, SN = Specific notification, individual briefings, or phone call, V = Verification monitoring, DR = Duration Reduction, RP = Respite Period, RO = Project specific respite offer, AA = Alternative accommodation.

Additional mitigation measures are required for out of hours work at residential receivers surrounding the Proposal. These mitigation measures mostly involve project notification and verification monitoring during OOHW periods. Receivers located to the immediate vicinity of Pymble Station require consideration of additional measures with several residential receivers qualifying for consideration of alternative accommodation during the most noise intensive OOHW.

The additional noise mitigation requirements are based on predicted exceedance of RBLs and NMLs assuming sensitivity to noise increases for the receivers outside standard construction hours. The NMLs for other sensitive receiver types are specific to the type of use rather than the time of operation in accordance with the ICNG. Notwithstanding, due to the potential noise impacts at adjacent other sensitive receiver types it is recommended to undertake letterbox drops at other sensitive receivers immediately adjacent the work to inform these receivers of the proposed work.

It is recommended that representative operator attended noise monitoring be carried out on the first night of the proposed work in order to verify that the impacts from the work is not greater than anticipated.

The extent of impacts would depend on the finalised scheduled Sydney Trains track work periods and work schedule (eg timing noise intensive plant during less sensitive periods) to be confirmed in a CNVIS for the possession activities and managed in accordance with the CNVMP.

6 Operational noise assessment

6.1 NPfI trigger noise levels

The EPA has regulatory responsibility for the control of noise from 'scheduled premises' under the *Protection of the Environment Operations Act 1997*. In implementing the NPfI, the EPA has two broad objectives:

- controlling intrusive noise levels in the short term
- maintaining noise amenity levels for particular land uses over the medium to long-term.

In general terms, the NPfI sets out procedures for establishing the project intrusiveness $L_{Aeq(15minute)}$ and project amenity $L_{Aeq(period)}$ noise levels, with a view to determining the lower (that is, the more stringent) being the Project Trigger Noise Level (PTNL), NPfI Section 2.1 states:

> *The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited and amenity is protected and that no single industry can unacceptably change the noise level of an area.*

For assessing intrusiveness, the existing background noise generally needs to be measured. The intrusiveness trigger level essentially means that the equivalent continuous noise level (L_{Aeq}) of the source should not be more than 5 dBA above the measured (or default) Rating Background Level (RBL).

The amenity assessment is based on amenity noise levels specific to the land use and associated activities. The project noise levels relate only to industrial-type noise and do not include road, rail or community-related noise. Based on the NPfI land use descriptions residences surrounding the development have been classified for the purposes of this noise assessment as 'Suburban'.

Applicable PTNLs for all noise sensitive receiver areas surrounding the Proposal have been established with reference to the NPfI and are contained in **Table 19**.

Table 19 Project Trigger Noise Levels

Type of receiver	Noise amenity area	NCA	Time of day	Measured level, dBA		Project Trigger Noise Level, dBA ($L_{Aeq(15minute)}$)		
				RBL[1]	$L_{Aeq(period)}$	Intrusive	Amenity[2,3]	**Overall**
Residential	Suburban	NCA01 (L01)	Day	51	60	56	53	**53**
			Evening	48	58	53	46[4]	**46**
			Night	37	56	42	44[4]	**42**
		NCA02 (L02)	Day	61	76	66	64[4]	**64**
			Evening	59	74	64	62[4]	**62**
			Night	43	72	48	60[4]	**48**
Commercial	n/a	All	When in use	n/a	n/a	n/a	63	**63**
Childcare[5,6]	n/a	All	When in use	n/a	n/a	n/a	48	**48**
Educational[5]	n/a	All	When in use	n/a	n/a	n/a	43	**43**
Medical	n/a	All	When in use	n/a	n/a	n/a	48	**48**
Hotel[7]	n/a	NCA01	Day	n/a	n/a	n/a	58	**58**
			Evening	n/a	n/a	n/a	51	**51**
			Night	n/a	n/a	n/a	49	**49**
Place of worship[5]	n/a	All	When in use	n/a	n/a	n/a	48	**48**
Passive recreation	n/a	All	When in use	n/a	n/a	n/a	48	**48**
Active recreation	n/a	All	When in use	n/a	n/a	n/a	53	**53**

Note 1: RBL = Rating Background Level.

Note 2: The recommended amenity noise levels have been reduced by 5 dB to give the project amenity noise levels due to other sources of industrial noise being present in the area, as outlined in the NPfI.

Note 3: The project amenity noise levels have been converted to a 15 minute level by adding 3 dB, as outlined in the NPfI.

Note 4: Existing road traffic noise exceeds the threshold level outlined in the NPfI. Project amenity level was set at 15 dB below the existing road traffic noise level, as outlined in the NPfI.

Note 5: The criterion is specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are therefore 10 dB higher than the corresponding internal level, which is generally considered representative of windows being partially open for ventilation.

Note 6: The NPfI and AS2107 do not provide specific guideline noise levels for childcare centres, as such an internal criteria of 40 dBA $L_{Aeq(15minute)}$ has been adopted.

Note 7: Recommended amenity noise level set at 5 dBA above relevant residential recommended amenity noise level, as outlined in the NPfI.

6.2 Operational noise sources

The key identified fixed noise sources associated with the station upgrade include:

- three new lifts connecting the existing footbridge to the Grandview Street station entrance, the Pacific Highway station entrance and the station platform
- public address (PA) system upgrade
- a new padmount substation.

The indicative positions of the three lifts and the padmount substation are displayed in **Figure 1**. The PA system components would be installed on the station platform.

6.3 Operational noise source management

At this stage of the design specific lift and substation systems have not been selected, which means it is too early to assess compliance with the applicable noise criteria. However, given this type of noise source generally has relatively low noise emissions, it is anticipated that the lift and substation system designs could be relatively easily mitigated if required during the detailed phase of the Proposal through the selection of appropriate equipment. While noise emissions from PA systems are generally louder than the other operational noise sources, they can typically be designed to minimise any impacts through the equipment selection, location, directionality and volume.

The applicable criteria for operational noise from the new station lifts, PA systems and padmount substation is shown in **Table 19**.

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other less-obtrusive noise sources at the same level. To account for this additional annoyance, the NPfI describes modifying factors to be applied when assessing amenity and intrusiveness. Substation fans have the potential to incur a tonality modifying factor. PA systems generally incur an intermittency modifying factor. The modifying factors should be considered when selecting equipment models.

Cumulative noise impacts from all station noise sources should be assessed in the detailed design stage when selecting specific equipment locations and models for the lift facilities, PA systems and padmount substation.

APPENDIX A

Acoustic Terminology

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2. 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3. Sound Power Level

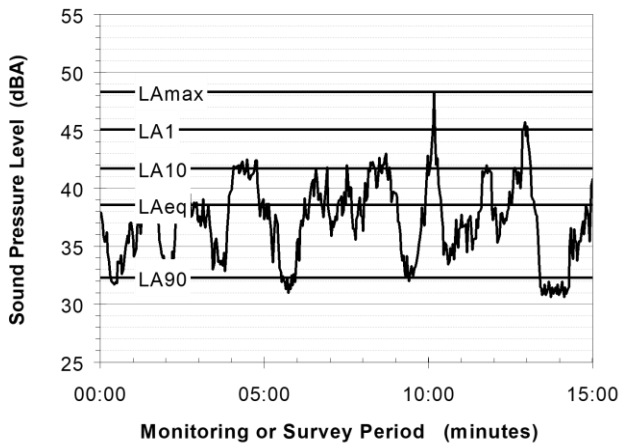
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of an electric radiator, which is characterised by a power rating but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

LAeq The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

5. Frequency Analysis

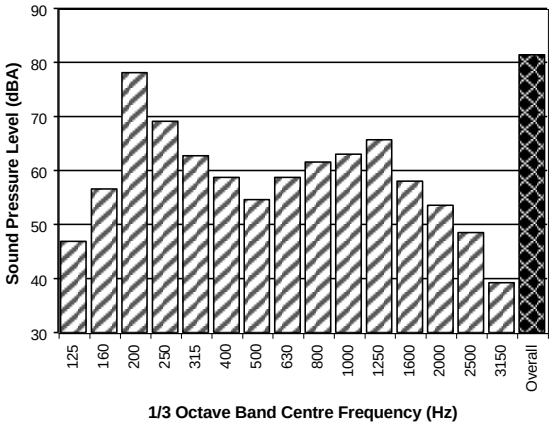
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (three bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

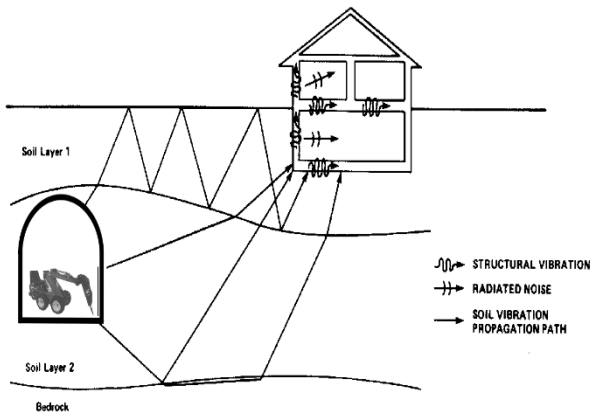
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

APPENDIX B

Ambient Noise Monitoring Results

Noise Monitoring Location	L.01
Noise Monitoring Address	**55 Grandview Street, Pymble**

Logger Device Type: Svantek 957, Logger Serial No: 20668
Sound Level Meter Device Type: Brüel and Kjær 2250L, Sound Level Meter Serial No: 3004636

Ambient noise logger deployed in on second floor balcony of commercial premises on Grandview Street. The logger was around 35 m from the closest point of the rail line, and around 90 m from the closest visible point of the Pacific Highway.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Pacific Highway. Vehicle passbys on Grandview Street, along with train passbys, aircraft and birds also contribute to the LAeq at this location.

