Noise and Vibration Impact Assessment – Lapstone Station Upgrade

Transport for NSW

c/o SNC-Lavalin

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Sydney NSW 2000

Noise and Vibration Impact Assessment Lapstone Station

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Noise and Vibration Impact Assessment – Lapstone Station Upgrade

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Noise and Vibration Impact Assessment Lapstone Station.docx	Draft 4	10 October 2019	Peter Gangemi	Matthew Harrison	Matthew Harrison

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

GLOSSARY / ABBREVIATIONS

Abbreviation	Explanation
dBA	Decibels using the A-weighted scale measured according to the frequency of the human ear.
DECC	NSW Department of Environment and Climate Change (now EPA)
DECCW	NSW Department of Environment Climate Change and Water (now EPA)
DPIE	Department of Planning, Industry and Environment
EPA	NSW Environment Protection Authority
High-noise impact activities and work	Jack hammering, rock breaking or hammering, pile driving, dynamic compaction, vibratory rolling, cutting of pavement, concrete or steel or other work occurring on the surface that generates noise with impulsive, intermittent, tonal or low frequency characteristics.
$L_{Aeq\ (15min)}$	The A-weighted equivalent continuous (energy average) A-weighted sound pressure level of the construction works under consideration over a 15-minute period and excludes other noise sources such as from industry, road, rail and the community.
$L_{A\ (max)}$	The A-weighted maximum noise level only from the construction works under consideration, measured using the fast time weighting on a sound level meter.
LGA	Local government area
Low-noise impact activities and work	Deliveries, site access, equipment pre-start, refueling, office works, foot-based and manual activities using hand tools, work in ancillary activities, finishing works and clean-up and activities that generate noise that is no more than 5 dB(A) above rating background level at any residence.
OEH	NSW Office of Environment and Heritage
PoEO Act	NSW Protection of the Environment Operations Act 1997
RBL	The Rating Background Level for each period is the medium value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period (day, evening and night)
RMS	(former) NSW Roads and Maritime Services
Sensitive receiver	Residence, educational institution (e.g. school, university, TAFE college), health care facility (e.g. nursing home, hospital), religious facility (e.g. church) and children's day care facility.
SWL	Sound Power Level
SPL	Sound Pressure Level
TfNSW	Transport for New South Wales

1 EXECUTIVE SUMMARY

This Noise and Vibration Impact Assessment forms part of the Review of Environmental Factors (REF) for the proposed Lapstone Station Upgrade associated with the Transport Access Program (TAP). The project aims to provide a station precinct that is accessible for all sections of the community including people with a disability, limited mobility, parents/carers with prams, and customers with luggage. The key features of the proposed Lapstone Station Upgrade include installing a lift at the eastern end of the footbridge, footpath access on the western side that meets DSAPT compliance, an accessible car parking bay and modifications to the station building.

This Noise and Vibration Impact Assessment identifies the surrounding receivers and outlines the conducted noise logging. Noise criteria for the predicted operational impacts are derived from the *Noise Policy for Industry*. Noise criteria for construction works are guided by the *Interim Construction Noise Guideline*. Criteria for Construction Vibration are given by NSW *Assessing Vibration: a technical guideline*, BS7385: Part 2-1993 and DIN 4150: Part 3 – 1999.

Operational and construction noise scenarios were modelled in 3D environmental acoustic modelling software called iNoise 2019.1. Operational noise impacts are predicted to comply with the project criteria at all considered receptors, and no further operational mitigation measures are recommended.

The potential for additional road traffic noise as a result of the upgrade was assessed, with no further road noise mitigation measures recommended.

Proposed construction activities were divided into eight scenarios associated with the proposed activities. Predicted construction noise impacts are shown in section 8.6, with recommended additional mitigation measures identified in section 8.8 in line with the TfNSW *Construction Noise and Vibration Strategy*. A Construction Noise and Vibration Management Plan (CNVMP) is recommended to be conducted to determine specific mitigation measures for construction activities

Minimum distances are recommended in section 8.7 to avoid cosmetic damage and human response to vibration impacts at nearby receivers.

2 INTRODUCTION

2.1 Purpose

Pulse Acoustics was commissioned by SNC Lavalin on behalf of Transport of New South Wales (TfNSW) to prepare a specialist assessment of Noise and Vibration to assess the impacts of the proposed Lapstone Station Upgrade (the Proposal). This specialist assessment forms part of the Review of Environmental Factors (REF) which is being prepared to assess the impacts of the Proposal, in the considerations for approval under Part 5 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

2.2 Background

TfNSW is the lead agency for integrated delivery of public transport services across all modes of transport in NSW. TfNSW is proposing to upgrade Lapstone Station as part of the NSW Government's Transport Access Program (TAP) which aims to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure.

Lapstone Station is approximately 63 kilometres from Central Station, Sydney on the Blue Mountains Line of the Intercity Trains Network. The station is located on the eastern edge of the settlement of Lapstone, with the Nepean River about 330m to the south-east. It is a dual platform station with the northbound side of the station (Platform 1) providing services to Central Station, Sydney, and the south bound side (Platform 2) providing services to the Blue Mountains and beyond to Lithgow.

The station building is located on the western side of the station on Platform 1 and contains a waiting room, staff office with ticketing window, storeroom and toilet facilities.

The station and Platform 1 are accessed via a combination of paths, ramps, and stairs from the station car park and pedestrian footpaths from adjoining roads.

The eastern side of the station (Platform 2) is accessed from the station building and western side of the rail corridor via a steel pedestrian footbridge located towards the northern end of the platforms. A dirt track provides informal access to pedestrians from the east, and the neighbouring residential settlement of Leonay, through the adjoining bushland.

The commuter car park is located on the western side of the station. It currently provides one accessible parking space. Untimed on-street parking on surrounding streets is also available on the western side of the station.

Figure 2-1 and Figure 2-2 provide the regional and local site context for the proposal.

Figure 2-1 Regional Context

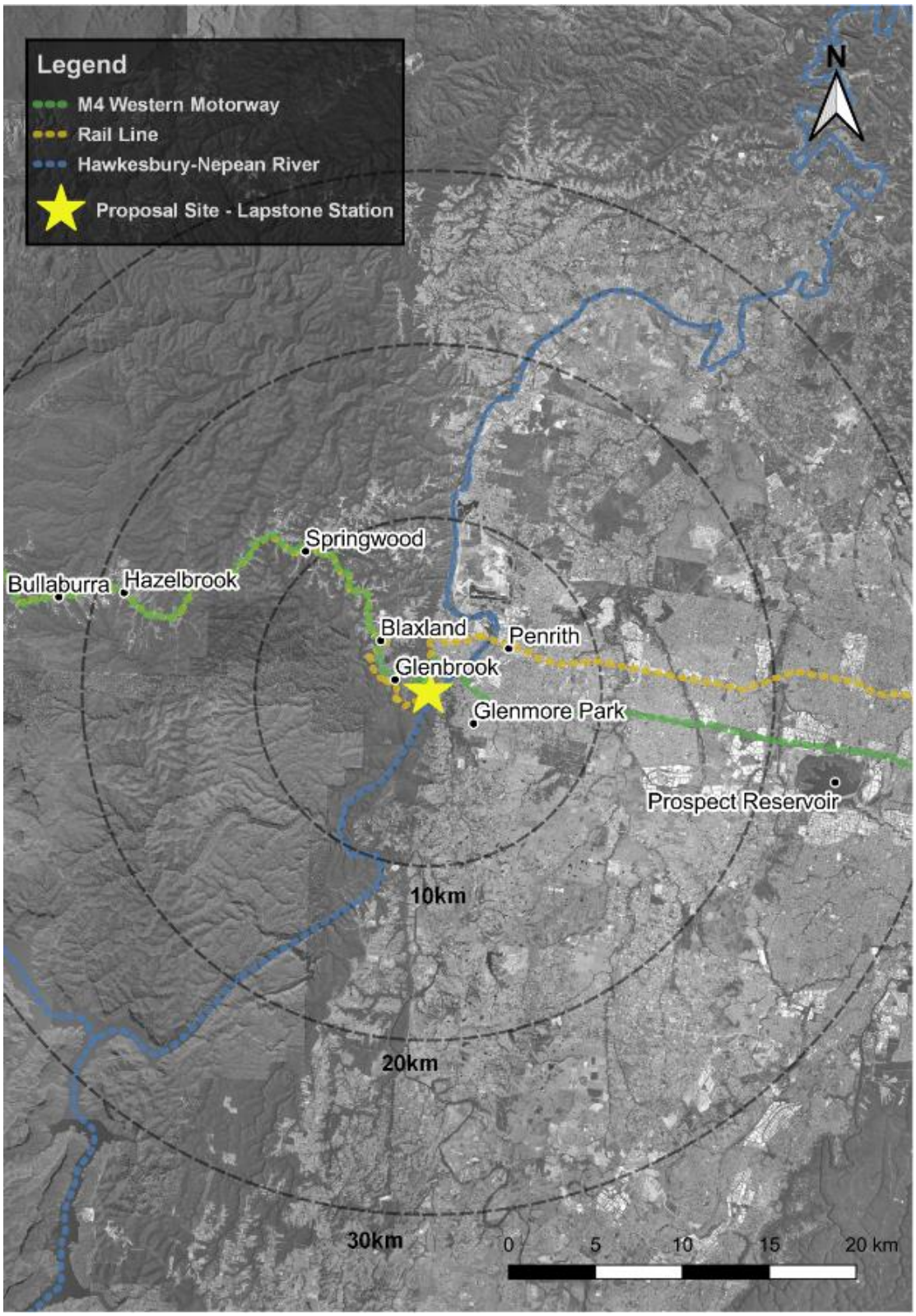
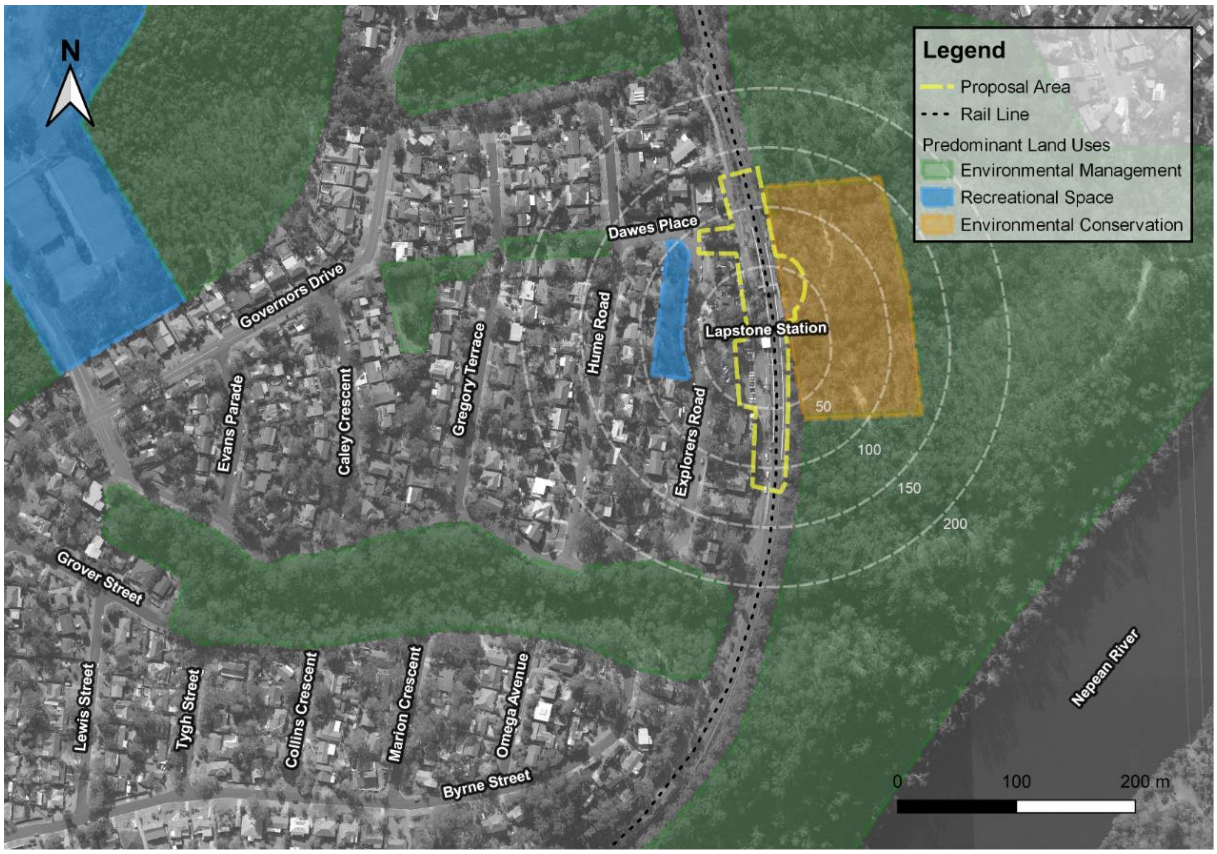


Figure 2-2 Local Site Context



2.3 Overview of Project

The Proposal area is identified in Figure 3. The proposal area includes:

- the rail corridor around Lapstone Station (including the station building, platforms, footbridge, shelter and connecting paths and stairs)
- an area of the bushland reserve to the east of the station footbridge
- a portion of the lower tier of the station commuter carpark
- a proposed construction compound area within the road reserve at the eastern extent of Dawes Place

Figure 2-3 Proposal Area

As part of the TAP program, the Proposal would aim to provide a station precinct that is accessible for all sections of the community including people with a disability, limited mobility, parents/carers with prams, and customers with luggage.

Key features of the Proposal are:

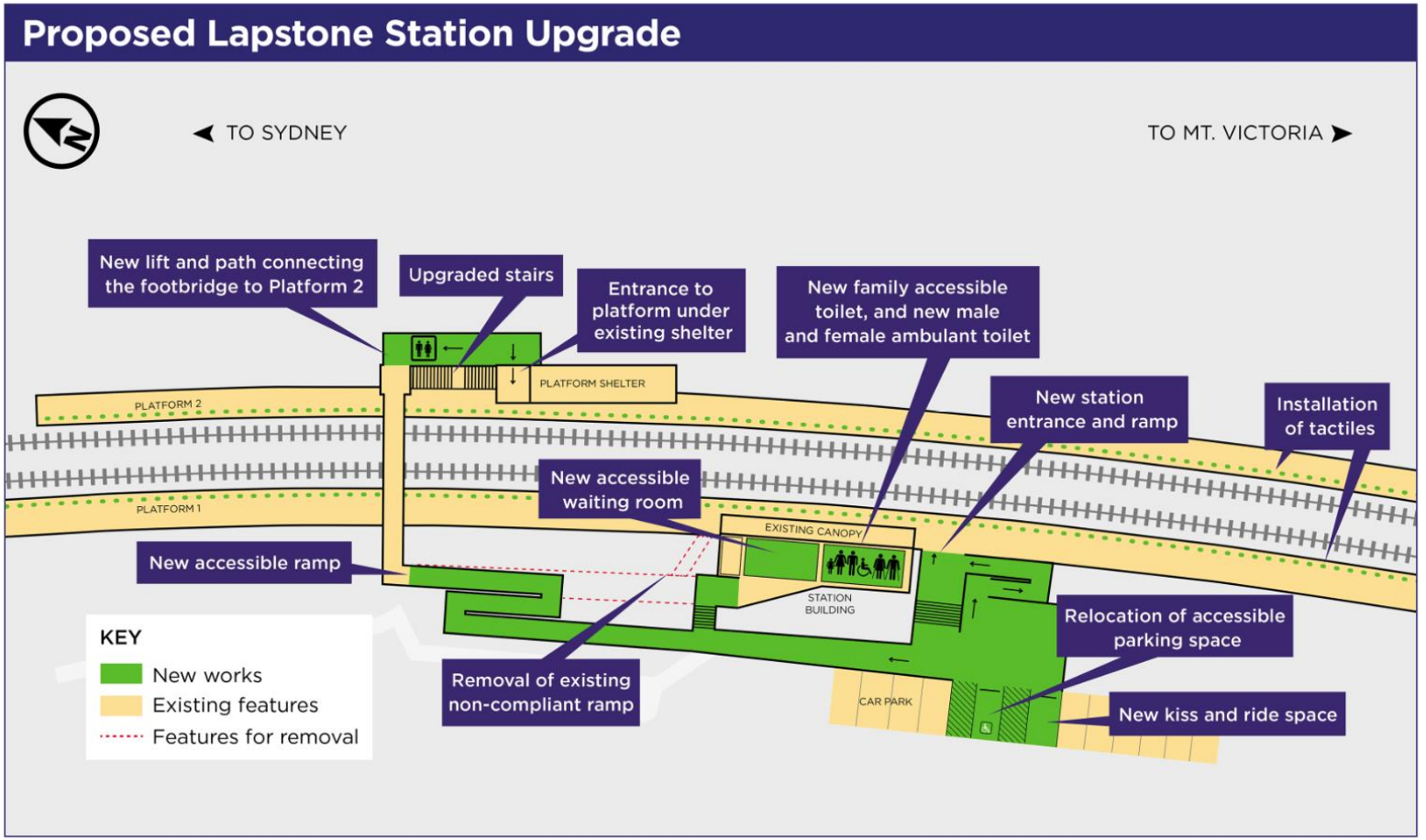
- installation of one new lift to the eastern end of the existing footbridge and a new footpath from the base of the lift to connect to Platform 2
- construction of a new DSAPT compliant ramp that provides access on the western side of station from the commuter car park to the footbridge
- construction of a new entrance point south of the station building on Platform 1, including new stair and ramp access from the commuter car park
- relocation and upgrade of the existing non-compliant accessible parking space within the commuter car park closer to the new Platform 1 entrance
- provision of a new kiss and ride space which will replace an existing car space
- closure of the steep ramp immediately north of the station building that currently provides access to Platform 1
- all stairs upgraded with compliant handrails, TGSIs and stair nosings
- installation of TGSIs along the full length of both platforms
- localised regrading of some platform areas to achieve compliant cross falls
- modifications to the existing station building layout including:
    - reconfigure the existing station toilets and store room to accommodate one family accessible toilet, one male ambulant toilet, one female ambulant toilet and a new store room
    - the building modifications will include providing level access from Platform 1 into both the waiting room and the new family accessible toilet
- installation of seating cut into the sandstone rail cutting on Platform 1
- closed circuit television (CCTV) cameras to provide coverage to meet security standards for new infrastructure
- power supply upgrade to support new infrastructure, including upgrade of existing connection, transformer and distribution board
- trimming and removal of trees and vegetation to construct and accommodate the new accessible paths and lift
- ancillary work including installation of platform hearing loops, electrical conduits, pits, cabling, service relocation, lighting, opal card reader relocation, landscaping, drainage works, wayfinding signage, relocation of bins and furniture, and new bin storage area.

Subject to planning approval, construction is expected to commence in mid-2020 and take around 12 to 18 months to complete

Temporary site compound facilities would be needed for laying down equipment and machinery, parking plant and vehicles and storage of materials. The proposed area is the vegetated road reserve at the eastern end of Dawes Place

Figure 2-4 shows the general layout of key elements of the Proposal based on the strategic concept design. The design would be further refined during the detailed design phase.

Figure 2-4 Key Features of the Proposal (subject to detailed design)



3 AIM AND OBJECTIVES

3.1 Aim

The aim of this Noise and Vibration Impact Assessment is to assess how the potential construction and operational impacts of the Lapstone station upgrades will be managed.