Recorded Noise Levels (LAmax):
27/08/2020: Light-vehicle passby Grandview Street: 50-64 dBA, Traffic on Pacific Hwy: cars 50-58 dBA, trucks up to 64 dBA, Aircraft: up to 63 dBA, Train passby: 60-70 dBA, Birds: up to 57 dBA

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L_{10}	L_1
Daytime	51	60	62	70
Evening	48	58	59	69
Night-time	37	56	55	67

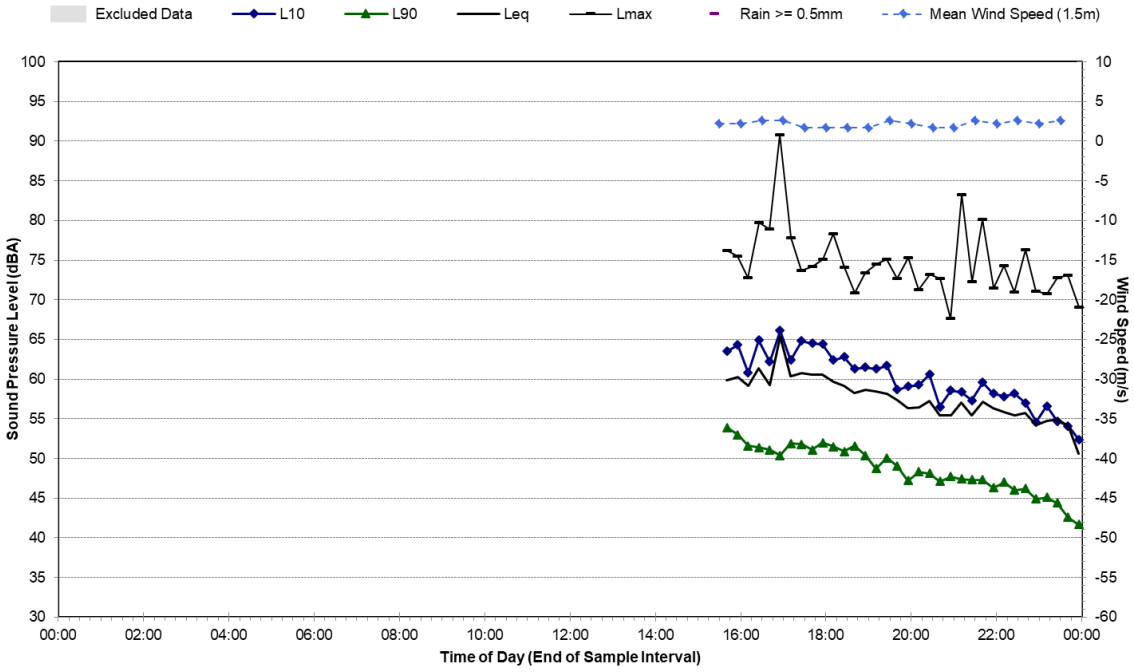
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
27/08/2020	2:57 pm	51	57	70

Photo of Noise Monitoring Location

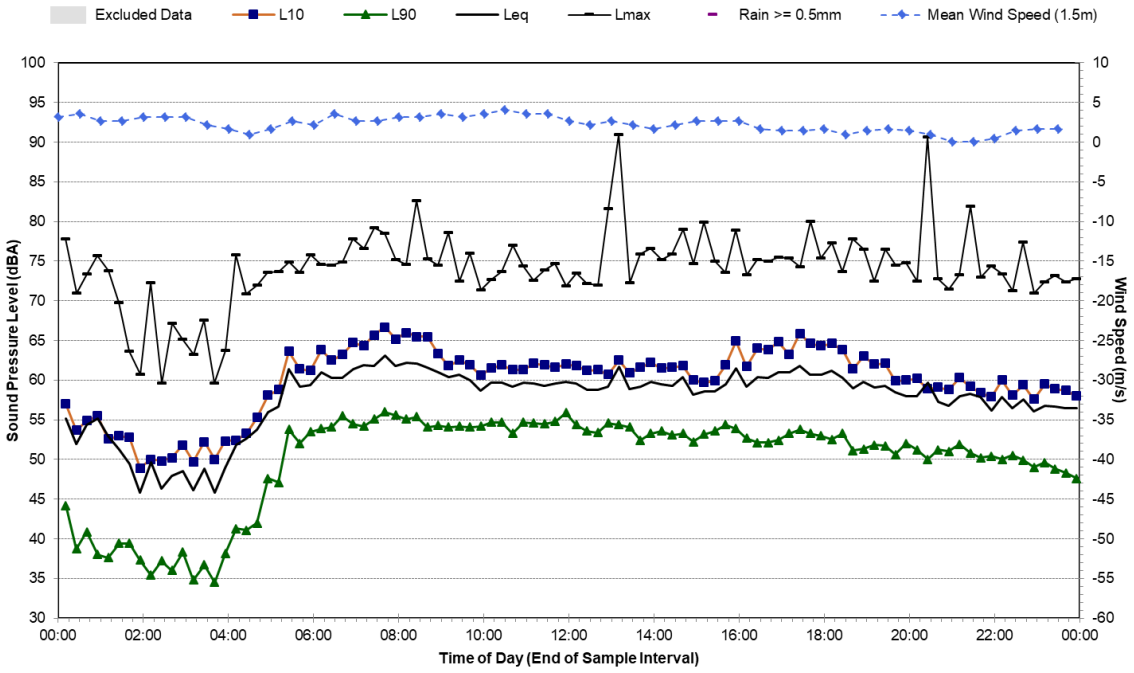
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Thursday, 27 August 2020



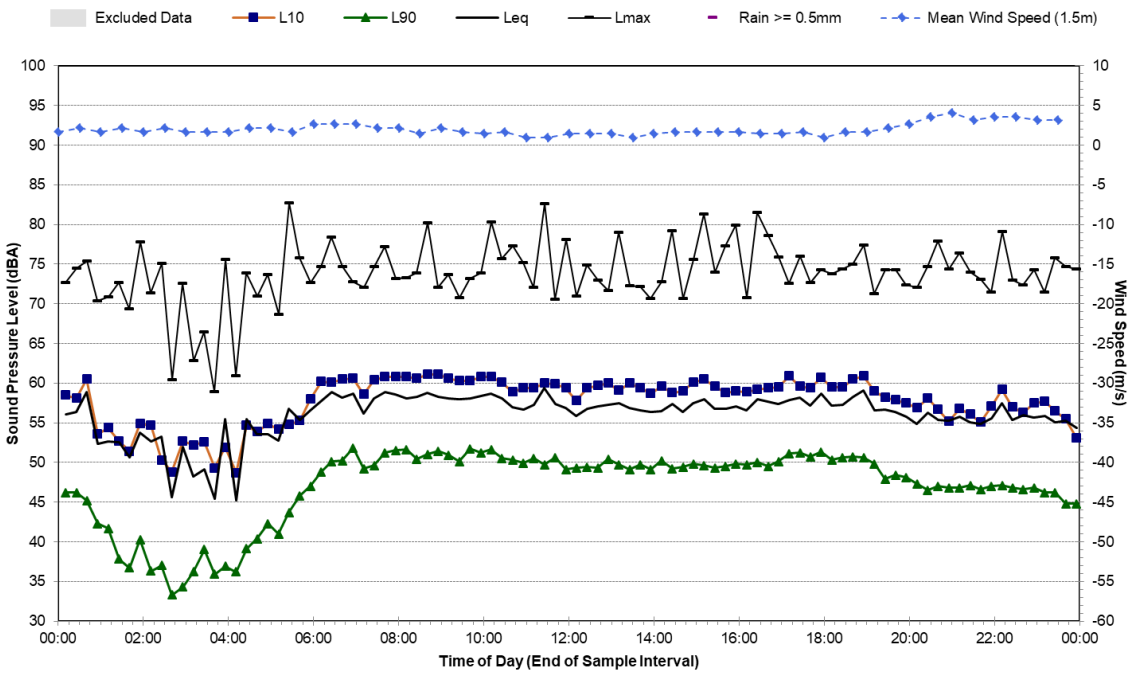
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Friday, 28 August 2020



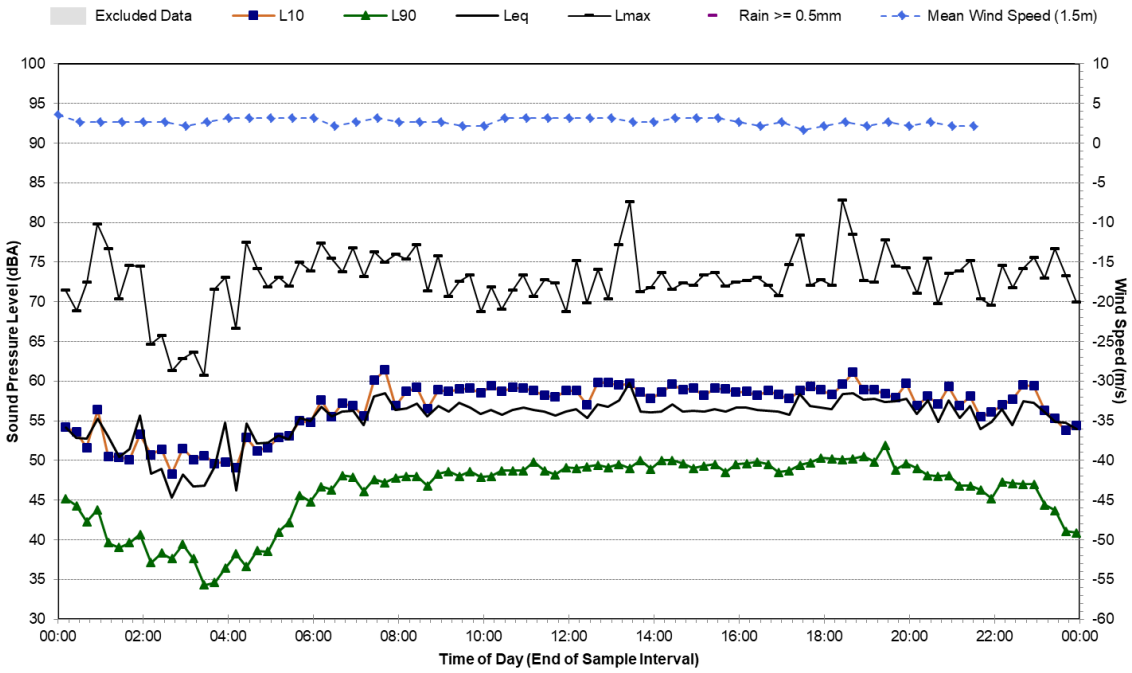
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Saturday, 29 August 2020