3.2 Objectives

The key objective of the Noise and Vibration Assessment is to ensure that impacts to the local community from noise and vibration are minimised and mitigated. Specific objectives include:

- identifying noise and vibration sensitive receivers within the study area
- ensuring appropriate environmental controls and procedures are implemented during construction and operation activities
- managing impacts, where they occur, through a systematic analysis of mitigation strategies
- ensure appropriate measures are implemented to comply with all relevant legislation

3.3 Targets

Targets have been established for the management of noise and vibration impacts during the Project to ensure:

- full compliance with the relevant legislative requirements
- the implementation of all feasible and reasonable noise mitigation measures with the aim of achieving the construction Noise Management Levels detailed in the *Interim Construction Noise Guideline* (ICNG) DECC, 2009
- the implementation of suitable noise mitigation measures with the aim of achieving the operational assessment criteria detailed in the *Noise Policy for Industry* (NPI) EPA, 2017
- complaints from the community and stakeholders are minimised

3.4 Relevant Legislation and Guidelines

Legislation and guidelines that are relevant to this project are shown below.

3.4.1 Legislation

Legislation applicable to noise and vibration management includes:

- *Protection of the Environment Operations Act 1997 (POEO Act)*
- *Protection of the Environment Operations (Noise Control) Regulation 2008*

3.4.2 Guidelines

The main guidelines, specifications and policy documents relevant to this assessment include:

- NSW *Noise Policy for Industry* (NPI) (EPA, 2017)
- NSW *Interim Construction Noise Guideline* (ICNG) (DECC, 2009)
- *Construction Noise and Vibration Strategy* (CNVS) (TfNSW, 2018)

- NSW *Assessing Vibration: A Technical Guideline* (DEC, 2006)
- British Standard *BS6472-1: 2008: Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration Sources other than Blasting, BSI, 2008*
- British Standard *BS7385: Part 2 Evaluation and Measurement of Vibration in Buildings*
- German *DIN 4150: Part 3 – 1999 Effects of Vibration on Structure* (DIN, 1999)
- NSW *Road Noise Policy* (RNP) (DECCW, 2011)
- Australian Standard A*S 2436 – 2010 Guide to noise and vibration control on construction, demolition and maintenance site*
- British Standard *BS 5228-2009 Code of practice for noise and vibration control on construction and open sites*

4 EXISTING ENVIRONMENT

4.1 Sensitive Receivers

The Lapstone Station upgrade project is located at Lapstone Station, on Explorers Road. The Lapstone residential community consists of low density properties and is located to the west of the station. The eastern side of the station features a heavily vegetated area that separates the Leonay suburb from Lapstone station. The closest residential receiver in Leonay is located 300m from Lapstone Station. Informal pedestrian traffic occurs occasionally from Leonay through a dirt track to the eastern side of the station. Residential dwellings are located 20m to the west of the western access ramp. No non-residential receivers are located within 200m of Lapstone Station.

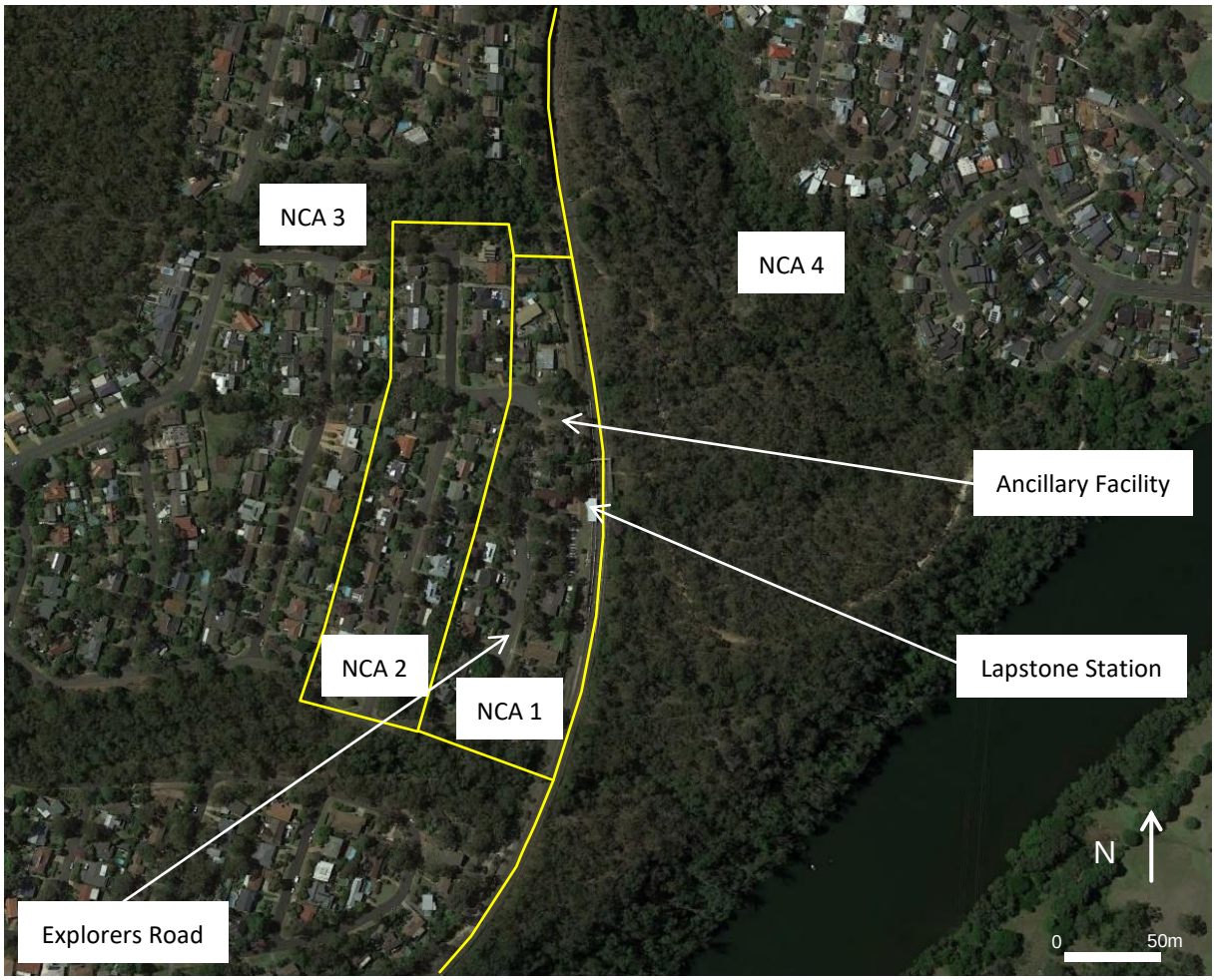
Construction works are primarily proposed to take place at the Lapstone Railway Station. However, an ancillary construction facility is proposed to be located 80m to the north of the station, on the vegetated road reserve at the eastern end of Dawes Place. Residential receivers are located to the south, north and to the west of the proposed ancillary facility (construction compound), along Explorers Road and Dawes Place.

This noise and vibration assessment considers potential noise impacts for each residential dwelling within the vicinity of the operational proposal area, construction works and ancillary facilities. A total of 4 Noise Catchment Areas (NCAs) have been utilised in this project. The catchment areas are identified as follows

- NCA 1: This catchment consists mostly of receivers located along Explorers Road in the section closest to Lapstone Station. The NCA consists entirely of residential dwellings, mostly single storey and double storey houses, with some townhouses next to the station.
- NCA 2: The catchment contains receivers that are primarily located along Hume Road, one block to the west of Explorers Road. The NCA entirely consists of residential dwellings, mostly double storey houses with some single storey houses.
- NCA 3: This catchment includes the remainder of the receivers west of the railway line, with all parts of the catchment being at least 170m from the station. The NCA consists mostly of residential dwellings, with some active recreation areas also present.
- NCA 4: The catchment contains all receivers to the east of the railway line in Leonay. The NCA consists mostly of bushland and residential dwellings.

The location of the catchment areas is shown in Figure 4-1.

Figure 4-1 Noise Catchment Areas



4.2 Ambient Noise

4.2.1 Noise monitoring results

Noise monitoring was undertaken to determine background noise levels to aid with establishing operational and construction noise criteria for areas of sensitive receivers close to the site and proposed works. As shown in Figure 4-2, two locations were used to characterise the existing noise environment at representative receivers.

Attended monitoring was conducted on Tuesday the 20 August 2019 at the closest residential receiver to Lapstone Station, being the residence at 2/215 Explorers Road (Location A). Monitoring was selected at this location, as numerous construction and operational activities are proposed in the vicinity of this receiver. Attended monitoring was also conducted at 10 Dawes Place Lapstone (Location B). Monitoring was conducted in this location as the receiver is in close proximity to the proposed ancillary facility. Attended monitoring results are shown in Table 4-1.

The attended noise monitoring showed that the background noise levels at the two receivers were almost identical. The similar background levels were due to the locations being just 80m apart, as well as the fact that the background noise levels at both locations are being equally driven by the same natural sounds of birds and distant traffic from the M4 and Great Western Highway.

Table 4-1 Attended Noise Monitoring Results for Location A and Location B

ID	Address	Time	$L_{Aeq,15\ min}$	L_{A90}
Location A	2/215 Explorers Road, Lapstone	10:02 – 10:17	50	**37**
Location B	10 Dawes Place, Lapstone	10:22 – 10:37	45	**36**

As can be seen above in Table 4-1, the attended background (L_{A90}) noise monitoring results were very similar for the two locations. Given that the attended noise monitoring results have similar background levels and that location B only represents one construction scenario which is predicted to have minor impacts, unattended monitoring was conducted only at Location A. Noise criteria for all the catchments was therefore taken from the single unattended noise logger.

The measured background noise levels for Location A are shown in Table 4-2. Distant road traffic noise and environmental noise is slightly quieter during the night period than the day and evening periods. Overall, the RBLs are low for a suburban area, with the day RBL being below the minimum RBL of 35 dB(A) outlined in Table 2.1 of the Noise Policy for Industry.