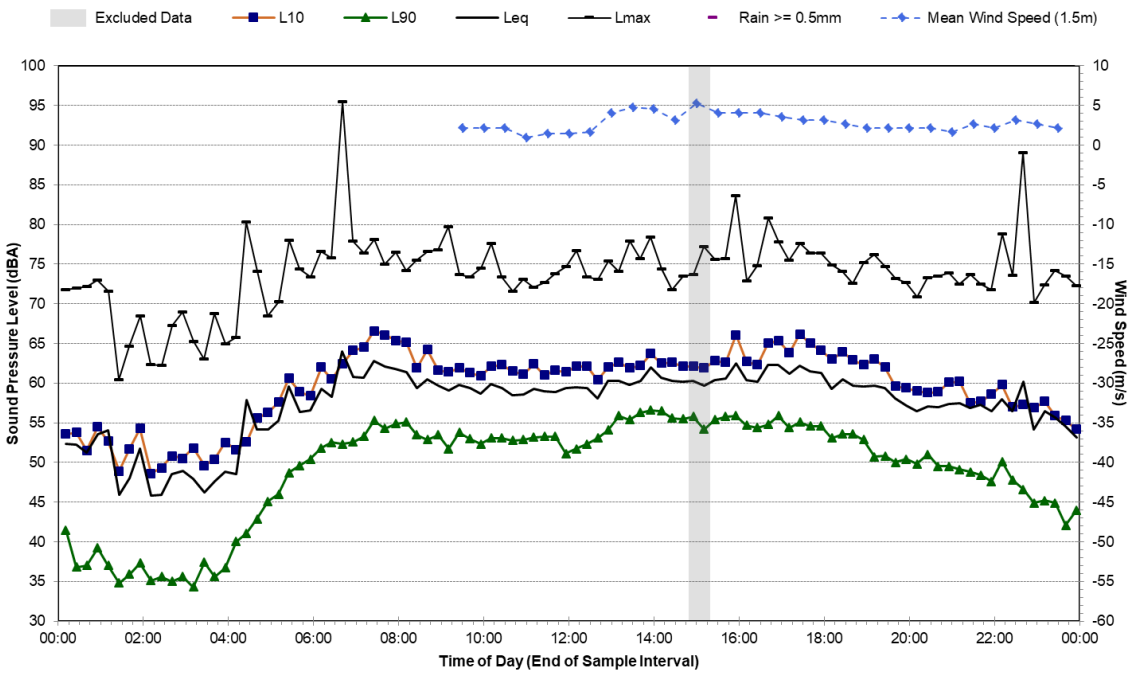
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Sunday, 30 August 2020



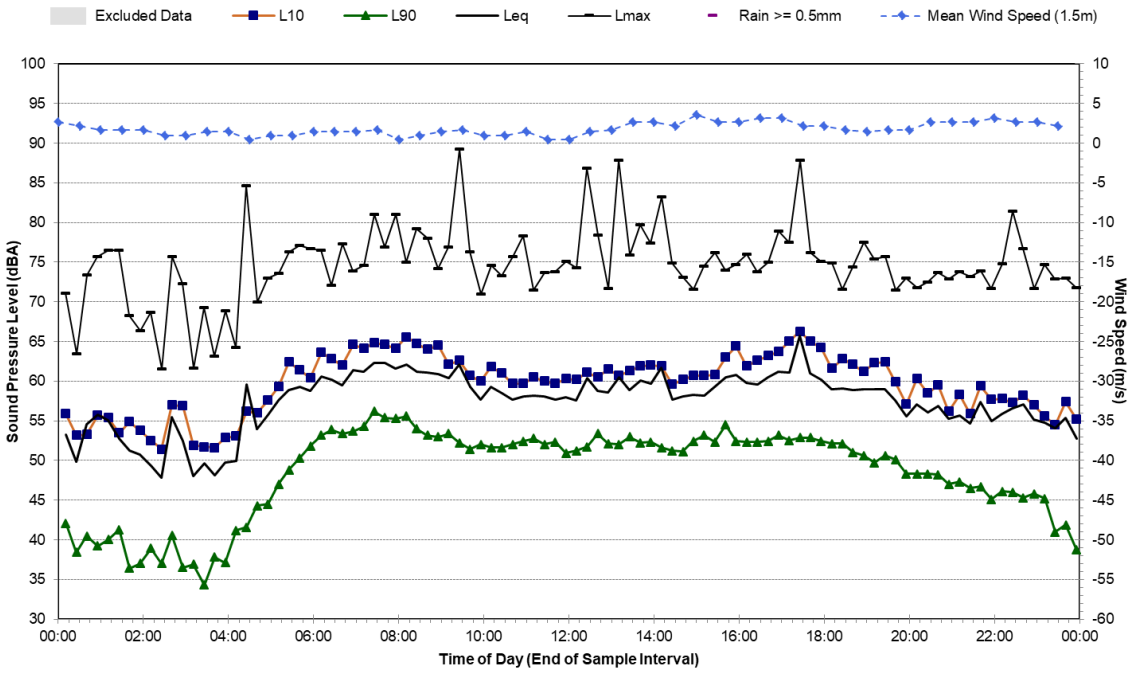
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Monday, 31 August 2020



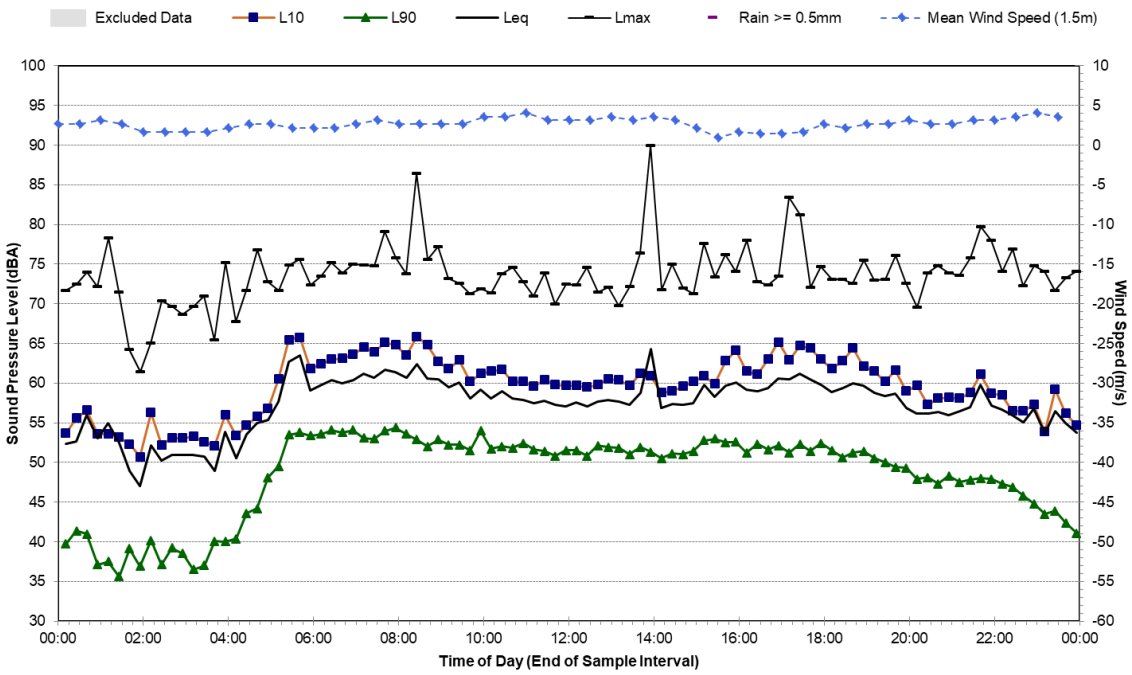
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Tuesday, 1 September 2020