Figure 4-2 Noise Monitoring Locations

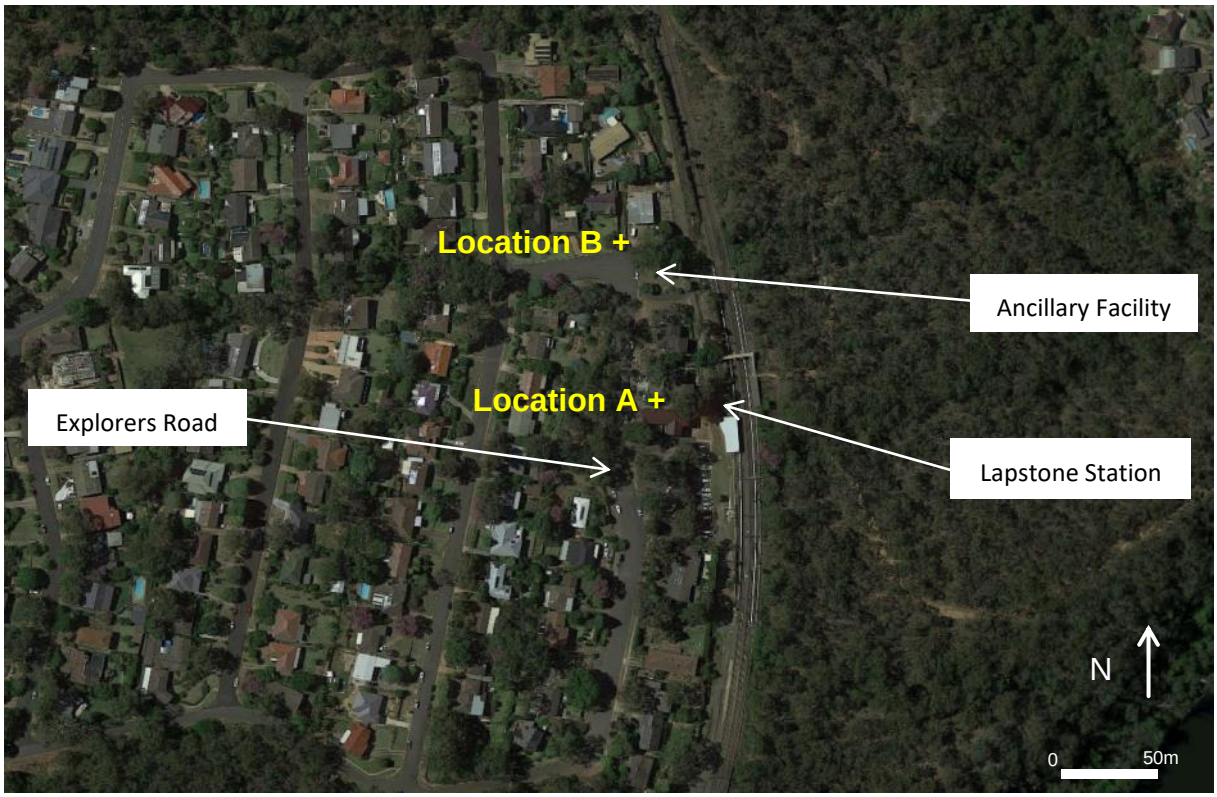


Table 4-2 Measured ambient noise levels – unattended noise survey

Measurement Location	Daytime[1] 7am to 6pm		Evening[1] 6pm to 10pm		Night-time[1] 10pm to 7am	
	L_{A90}[2]	LAeq[3]	L_{A90}[2]	LAeq[3]	L_{A90}[2]	LAeq[3]
Location A	32	55	32	55	30	55

Note 1: For Monday to Saturday, Daytime 7am – 6pm; Evening 6pm – 10pm; Night-time 10pm – 7am. On Sundays and Public Holidays, Daytime 8am – 6pm; Evening 6pm – 10pm; Night-time 10pm – 8am

Note 2: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The LAeq is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

4.2.2 Minimum Background Noise Levels and Project Trigger Noise Levels

When very low background noise levels are measured in an environment, the minimum assumed RBLs given in section 2.3 and Table 2.1 of the NPI are to be used in preference to the measured background noise levels. These minimum background noise levels and project intrusiveness limits are shown in Table 4-3 below:

Table 4-3 NSW NPI – Minimum assumed RBLs and project intrusiveness noise levels.

Time of day	Minimum assumed rating background noise level (dBA)	Minimum project intrusiveness noise levels ($L_{Aeq,15min}$ dBA)
Day	35	**40**
Evening	30	**35**
Night	30	**35**

Note 1: For Monday to Saturday, Daytime 7am – 6pm; Evening 6pm – 10pm; Night-time 10pm – 7am. On Sundays and Public Holidays, Daytime 8am – 6pm; Evening 6pm – 10pm; Night-time 10pm – 8am

Where the measured background noise level is lower than the minimum assumed background noise level**, the minimum assumed RBLs given in the NPI will apply.**

5 NOISE AND VIBRATION CRITERIA

Noise criteria are outlined for operational activities and construction activities in line with relevant guidelines.

For operational activities, the NSW EPA recommends the

- NSW *Noise Policy for Industry* (NPI)

For construction works, the EPA recommends management levels and goals, as outlined in:

- NSW *Interim Construction Noise Guideline* (ICNG)
- NSW Construction Noise and Vibration Strategy (CNVS)
- NSW *Assessing Vibration: a technical guideline*
- British Standard *BS7385: Part 2-1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration (BSI 1993)*
- German *DIN 4150: Part 3 – 1999 Effects of Vibration on Structure (DIN 1999)*

For road traffic activities, the NSW EPA recommends the

- NSW *Road Noise Policy* (RNP)

Relevant elements of these documents are summarised and discussed in this section.

5.1 Operational Noise Criteria

In NSW, the control of noise emission is the responsibility of Local Government and the NSW Environment Protection Authority (NSW EPA). In October 2017, the NSW EPA released the *Noise Policy for Industry* (NSW NPI). The purpose of the policy is to ensure that noise impacts associated with particular industrial developments are evaluated and managed in a consistent and transparent manner. The policy aims to ensure that noise is kept to acceptable levels in balance with the social and economic value of industry in NSW.

The NSW NPI criteria for industrial noise sources have two components:

- controlling the intrusive noise impacts for residential receivers in the short-term
- maintaining noise level amenity of particular land uses for residents and sensitive receivers in other land uses

The project noise trigger level is derived from the more stringent of the project intrusiveness noise level and the project amenity noise level.

5.1.1 Intrusive Noise Impacts (Residential Receivers)

The NSW NPI states that the noise from any single source should not intrude greatly above the prevailing background noise level. The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15-minute period, does not exceed the background noise level by more than 5 dB(A). This is often termed the Intrusiveness Criterion, as shown below.

$$L_{Aeq,\ 15\ minute} = \text{rating background noise level} + 5\ dB$$

Using the rating background noise level approach results in the intrusiveness criterion being met for at least 90% of the 15 minute time periods.

5.1.2 Protecting Noise Amenity (All Receivers)

To limit continuing increase in noise levels, the maximum ambient noise level within an area from all industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.2 of the NSW Noise Policy for Industry. The recommended amenity noise levels have been subjectively scaled to reflect perceived differential expectations and ambient noise environments of rural, suburban and urban communities for residential receivers.

"Existing plus new" industrial noise levels are recommended to remain within the **recommended amenity** noise levels for an area. Therefore, a **project amenity** noise level applies for each new source of industrial noise as follows:

Project amenity noise level = recommended amenity noise level (Table 2.2 of NPI) minus 5 dB(A)

5.1.3 Area Classification

The amenity noise levels presented in Table 2.2 of the Noise Policy for Industry categorise residential receivers into rural, suburban and urban noise amenity areas. Table 2.3 of the Noise Policy for Industry characterises the "Suburban Residential" noise environment as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. Additionally, this area often has evening ambient noise levels defined by the natural environment and human activity.

Therefore, the suburban residential receiver category corresponds best with the residential receptors surrounding the project area.

For the considered receptors in the suburban area, the recommended amenity noise level is shown in Table 5-1 below. When the existing noise level from industrial noise sources is close to the recommended "Amenity Noise Level" (ANL) given above, noise from the new source must be controlled to preserve the amenity of the area in line with the requirements of the NSW NPI.

Table 5-1 NSW NPI – Recommended L_{Aeq} Noise Levels from Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day [1]	Recommended Amenity Noise Level ($L_{Aeq, period}$) [2]
Residence	Suburban	Day	55
Residence	Suburban	Evening	45
Residence	Suburban	Night	40

Note 1: Time periods defined as:
Day: 7am to 6pm Monday to Saturday, 8am to 6pm Sunday;
Evening, 6pm to 10pm Monday to Sunday
Night 10pm to 7am Monday to Saturday, 10pm to 8am Sunday

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound

5.1.4 Project Trigger Noise Levels

The project trigger noise levels for the operational activities are derived from the amenity and intrusive criterion in Table 5-2. The amenity and intrusive criterion are nominated for the purpose of determining the operational noise limits for noise sources associated with the development which can potentially affect noise sensitive receivers.

For each assessment period, the project trigger noise levels are the lower (i.e. the more stringent) of the amenity or intrusive criteria. The project trigger noise levels are shown in bold text in Table 5-2.

Table 5-2 External Noise Level Criteria in Accordance with the NSW NPI

Location	Time of Day	Project Amenity Noise Level, $L_{Aeq, period}$ [1] (dBA)	Measured $L_{A90, 15\ min}$ (RBL) [2] (dBA)	Measured $L_{Aeq, period}$ Noise Level (dBA)	Intrusive $L_{Aeq, 15\ min}$ Criterion for New Sources [3] (dBA)	Amenity $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA) [3,5]
Residences	Day	50	32	55	**40**[6]	53
Residences	Evening	40	32	55	**37**	48[4]
Residences	Night	35	30	55	**35**	48[4]

Note 1: Project Amenity Noise Levels corresponding to "suburban" areas, equivalent to the Recommended Amenity Noise Levels (Table 5-1) minus 5 dBA

Note 2: L_{A90} Background Noise or Rating Background Level

Note 3: Project Noise Trigger Levels are shown in bold

Note 4: Where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level, the project amenity noise levels can be set at 10 dB below existing industrial noise levels (if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time).

Note 5: According to section 2.2 of the NSW NPI, the LAeq, 15 minutes is equal to the LAeq, period + 3 dB

Note 6: As per Table 2.1 of the Noise Policy for Industry, the minimum project intrusiveness level is 35 dBA during the day period and 30 dBA during the evening and night period

Therefore, the operational noise criterion at the surrounding receivers is shown in Table 5-3 below.

Table 5-3 Project Trigger Noise Level ($L_{Aeq(15\ min)}$)

Location	Time of Day	Project Trigger Level (dBA)
Residences	Day	**40**
Residences	Evening	**37**
Residences	Night	**35**

Note 1: Project Trigger Level is given in terms of an LAeq(15 min) noise levels

5.1.5 Operational Sleep Disturbance Criteria

The sleep disturbance criterion, obtained from the NSW *Road Noise Policy* (RNP), provides an assessment criterion for the expected quality of sleep of residential receivers during the night.

An accurate representation of sleep disturbance impacts on a community from a noise source is particularly difficult to quantify mainly due to differing responses of individuals to sleep disturbance – this is found even within a single subject monitored at different stages of a single night's sleep or during different periods of sleep.

In addition the differing grades of sleep state make a definition difficult, and even where sleep disturbance is not noted by the subject, factors such as heart rate, mood and performance can still be negatively affected.

An assessment of sleep disturbance should consider the maximum noise level or $L_{A1(1\ minute)}$, and the extent to which the maximum noise level exceeds the background level as well as the number of times this may happen during the night-time period. Factors that may be important in assessing the extent of impacts on sleep include:

- how often high noise events will occur
- time of day (normally between 10pm and 7am)
- whether there are times of the day when there is a clear change in the existing noise environment (such as during early morning shoulder periods)

Currently the information relating to sleep disturbance impacts indicates that:

- maximum internal noise levels below 50-55 dBA are unlikely to cause an awakening from a sleep state
- one or two noise events per night with maximum internal noise levels of 65-70 dBA are not likely to affect health and wellbeing significantly

As a result, the adopted sleep disturbance criterion for the project is an internal noise level of 50 dB L_{Amax}. This criterion is applicable for noise emissions generated by short term events occurring during the night time period. As a guide, the difference between the internal noise level and the external noise level is typically 10 dB with windows open for adequate ventilation therefore, allowing for a 10 dB reduction for open windows, **the proposed noise screening criterion for sleep disturbance is 60 dB L_{Amax} external noise level at residential properties.**

5.2 Operational Road Traffic Noise Criteria

The NSW Road Noise Policy (RNP) aims to identify the strategies that address the issue of road traffic noise from:

- existing roads
- new road projects
- road redevelopment projects
- new traffic generating developments

The RNP also outlines the noise assessment criteria for the road traffic noise generated by the development.

5.2.1 Operational Road Noise Assessment Criteria

Error! Reference source not found. sets out the assessment criteria for residences to be applied to p articular types of project, road category and land use. These criteria are for assessment against façade-corrected noise levels when measured 1m in front of a building façade. The relevant road category in **Error! Reference source not found.** is a local road, corresponding to Explorers Road.

Table 5-4 Road Traffic Noise Assessment Criteria for Residential Land Uses

Road Category	Type of project/land use	Day Criteria dBA (7am – 10pm)	Night Criteria dBA (10pm – 7am)
Local Roads	1. Existing residences affected by noise from new local corridors 2. Existing residences affected by noise from redevelopment of existing local roads 3. Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,(1\ hour)}$ 55 (external)	$L_{Aeq,\ (1\ hour)}$ 50 (external)

5.2.2 Relative Increase Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the RNP states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

5.3 Construction Noise and Vibration Criteria

The DECC *Interim Construction Noise Guideline* (ICNG, July 2009) provides guidelines for the assessment and management of construction noise. The NSW EPA's *Road Noise Policy* (RNP) refers to the use of the ICNG for the assessment of construction noise impacts.

The ICNG focuses on applying a range of work practices and management strategies to minimise construction noise impacts rather than focusing on achieving a numerical noise levels which is not always practical on large infrastructure projects.

The main objectives of the ICNG are to:

- identify and minimise noise from construction works
- focus on applying all ‘feasible’ and ‘reasonable’ work practices to minimise construction noise impacts
- encourage construction during the recommended standard hours only, unless approval is given for works that cannot be undertaken during these hours
- reduce time spent dealing with complaints at the project implementation stage
- provide flexibility in selecting site-specific feasible and reasonable work practices to minimise noise impacts

5.3.1 Quantitative Noise Assessment Criteria

Construction noise assessment goals presented in the ICNG are referred to as Noise Management Levels (NMLs) for residential, sensitive land uses and commercial/industrial premises.

Residential premises

Table 5-5 sets out NMLs for noise at residences and how they are to be applied.

In Table 5-5 the Rating Background Level (RBL) is used when determining the management level. 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 NPI.

Table 5-5 Noise at Residents Using Quantitative Assessment

Time of day	Management Level $L_{Aeq\ (15\ min)}$[1]	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. - Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. - The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. - Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: ▪ times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences ▪ if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	- A strong justification would typically be required for works outside the recommended standard hours. - The proponent should apply all feasible and reasonable work practices to meet the noise affected level. - Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

5.3.2 Adopted Project Noise Management Levels

Based on the measured noise levels described in section 4, the broader adopted construction NMLs are presented in Table 5-6 including NMLs for out-of-hours works.

Table 5-6 Adopted Construction Noise Management Levels – Residential receivers

	Standard Hours– Daytime (7am–6pm M-F, 8am-1pm Sat)	OOHW 1 – Daytime (7am-8am and 1pm–6pm Sat, 8am-6pm Sun)	OOHW 1 – Evening (6pm–10pm Mon-Sat)	OOHW 2 – Night-time (10pm–7am Mon-Sat, 6pm -8am Sundays and public holidays)
	NML	NML	NML	NML
Residential	45[1]	40[1]	37	35

Note 1: As per Table 2.1 of the Noise Policy for Industry, the minimum project intrusiveness level is 35 dBA during the day period. Therefore the standard daytime construction noise management level is set 10 dB above the minimum criteria, and the OOHW daytime construction noise management level is set 5 dB above the minimum criteria

5.3.3 Construction Sleep Disturbance Criteria

Sleep disturbance criteria was recommended for operational noise sources in section 5.1.5. In a similar way, sleep disturbance criteria is recommended for any construction activities that may take place during the night time period.

Sleep disturbance for construction noise is recommended to adopt the same criteria as sleep disturbance for operational noise. That is, the proposed noise screening criterion for sleep disturbance is 60 dB L_{Amax} external noise level at residential properties.

5.3.4 Construction Road Traffic Noise

Noise from vehicles when conducting construction activities off public roads is assessed against the *Interim Construction Noise Guideline*.

Noise from construction vehicles on public roads will be assessed against the NSW *Road Noise Policy* Criteria.

5.4 Vibration Criteria

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed
- effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects
- effects on building structures – where vibration can compromise the integrity of the building or structure itself

The first of these vibration effects relating specifically to the human comfort aspects of the project are taken from the *Assessing Vibration – A Technical Guideline*. This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- continuous vibration – from uninterrupted sources (see Table 5-7)
- Impulsive vibration – up to three instances of sudden impact e.g. dropping heavy items, per monitoring period (see Table 5-8)
- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (see Table 5-9)

Table 5-7 Continuous Vibration Acceleration Criteria (m/s^2) 1-80Hz

Location	Assessment Period	Preferred Values z-axis	Preferred Values x- and y-axis	Maximum Values z-axis	Maximum Values x- and y-axis
Residences	Daytime	0.010	0.0071	0.020	0.014
Residences	Night-time	0.007	0.005	0.014	0.010

Note 1: From Assessing Vibration – A Technical Guideline DEC (2006)

Table 5-8 Impulsive Vibration Acceleration Criteria (m/s^2) 1-80Hz

Location	Assessment Period	Preferred Values z-axis	Preferred Values x- and y-axis	Maximum Values z-axis	Maximum Values x- and y-axis
Residences	Daytime	0.30	0.21	0.60	0.42
Residences	Night-time	0.10	0.071	0.20	0.14

Note 1: From Assessing Vibration – A Technical Guideline DEC (2006)

Table 5-9 Intermittent Vibration Impacts Criteria (m/s$^{1.75}$) 1-80Hz

Location	Daytime Preferred Values	Daytime Maximum Values	Night-time Preferred Values	Night-time Maximum Values
Residences	0.20	0.40	0.13	0.26

Note 1: From Assessing Vibration – A Technical Guideline DEC (2006)

The other two effects relate to impacts on the building itself and are assessed against international standards as follows:

- British Standard *BS7385: Part 2-1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration (BSI 1993)*
- German *DIN 4150: Part 3 – 1999 Effects of Vibration on Structure (DIN 1999)*

The German standard provides the most stringent criteria and has been used in this assessment. The DIN standard specifically mentions heritage items as being more sensitive. The DIN guideline values for peak particle velocity (mm/s) measured at the foundation of the building are summarised in Table 5-10. The criteria are frequency dependent and specific to particular categories of structures.

Table 5-10 Structural Damage Criteria

Type of Structure, Peak Component Particle Velocity mm/s	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	Vibration of horizontal plane of highest floor at all frequencies
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

6 OPERATIONAL NOISE ASSESSMENT

Operational noise sources associated with the Lapstone station upgrade are expected to be minor in nature. Operational noise sources at Lapstone Station are expected to include the following equipment

- Lift motor
- Lift air conditioning
- Building air conditioning
- Bathroom exhaust fans

As final equipment has not yet been selected, the operational noise levels cannot be predicted. However from other station upgrades, it is predicted that the sound power levels of such equipment will be low. Therefore operational noise impacts at neighbouring receivers are predicted to readily comply with the operational project trigger levels in Table 5-3 and operational sleep disturbance criteria in section 5.1.5.

7 OPERATIONAL ROAD TRAFFIC NOISE ASSESSMENT

Operational road traffic noise impacts of the completed Lapstone Station upgrade are assessed in this section. Vehicles travelling to and from Lapstone Station on local streets such as Explorers Road, Dawes Place, Hume Road and Governors Drive are travelling on local roads.