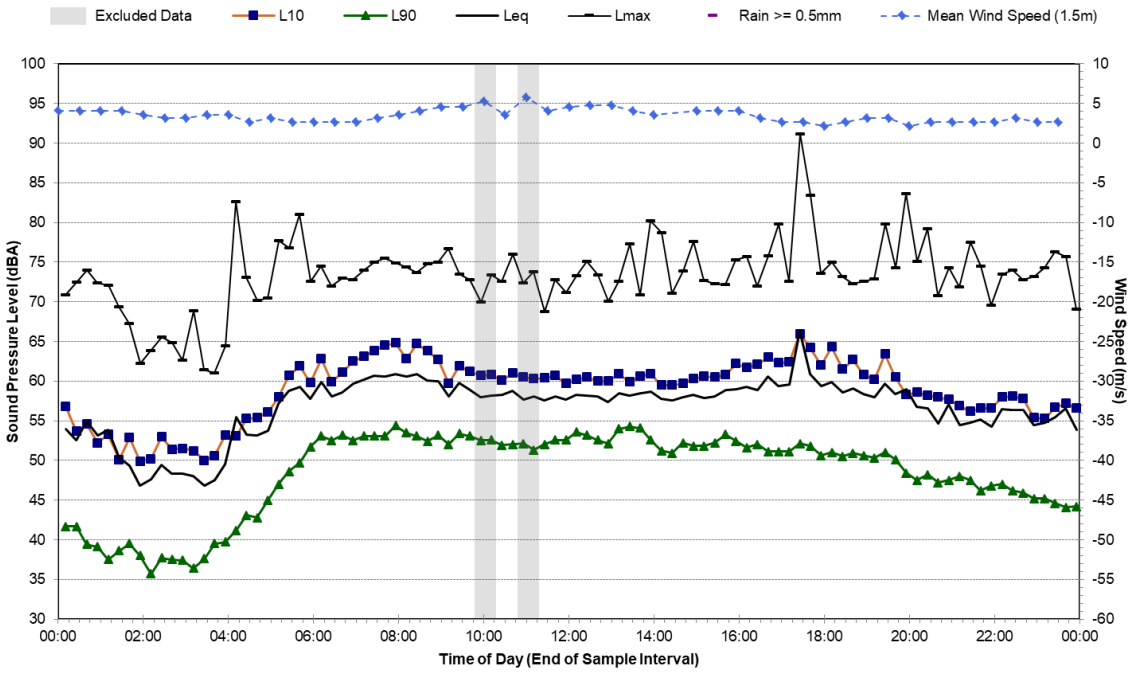
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Wednesday, 2 September 2020



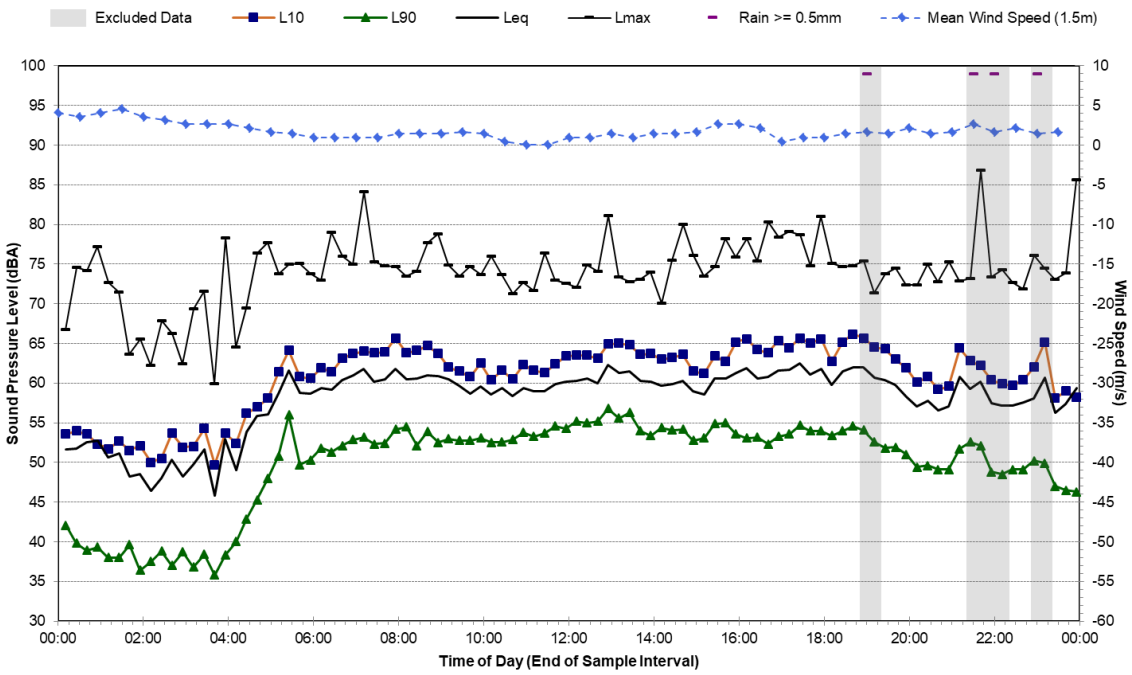
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Thursday, 3 September 2020



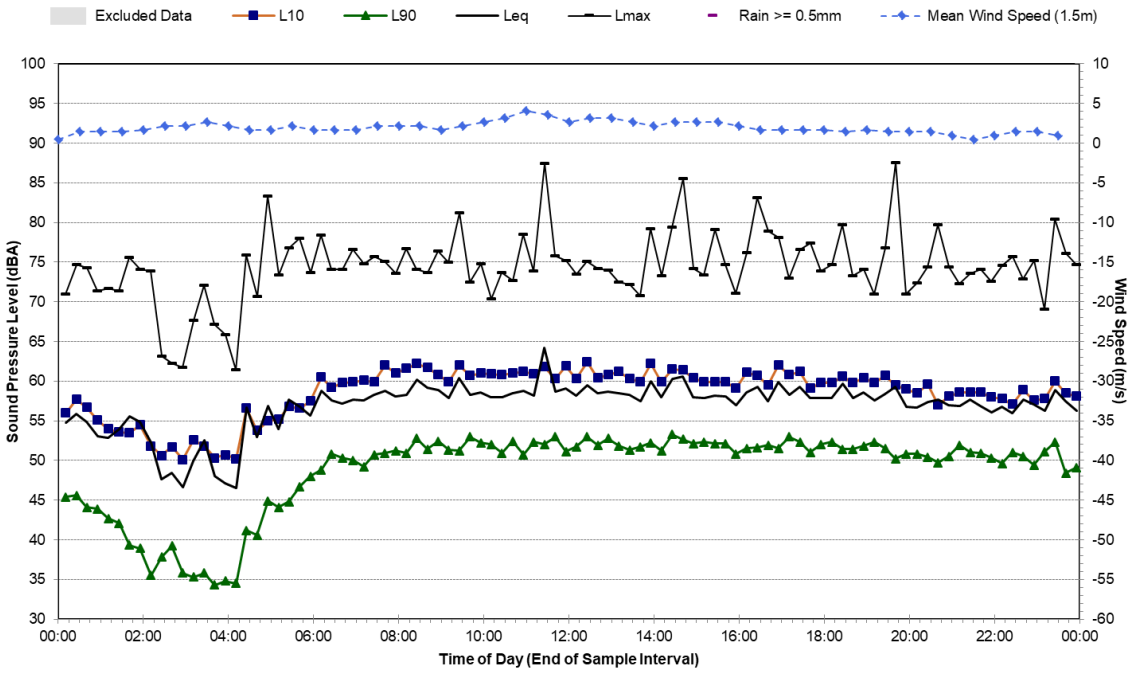
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Friday, 4 September 2020



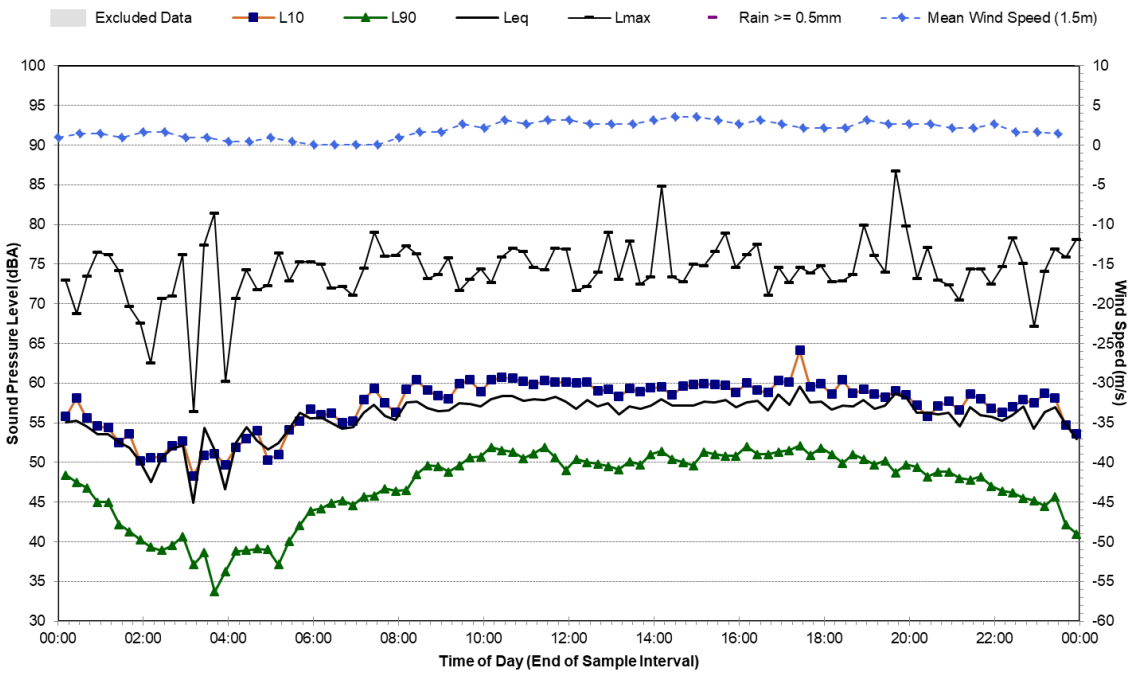
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Saturday, 5 September 2020