Under section 3.4.1 of the Road Noise Policy “for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding ‘no build option’”. A 2 dB increase equates to approximately a 60% increase in total traffic along the subject road. While the proposed Lapstone Station Upgrade has the potential to increase traffic along local roads, any proportional traffic increase is predicted to be far smaller than this amount.

The road traffic noise levels are therefore predicted to not increase by 2 dB or more. Therefore the proposed road movements are predicted to comply with the Road Noise Policy and no further noise mitigation measures are recommended.

8 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

At this stage, a detailed construction management plan has not been completed. Therefore the scenarios assessed in this chapter are considered to be in-principle and subject to further analysis from a future Construction Noise & Vibration Management Plan (CNVMP).

Additionally, while the majority of activities are expected to take place during standard construction hours, construction work will also take place during weekend track possessions. It is expected that a future CNVMP would provide greater clarification on construction hours for each activity.

In this section, the in-principle construction noise and vibration generating scenarios are identified. Potential construction noise and vibration impacts are predicted at the nearby receivers. In principle recommended mitigation measures against potential noise and vibration impacts are given, subject to a future CNVMP.

8.1 Impacts

The potential for noise and vibration impacts on sensitive receivers will depend on a number of factors. Typically these include:

- the type of equipment and number of simultaneously operating plant items
- topography and the presence of any other physical barriers
- proximity to sensitive receivers
- hours/duration of construction works
- the prevailing background noise level
- ground conditions

Construction noise and vibration impacts attributable to the project are anticipated. The following sections predict the potential construction impacts at the receivers and recommends mitigation measures that will be implemented to minimise impacts on the receiving community.

8.2 Construction Activities

A range of plant and equipment will be required to undertake activities associated with the upgrade of Lapstone Station.

A summary of in principle construction scenarios and the sound power levels of the plant expected to be used are provided in Table 8-1. This information will be used to determine potential impacts on the surrounding receivers.

Typical construction equipment noise levels have been obtained from 'Appendix A' of A*S 2436 – 2010 Guide to noise and vibration control on construction, demolition and maintenance site*; *BS 5228-2009 Code of practice for noise and vibration control on construction and open sites* and the UK Department for Environment, Food and Rural Affairs databases (DEFRA).

The levels assume that the use of hand tools and the concrete boom pump will be operational for the full 15 minute period. The jackhammer, excavator with hydraulic hammer and concrete saw are expected to be used on and off during the 15 minute period, and have therefore been applied for 5 minutes of the 15 minute scenario. Idling trucks have also been assumed to be operational for 5 of the 15 minute scenario, consistent with an arrival or departure on site combined with a few minutes of idling.

8.3 Recommended Construction Hours

The majority of works are expected to take place during standard construction hours however works may also take place during full track possessions.

It is expected that scenarios 3-6 and 8 would be conducted during the following periods

- Standard construction hours: Monday to Friday 7am to 6pm and Saturday 8am to 1pm
- Out of Hours Work 1 (Day NPI period): Saturday 7am to 8am and 1pm to 6pm, and Sunday/Public Holidays 8am to 6pm
- Out of Hours Work 1 (Evening NPI period): Monday to Saturday 6pm to 10pm

It is expected that scenarios 1, 2 and 7 would be conducted during the following periods

- Standard construction hours: Monday to Friday 7am to 6pm and Saturday 8am to 1pm
- Out of Hours Work 1 (Day NPI period): Saturday 7am to 8am and 1pm to 6pm, and Sunday/Public Holidays 8am to 6pm
- Out of Hours Work 1 (Evening NPI period): Monday to Saturday 6pm to 10pm
- Out of Hours Work 2: Monday to Saturday 10pm to 7am and Sunday/Public Holidays 6pm to 8am

The modelled construction scenarios and associated equipment are shown below in Table 8-1.

Table 8-1 Construction Scenarios and Associated Plant and Equipment

Construction scenario	Equipment Type	Number of Equipment	Height	Usage per 15 minute period (minutes)	Sound power level $L_{Aeq(15min)}$ dBA	Sound power level L_{AMax} dBA
Scenario 1: Ancillary Facility (Potential Night OOHW 2)	Truck (idle)	1	2	5	102	106
Scenario 2: Platform Rock Sawing (Potential Night OOHW 2)	Concrete Saw[1]	1	0.5	5	110	114
Scenario 3: Ramp Demolition (Potential Evening OOHW 1)	3T Excavator with Hydraulic Hammer[1]	1	2	5	110	114
	Truck (idle)	1	2	5	102	106
	Hand Tools	1	0.5	15	100	103
Scenario 4: Ramp Installation (Potential Evening OOHW 1)	Truck (idle)	1	2	5	102	106
	Hand Tools	1	0.5	15	100	103

Construction scenario	Equipment Type	Number of Equipment	Height	Usage per 15 minute period (minutes)	Sound power level $L_{Aeq(15min)}$ dBA	Sound power level L_{AMax} dBA
	Concrete Boom Pump	1	2	15	106	109
Scenario 5: Lift Pit Excavation (Potential Evening OOHW 1)	3T Excavator with Hydraulic Hammer[1]	1	2	5	110	114
	Hand Tools	1	0.5	15	100	103
Scenario 6: Western Entrance (Potential Evening OOHW 1)	Hand Tools	1	0.5	15	100	103
	Truck (idle)	1	2	5	102	106
	Concrete Boom Pump	1	2	15	106	109
Scenario 7: Internal Demolition (Potential Night OOHW 2)	Jackhammer[1]	1	0.5	5	112	116
	Hand Tools	1	0.5	15	100	103
Scenario 8: Carpark Grading Preparation (Potential Evening OOHW 1)	Truck (idle)	1	2	5	102	106
	3T Excavator with Hydraulic Hammer[1]	1	2	5	110	114

Note 1: As per section 4.5 of the NSW Interim Construction Noise Guideline, a number of items that are particularly annoying to local residents including power saws, rock drilling, or jackhammering should have 5 dB added to the predicted noise levels.

8.4 Noise Assessment Methodology

Potential construction noise impacts were modelled for the eight construction scenarios identified in Table 8-1, using the ISO9613 algorithm in the iNoise 2019.1 noise modelling software. The noise modelling takes into account source sound level emissions and locations, screening effects, receiver locations, ground topography and noise attenuation due to spherical spreading and atmospheric absorption.

Noise contours for each of the construction sites have been generated for eight construction scenarios; they are:

- Scenario 1: Ancillary Facility (Construction Compound)
- Scenario 2: Platform Rock Sawing

- Scenario 3: Ramp Demolition
- Scenario 4: Ramp Installation
- Scenario 5: Lift Civil Works
- Scenario 6: Western Entrance
- Scenario 7: Internal Demolition
- Scenario 8: Carpark Grading Preparation

8.5 Construction Noise Results

8.5.1 Predicted Noise Levels

Predicted construction noise results are presented in Table 8-2 and Table 8-3 for standard hours and OOHW 1 period activities. The predicted noise levels for the worst case receiver in each catchment are shown in Table 8-2. The quantities of receivers that are predicted to have exceedances of the criteria per catchment are shown in Table 8-3.

Table 8-2 Worst Case Construction Scenario Results, Standard Hours and OOHW 1, Scenarios 1-8

Catchment	Standard Day Criteria	OOHW 1 Day Criteria	OOHW 1 Evening Criteria	Scenario							
				1	2	3	4	5	6	7	8
NCA 1	45	40	37	56	50	68	67	59	63	49	66
NCA 2	45	40	37	52	37	50	55	46	55	37	59
NCA 3	45	40	37	30	32	41	35	41	32	21	32
NCA 4	45	40	37	32	40	44	37	41	34	24	33

Note:
- Predicted to Exceed the OOHW 1 Evening NML
- Predicted to Exceed the OOHW 1 Day NML
- Predicted to Exceed the Standard Day NML
- Predicted to Exceed the 75 dB(A) Highly Noise Affected Criteria

Table 8-3 Construction Noise Scenario Results, Number of Receivers with Predicted Exceedances, Standard Hours and OOHW 1, Scenarios 1-8

Catchment	1	2	3	4	5	6	7	8
NCA 1	6	10	22	19	19	19	8	20
NCA 2	13	-	31	27	20	28	-	29
NCA 3	-	-	4	-	5	-	-	-
NCA 4	-	5	18	-	5	-	-	-

Predicted construction noise results are presented in Table 8-4 and Table 8-5 for standard hours, OOHW 1 and OOHW 2 period activities. The predicted noise levels for the worst case receiver in each catchment are shown in Table 8-4. The quantities of receivers that are predicted to have exceedances of the criteria per catchment are shown in Table 8-5.

Table 8-4 Worst Case Construction Noise Scenario Results, OOHW 2, Scenarios 1, 2 and 7

Catchment	OOHW 2 Night Criteria	1	2	7
NCA 1	35	56	50	49
NCA 2	35	52	37	37
NCA 3	35	30	32	21
NCA 4	35	32	40	24

Note: Predicted to Exceed the OOHW 2 Night NML
Predicted to Exceed the 75 dB(A) Highly Noise Affected Criteria

Table 8-5 Construction Noise Scenario Results, Number of Receivers with Predicted Exceedances, OOHW 2, Scenarios 1, 2 and 7

Catchment	1	2	7
NCA 1	7	11	8
NCA 2	20	2	3
NCA 3	-	-	-
NCA 4	-	7	-

8.6 Construction Noise Results Discussion

8.6.1 Scenario 1: Ancillary Facilities

Exceedances of the NMLs are predicted during the use of the ancillary facility (construction compound). During the evening OOHW 1 period, the ancillary facility activities are predicted to exceed the NMLs at six receivers in NCA 1 and 13 receivers in NCA 2. No exceedances of the NMLs are predicted in NCA 3 or 4 during use of the OOHW 1 evening use of the ancillary facility. A maximum exceedance of 19 dB is predicted in the NCA 1 catchment during the evening OOHW 1 period.

For the OOHW 2 period, the use of the ancillary facility is predicted to exceed the NMLs at seven receivers in NCA 1 and 20 receivers in NCA 2. The use of the ancillary facility is predicted to comply with the OOHW 2 period criteria at all receivers in NCA 3 or NCA 4.