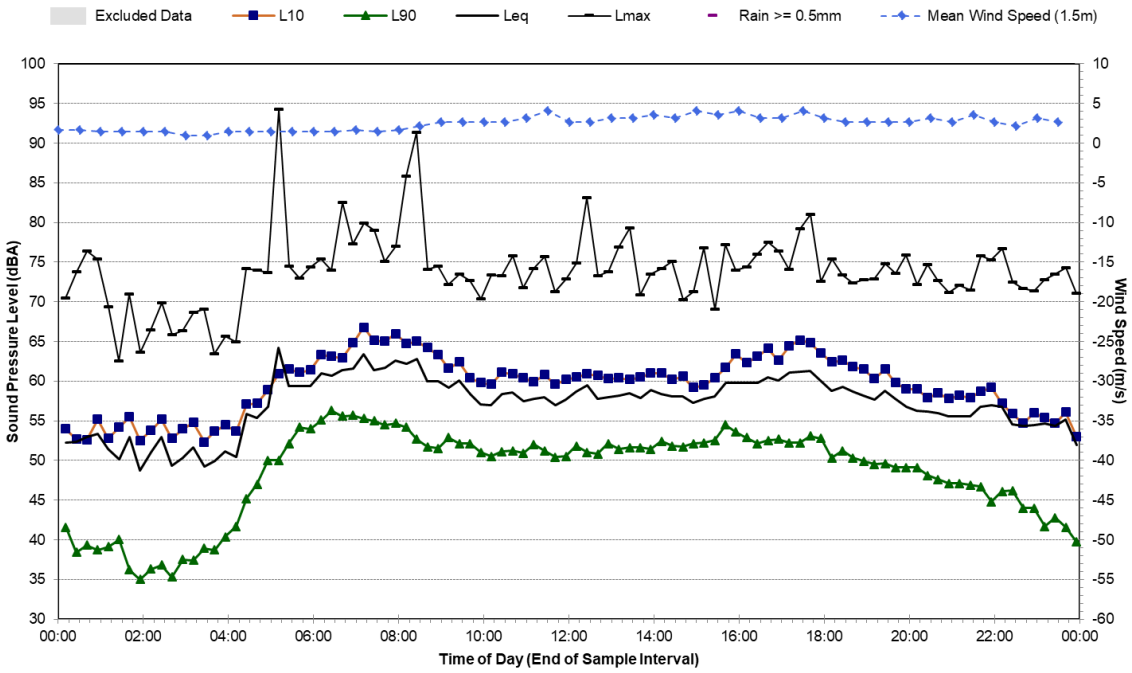
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Sunday, 6 September 2020



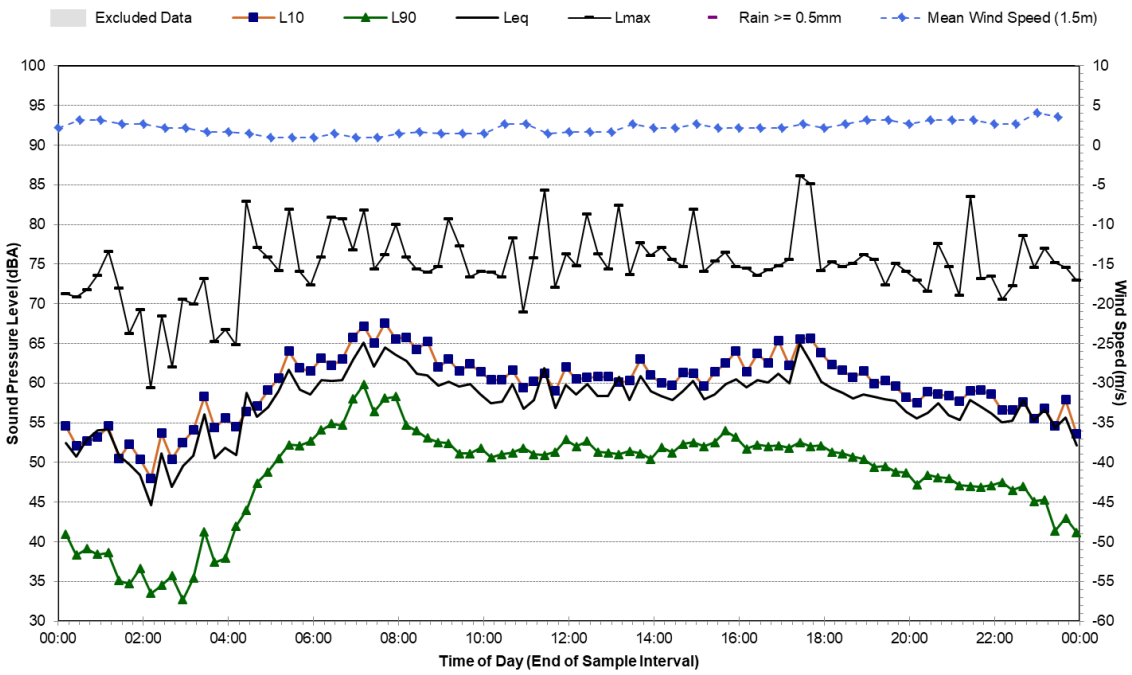
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Monday, 7 September 2020



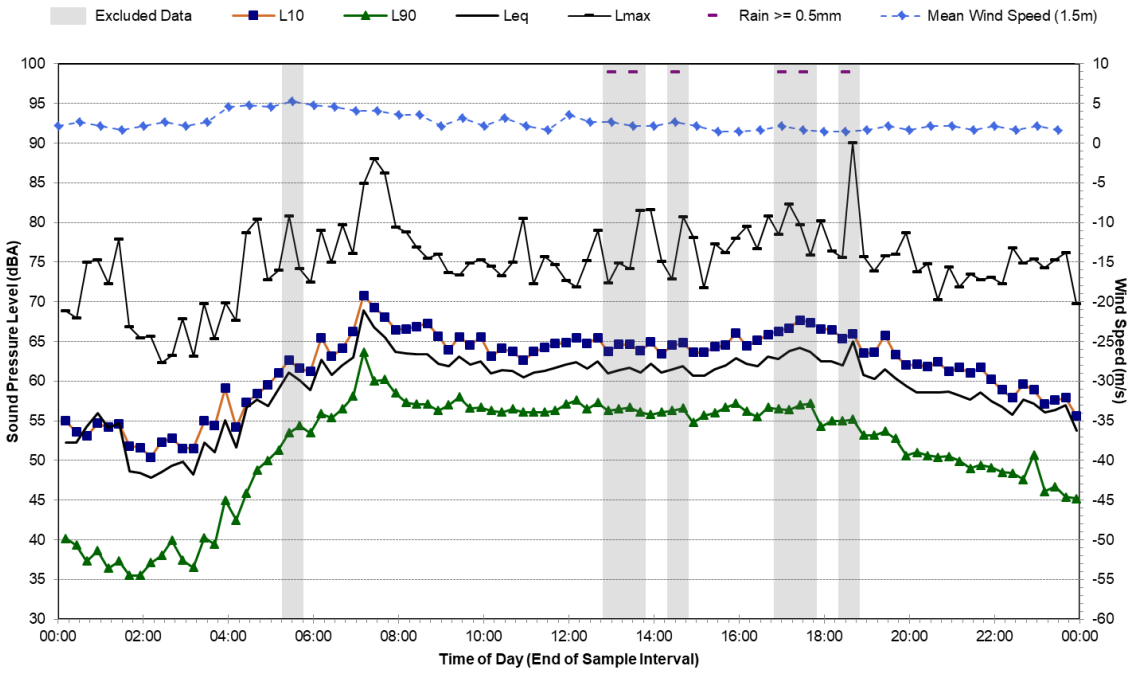
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Tuesday, 8 September 2020



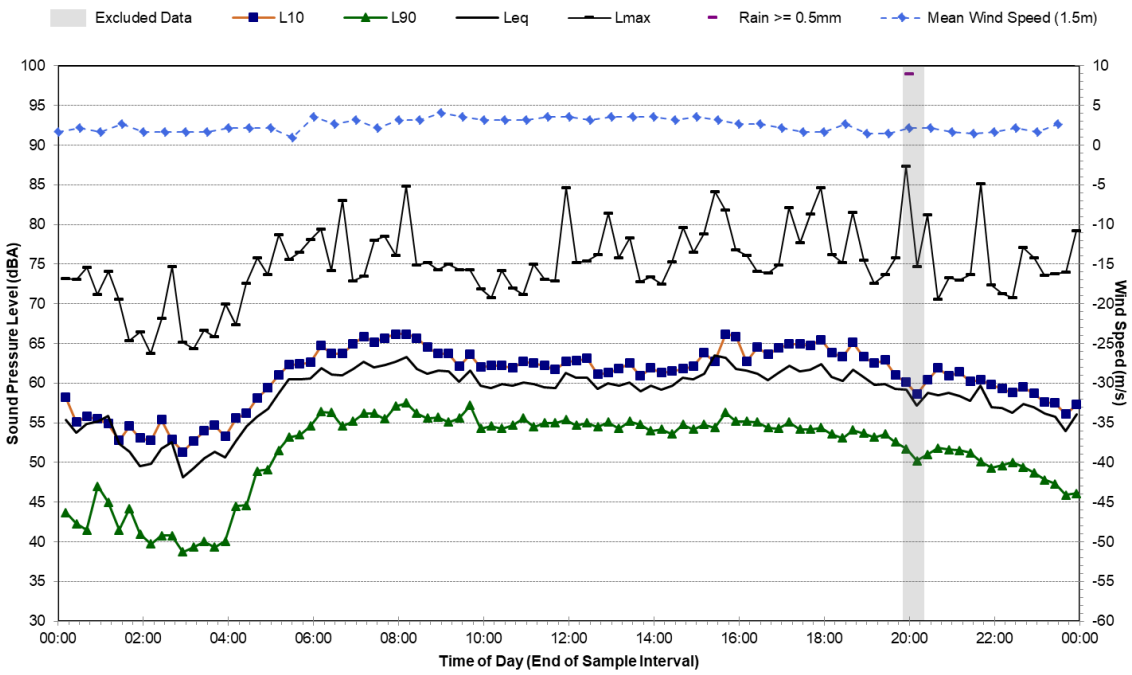
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Wednesday, 9 September 2020



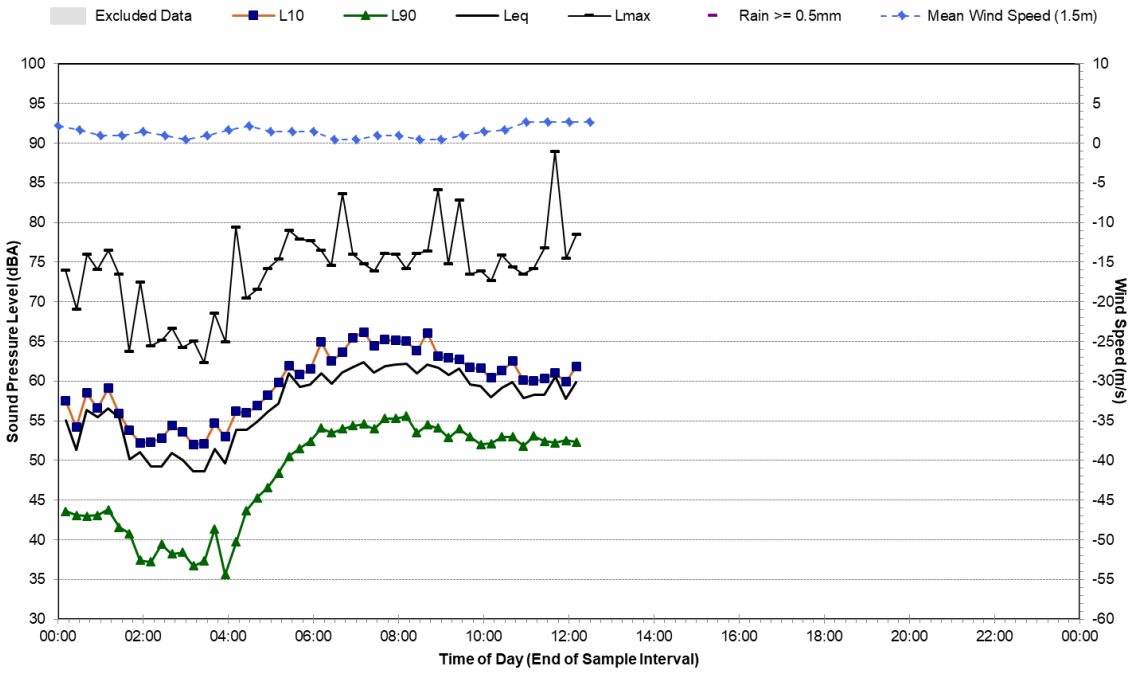
Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Thursday, 10 September 2020



Statistical Ambient Noise Levels

L.01 - 55 Grandview Street, Pymble - Friday, 11 September 2020



Noise Monitoring Location	L.02
Noise Monitoring Address	**1 Livingstone Avenue, Pymble**

Logger Device Type: Svantek 957, Logger Serial No: 23241
Sound Level Meter Device Type: Brüel and Kjær 2250L, Sound Level Meter Serial No: 3004636

Ambient noise logger deployed on ground floor outside place of worship on Pacific Highway. The logger was adjacent to the Pacific Highway, and around 70 m from the closest visible point of the rail line.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Pacific Highway. Idling traffic at the traffic lights, along with train passbys also contribute to the LAeq at this location.

Recorded Noise Levels (LAmax):
2/09/2020: Light-vehicle passby Pacific Hwy: 70-83 dBA, Idling traffic at lights: 56-66 dBA,
Heavy-vehicle passby: up to 89 dBA, Distant traffic 56-66 dBA, Loud car passby: 85 dBA, Motorbike passby: 86, 93 dBA,
Trains audible during breaks in road traffic

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L_{10}	L_1
Daytime	62	76	78	85
Evening	59	74	77	83
Night-time	44	72	74	82

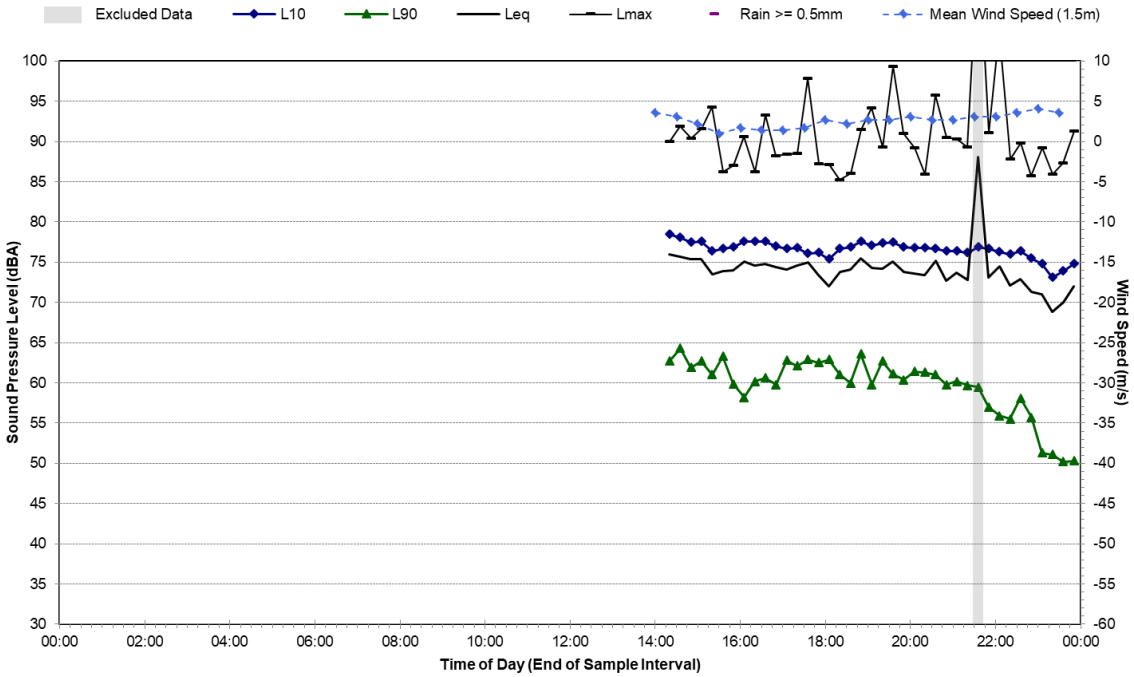
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
2/09/2020	1:37 pm	63	76	93

Photo of Noise Monitoring Location

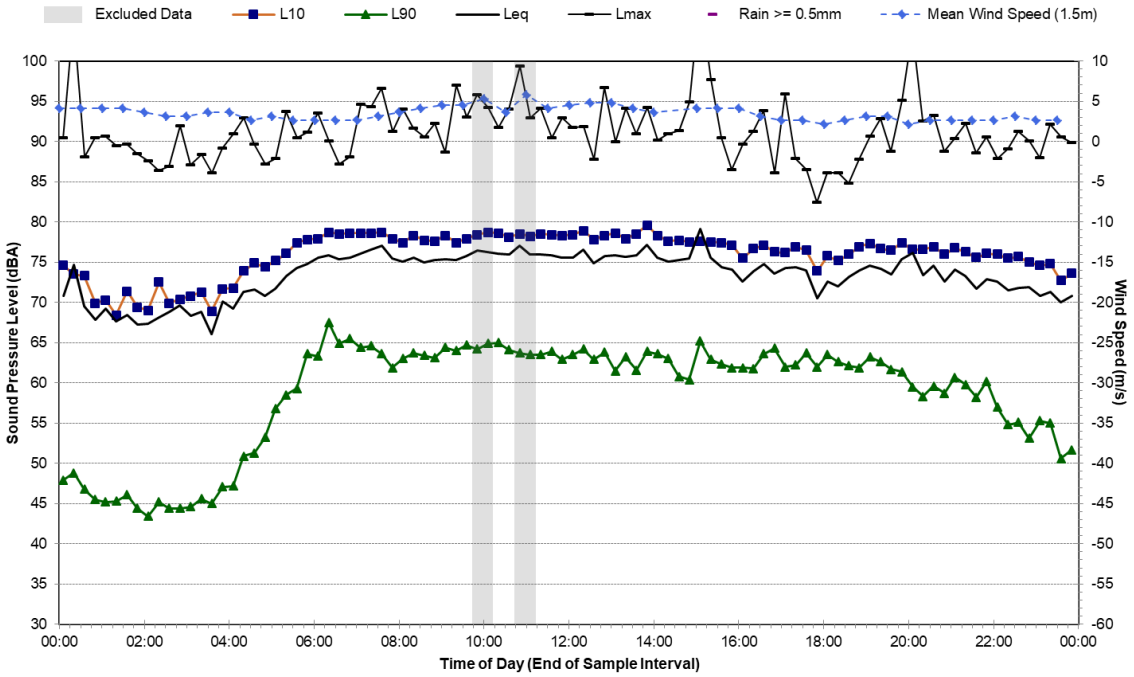
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Wednesday, 2 September 2020