8.6.2 Scenario 2: Platform Rock Sawing

The evening OOHW 1 period criterion is predicted to be exceeded at 10 receivers in NCA 1 and 5 receivers within in NCA 4. Compliance with the NMLs is predicted at all receivers in NCA 2 and NCA 3 during the evening OOHW 1 period. The maximum exceedance in NCA 1 is predicted to be 13 dB above the evening OOHW 1 criteria.

The OOHW 2 period criterion is predicted to be exceeded at 11 receivers in NCA 1, 2 receivers in NCA 2 and 7 receivers within in NCA 4. Compliance with the NMLs is predicted at all receivers in NCA 3 during the evening OOHW 1 period. The maximum exceedance in NCA 1 is predicted to be 15 dB above the evening OOHW 1 criteria.

8.6.3 Scenario 3: Ramp Demolition

Exceedances of the NMLs are expected during ramp demolition. During the evening OOHW 1 period, the ramp demolition scenario is predicted to exceed the NMLs at 22 receivers in NCA 1, 31 receivers in NCA 2, four receivers in NCA 3 and 18 receivers in NCA 4. A maximum exceedance of 31 dB is predicted in the NCA 1 catchment during the evening OOHW 1 period.

8.6.4 Scenario 4: Ramp Installation

The evening OOHW 1 period criterion is predicted to be exceeded at 19 receivers in NCA 1 and 27 receivers within in NCA 2 for ramp installation. Compliance with the OOHW 1 period NMLs is predicted at all receivers in NCA 3 and NCA 4 during ramp installation. The maximum exceedance in NCA 1 is predicted to be 30 dB above the evening OOHW 1 criteria.

8.6.5 Scenario 5: Lift Civil Works

For the OOHW 2 period, the lift civil works are predicted to exceed the NMLs at 19 receivers in NCA 1, 20 receivers in NCA 2, five receivers in NCA 3 and five receivers in NCA 4. A maximum exceedance of 22 dB is predicted in the NCA 1 catchment during the evening OOHW 1 period.

8.6.6 Scenario 6: Western Entrance

Exceedances of the NMLs are predicted during western entrance works. The evening OOHW 1 period criterion is predicted to be exceeded at 19 receivers in NCA 1 and 28 receivers within NCA 2 for western entrance activities. Compliance with the NMLs is predicted at all receivers in NCA 3 and NCA 4 during the evening OOHW 1 period. The maximum exceedance in NCA 1 is predicted to be 26 dB above the evening OOHW 1 criteria.

8.6.7 Scenario 7: Internal Demolition

During the evening OOHW 1 period, the internal demolition activities are predicted to exceed the NMLs at eight receivers in NCA 1. No exceedances of the NMLs are predicted in NCA 2, 3 or 4 during use OOHW 1 evening internal demolition activities. A maximum exceedance of 12 dB is predicted in the NCA 1 catchment during the evening OOHW 1 period.

For the OOHW 2 period, the internal demolition activities are predicted to exceed the NMLs at eight receivers in NCA 1 and three receivers in NCA 2. The internal demolition activities are predicted to comply with the OOHW 2 period criteria at all receivers in NCA 3 or NCA 4.

8.6.8 Scenario 8: Carpark Grading Preparation

The evening OOHW 1 period criterion is predicted to be exceeded at 20 receivers in NCA 1 and 29 receivers within in NCA 2 for carpark grading preparation. Compliance with the NMLs is predicted at all receivers in NCA 3 and NCA 4 during the evening OOHW 1 period. The maximum exceedance in NCA 1 is predicted to be 29 dB above the evening OOHW 1 criteria.

8.6.9 Sleep Disturbance

If construction scenarios are to be conducted at night, the potential for sleep disturbance at the nearby receptors has been predicted in Table 8-6 and Table 8-7. Sleep disturbance may occur at two receivers in NCA 1 and one receiver within NCA 2 when a truck is operating at the ancillary facility. Sleep disturbance is not predicted at any receivers in any catchment during scenarios 2 and 7.

Table 8-6 Worst Case Sleep Disturbance Results, Scenarios 1, 2 and 7

Catchment	Sleep Disturbance Criteria	1	2	7
NCA 1	60	65	54	58
NCA 2	60	61	41	46
NCA 3	60	39	36	29
NCA 4	60	41	44	33

Note: Predicted to Exceed the Sleep Disturbance Criteria (only relevant if the construction scenario is occurring during the night-time period)

Table 8-7 Construction Noise Scenario Results, Number of Receivers with Predicted Exceedances, OOHW 2, Scenarios 1, 2 and 7

Catchment	1	2	7
NCA 1	2	-	-
NCA 2	1	-	-
NCA 3	-	-	-
NCA 4	-	-	-

8.6.10 Construction Road Traffic Noise

Road traffic noise from construction vehicles is assessed in this section. A distinction is made between construction vehicles travelling on public roads, and vehicles not travelling to a destination but involved in construction works. Construction noise from vehicles not travelling to a destination but involved in works off public roads was previously considered in construction scenarios 1-8.

Regarding construction vehicles travelling on public roads, in a similar way to operational road traffic noise in section 7, the amount of construction vehicles on public roads is relatively small compared to existing road traffic. Therefore no mitigation measures are proposed for construction road traffic noise.

8.7 Construction Vibration Impact Assessment

The operational noise sources within section 6 do not contain any significant sources of vibration. The construction noise sources in Table 8-1 include the excavator with hydraulic hammer and jackhammer.

From BS 7385 within the Transport for NSW Construction Noise and Vibration Strategy, the minimum recommended distance to avoid cosmetic damage from a jackhammer is 1m. The minimum distance for a 300kg hydraulic hammer is 2m, for a 900kg hydraulic hammer is 7m and for a 1600kg hydraulic hammer is 22m, as shown in Table 8-8.

Table 8-8 Recommended Minimum Working Distances from Vibration Intensive Plant (as taken from TfNSW Construction Noise and Vibration Strategy)

Plant Item	Approx. Size / Weight / Model	Minimum Distance – Cosmetic Damage (BS 7385)	Minimum Distance – Human Response (OE&H Vibration Guideline)
Vibratory Roller	1-2 tonne	5 m	15 m to 20 m
	2-4 tonne	6 m	20 m
	4-6 tonne	12 m	40 m
	7-13 tonne	15 m	100 m
	13-18 tonne	20 m	100 m
	>18 tonne	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
Pile Driver – Vibratory	Sheet piles	2 m to 20 m	20 m
Piling Rig – Bored	≤ 800 mm	2 m (nominal)	N/A
Piling Rig – Hammer	12 t down force	15 m	50 m
Jackhammer	Hand held	**1 m (nominal)**	Avoid contact with structure

Note 1: From construction noise and vibration strategy 7TP-ST-157 - May 2018

Note 2: More stringent conditions may apply to heritage or other sensitive structures

Note 3: The minimum working distances presented in Table 20 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions. Vibration monitoring is recommended to confirm the minimum working distances at specific sites.

Therefore the following minimum distances between the equipment and any neighbouring on-site buildings are recommended, should any of the following equipment be utilised

- small hydraulic hammer 300kg (5 to 12T excavator): 2m
- medium hydraulic hammer 900kg (12 to 18T excavator): 7m
- large hydraulic hammer 1600kg (18 to 34T excavator): 22m
- jackhammer: 1m

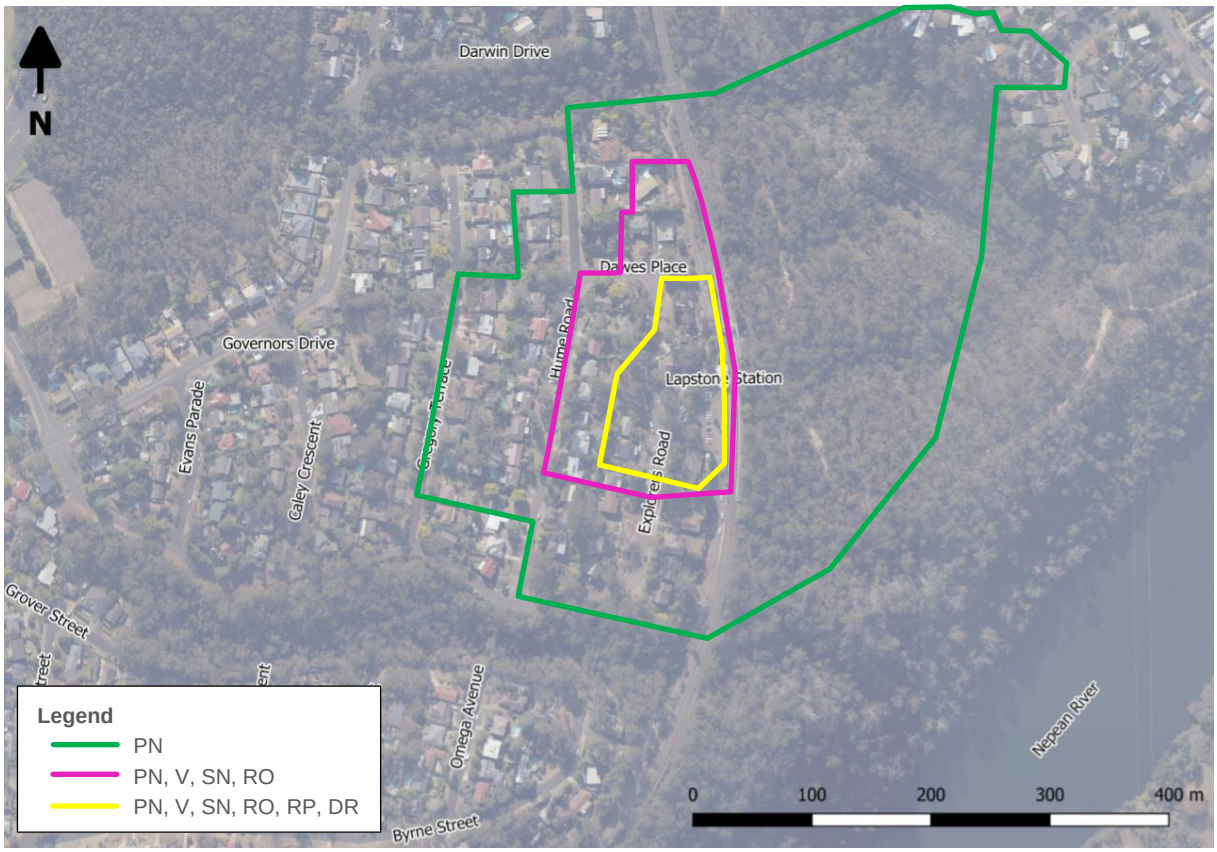
8.8 Additional Mitigation Measure Matrices

Section 8.2.2 of the TfNSW *Construction Noise and Vibration Strategy* outlines the additional mitigation measures recommended for surrounding receivers. Using the additional mitigation measures matrix, receivers recommended for additional mitigation are shown in Figure 8-1 and Figure 8-2 that may be considered for project notification, verification monitoring, respite periods, specific notifications, duration reductions and project specific respite offer.