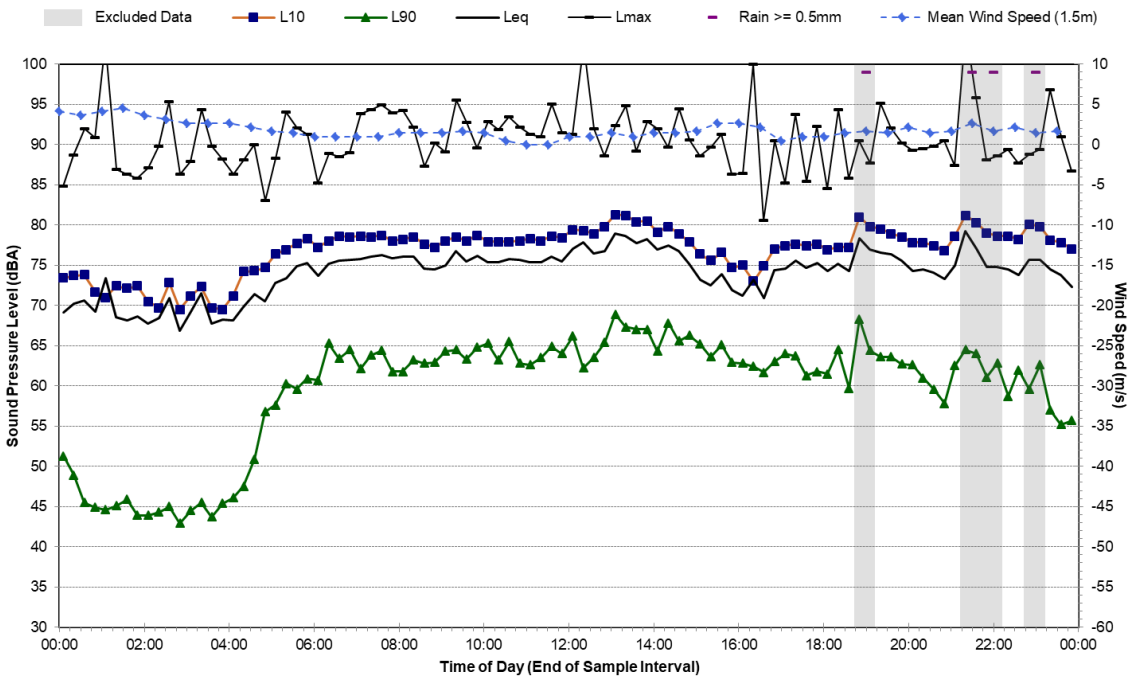
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Thursday, 3 September 2020



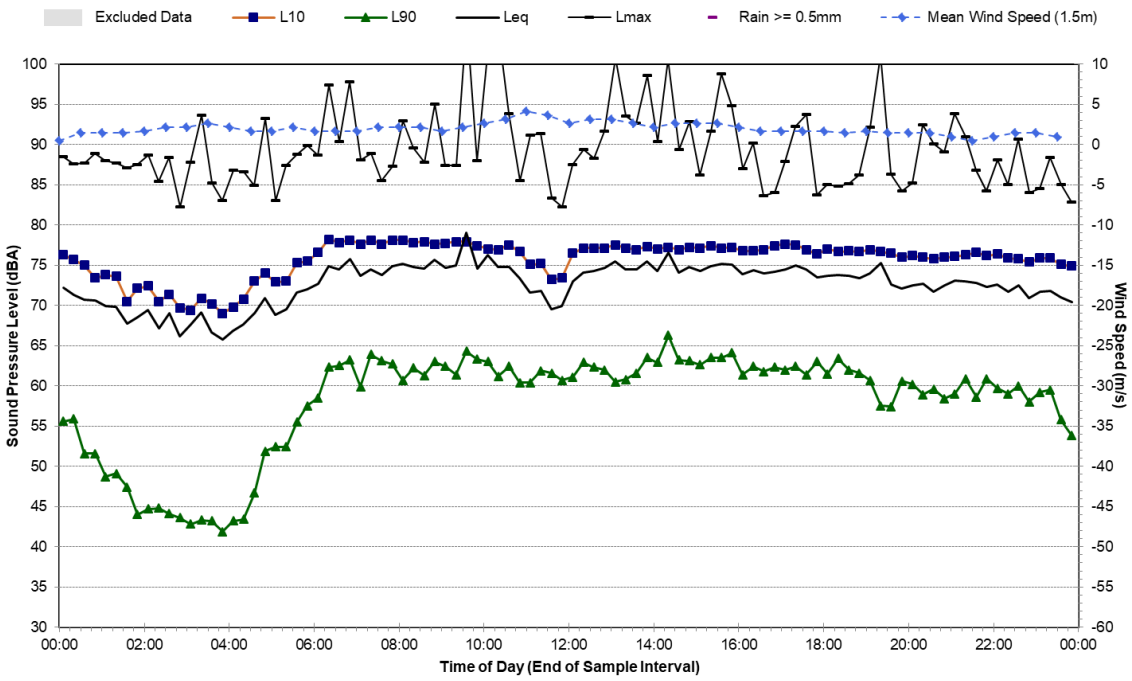
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Friday, 4 September 2020



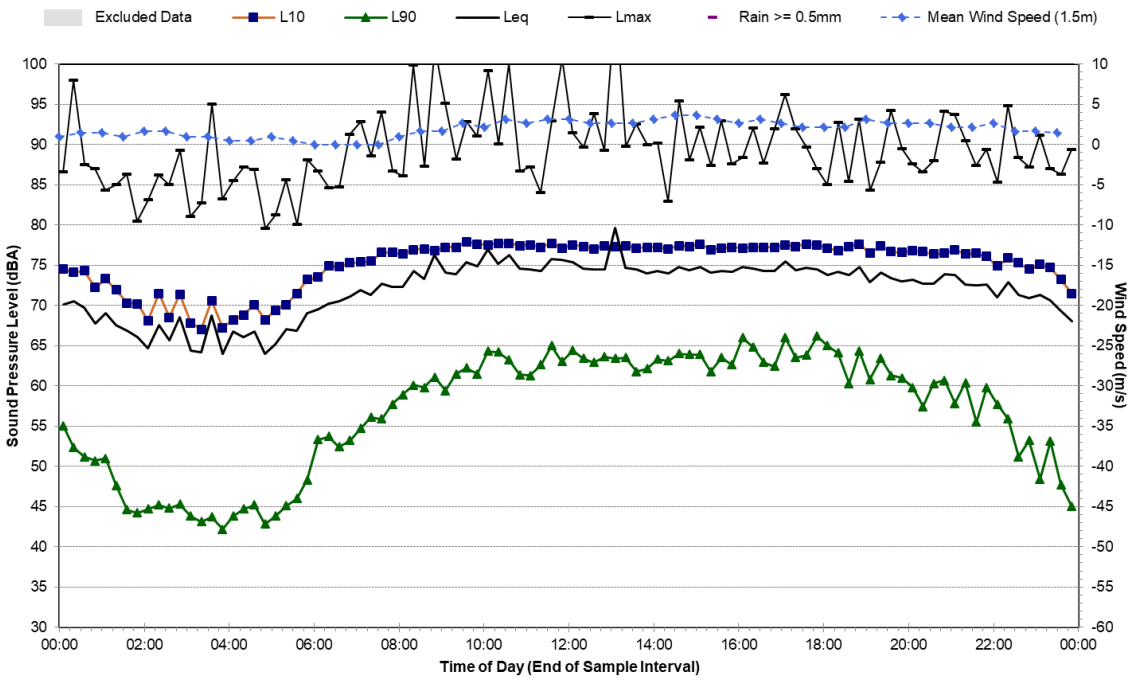
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Saturday, 5 September 2020



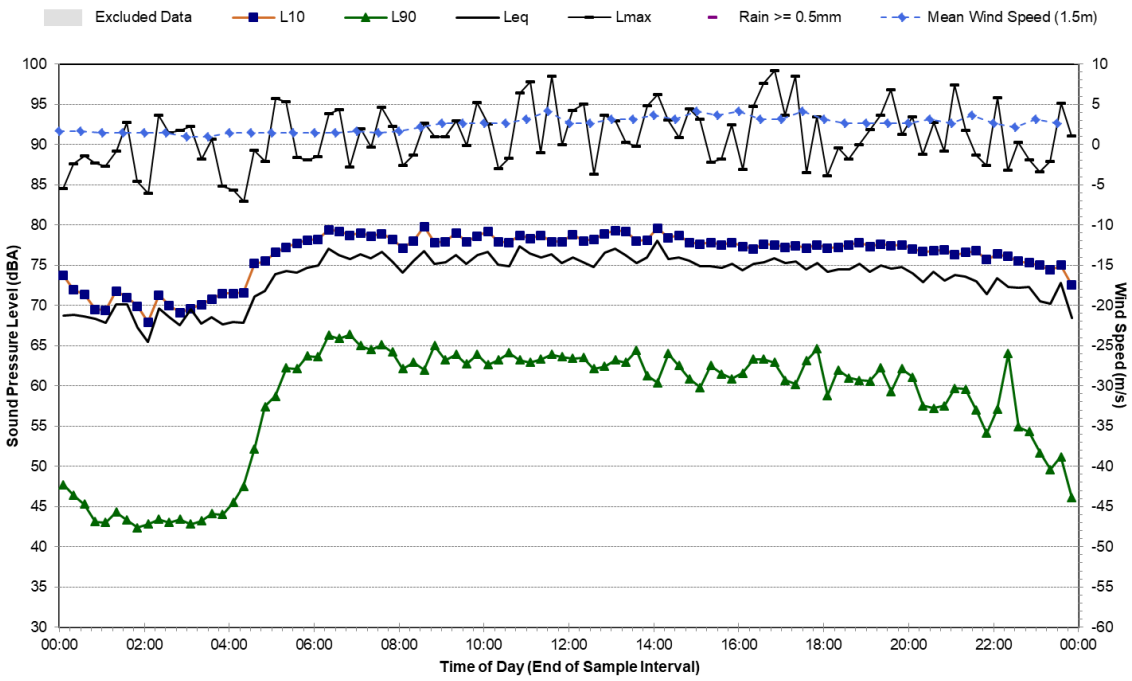
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Sunday, 6 September 2020



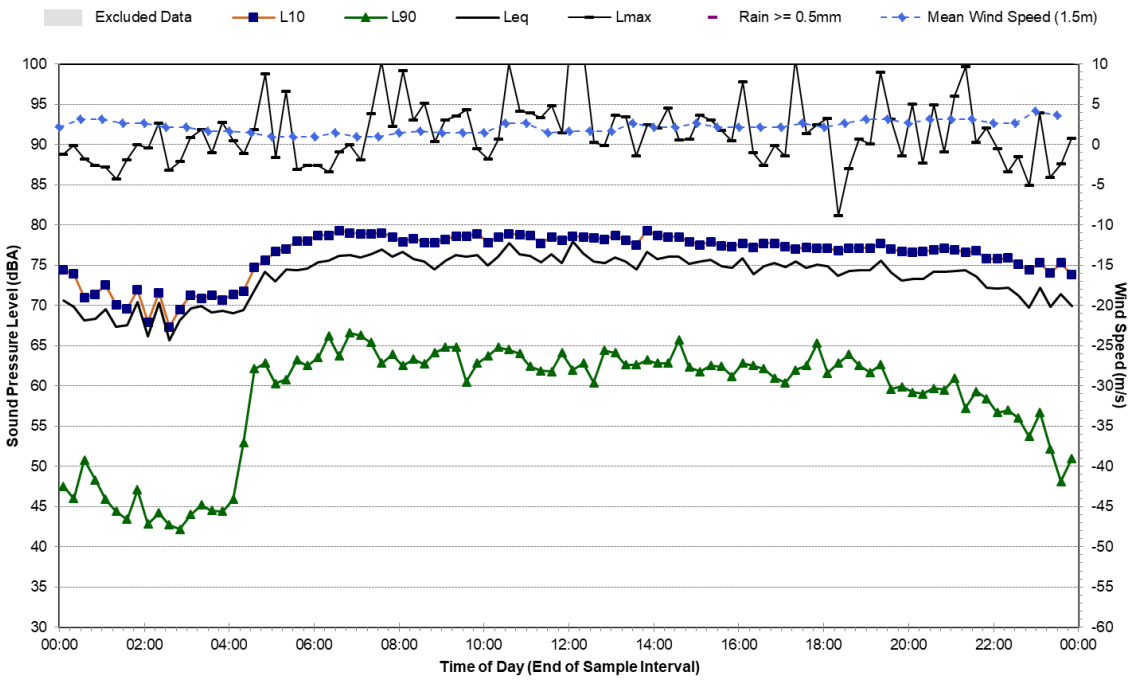
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Monday, 7 September 2020



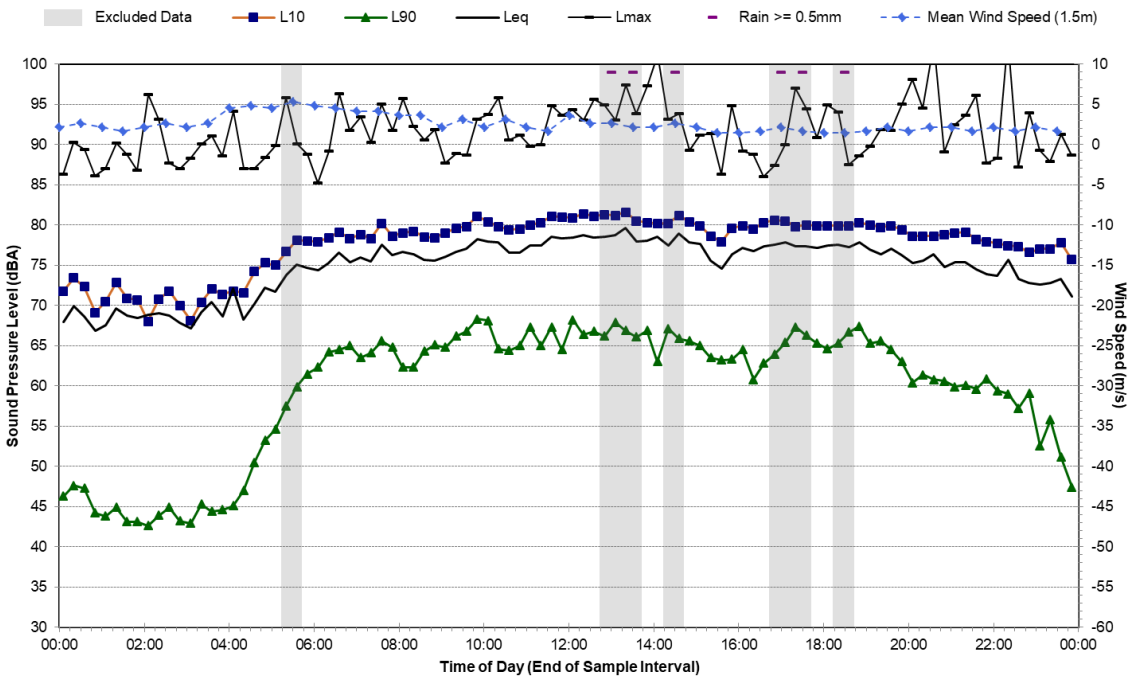
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Tuesday, 8 September 2020



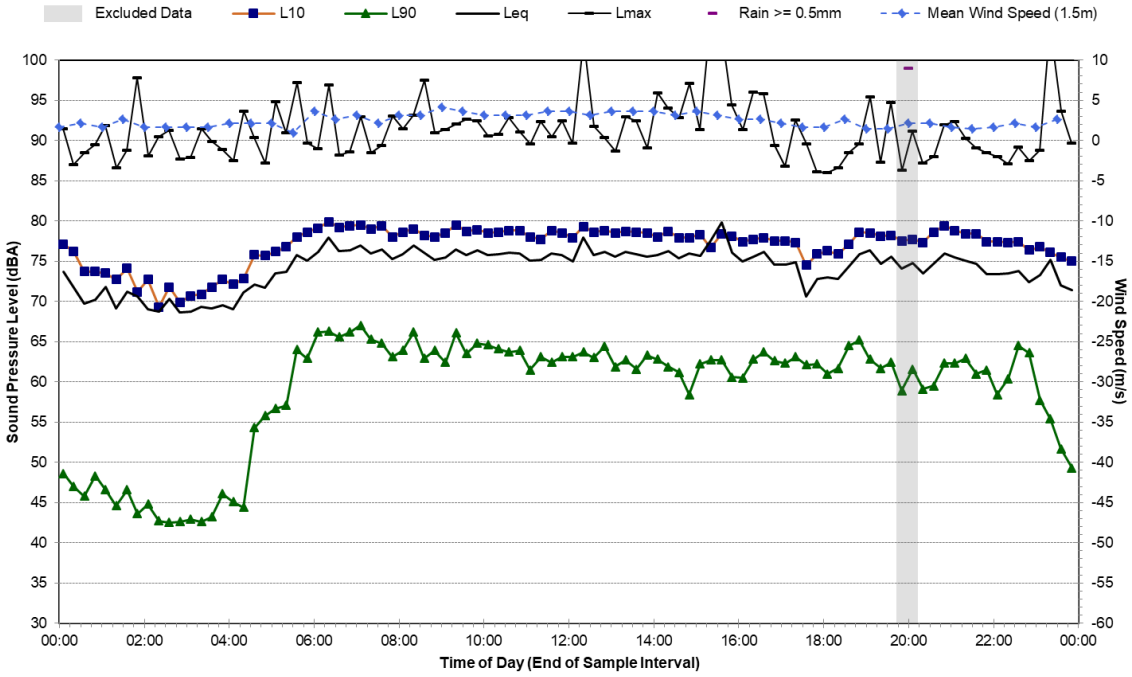
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Wednesday, 9 September 2020



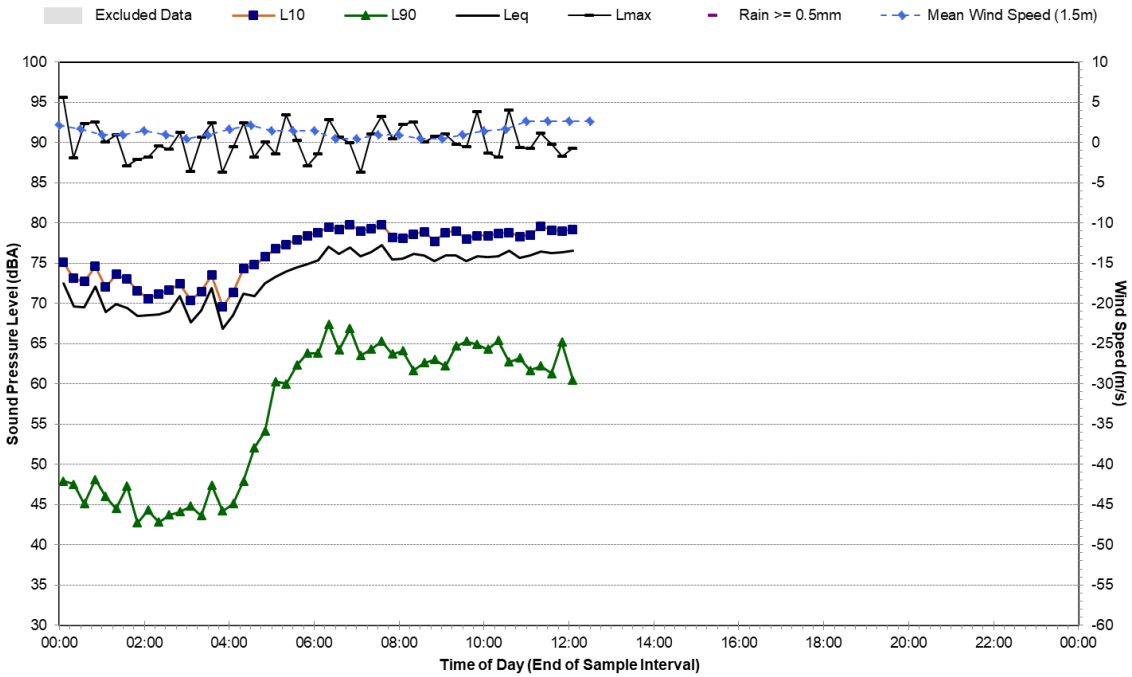
Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Thursday, 10 September 2020



Statistical Ambient Noise Levels

L.02 - 1 Livingstone Avenue, Pymble - Friday, 11 September 2020



ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 2 4249 1000

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628