Definitions of the relevant additional mitigation measures are shown in full in Table 8 of the TfNSW Construction Noise and Vibration Strategy. Brief definitions are shown below:

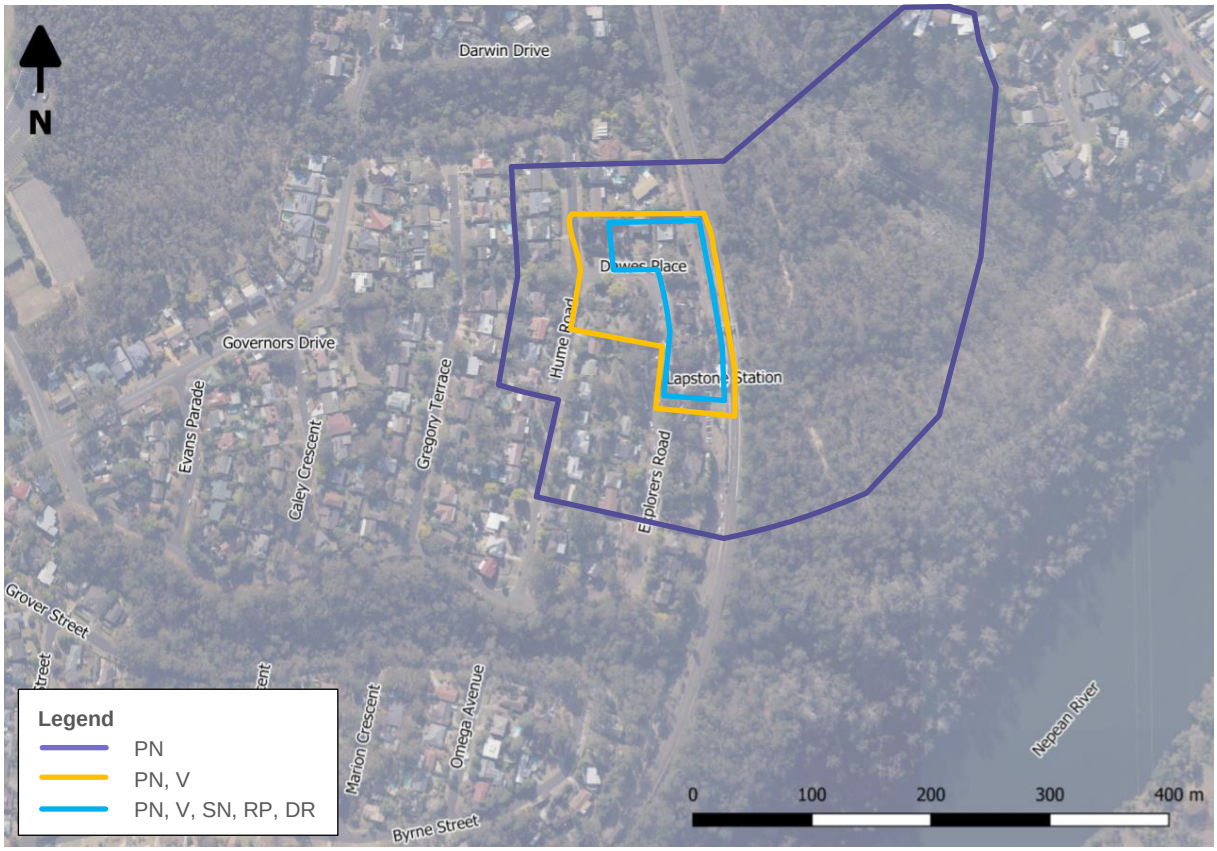
- project notification: a project notification is distributed to stakeholders by letterbox drop
- verification monitoring: noise monitoring is conducted at the nearest receivers to verify that construction noise is consistent with the predicted noise levels
- specific notifications: a personalised letter or phone call to stakeholders that serves as an individual briefing
- respite periods: OOHW during evening and nights are restricted so that work occurs no more than 3 consecutive evenings, and 2 consecutive nights in the same week
- project specific respite offer: a project specific respite offer to residents that are subjected to lengthy periods of noise impacts
- duration reductions: where respite periods are counterproductive, it may be beneficial to increase number of consecutive evenings and/or nights to minimise the duration of activities

Figure 8-1 Recommended Additional Mitigation Evening OOHW 1



Note: PN = Project Notification
V = Verification Monitoring
RP = Respite Period
SN = Specific Notification, individual briefing, or phone call
DR = Duration reduction
RO = Project Specific Respite Offer

Figure 8-2 Recommended Additional Mitigation Night OOHW 2



Note: PN = Project Notification
V = Verification Monitoring
RP = Respite Period
SN = Specific Notification, individual briefing, or phone call
DR = Duration reduction
RO = Project Specific Respite Offer

8.9 Construction Control Measures

Noise and vibration control measures for construction activities are recommended to be identified and adopted as part of a Construction Noise Vibration Management Plan (CNVMP). These appropriate construction noise and vibration management controls will also be dependent on the time periods in which the works are required to be conducted.

9 CONCLUSIONS

This document analyses the potential noise and vibration impacts of the proposed Lapstone Station Upgrade on the surrounding receptors. The proposed works include installing a lift at the eastern end of the footbridge, footpath access on the western side that meets DSAPT compliance, an accessible car parking bay and modifications to the station building layout.

Operational noise impacts of the proposed equipment at the station were analysed. It was predicted that operational noise impacts at neighbouring receivers are predicted to readily comply with the operational project trigger levels and operational sleep disturbance criteria. No further operational mitigation measures are therefore recommended.

Any potential increase of road traffic noise as a result of the proposal is expected to be minimal. As road traffic noise levels are predicted to comply with the Road Noise Policy, no additional road noise mitigation measures recommended.

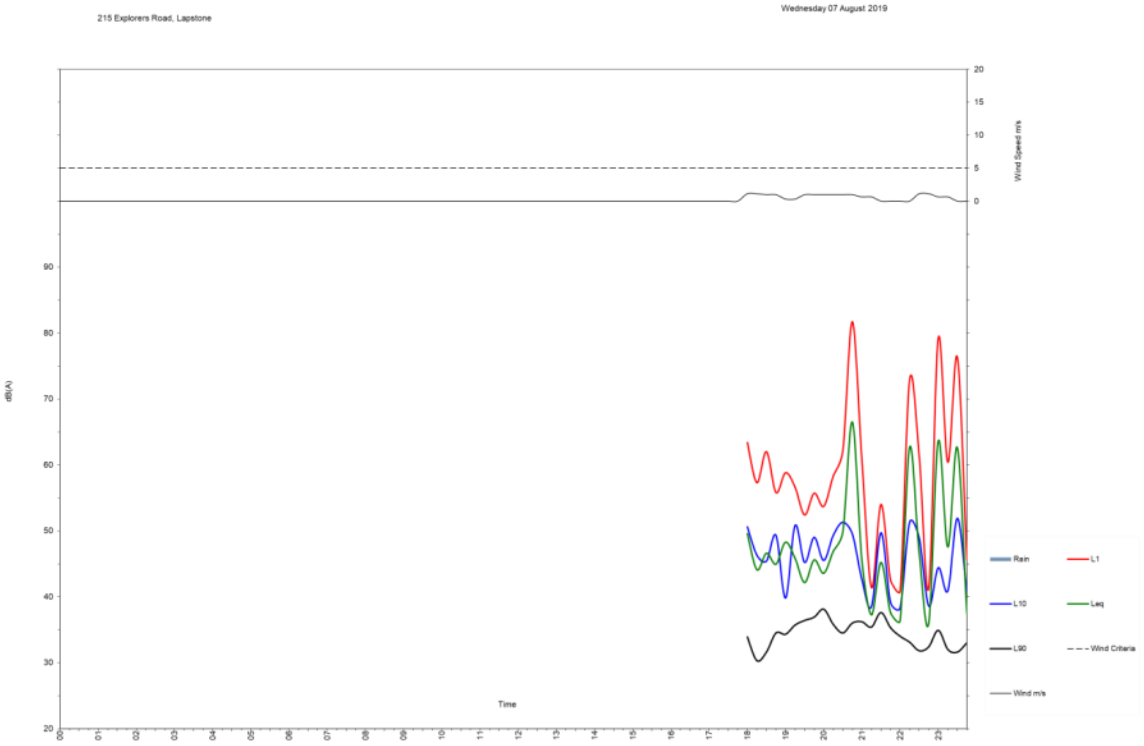
Construction activities including operation of the ancillary facility (scenario 1), platform rock sawing (scenario 2) and internal demolition (scenario 7) are recommended to take place during standard, OOHW 1 or OOHW 2 periods. Construction activities involving ramp demolition (scenario 3), ramp installation (scenario 4), lift civil works (scenario 5), western entrance (scenario 6) and carpark grading preparation (scenario 8) are recommended to take place during standard or OOHW 1 periods. Additional mitigation measures for nearby receivers are recommended in Figure 8-1 and Figure 8-2 including project notification, verification monitoring, respite periods, specific notifications, duration reductions and project specific respite offer. A Construction Noise and Vibration Management Plan (CNVMP) is recommended to be conducted to determine specific mitigation measures for construction activities.

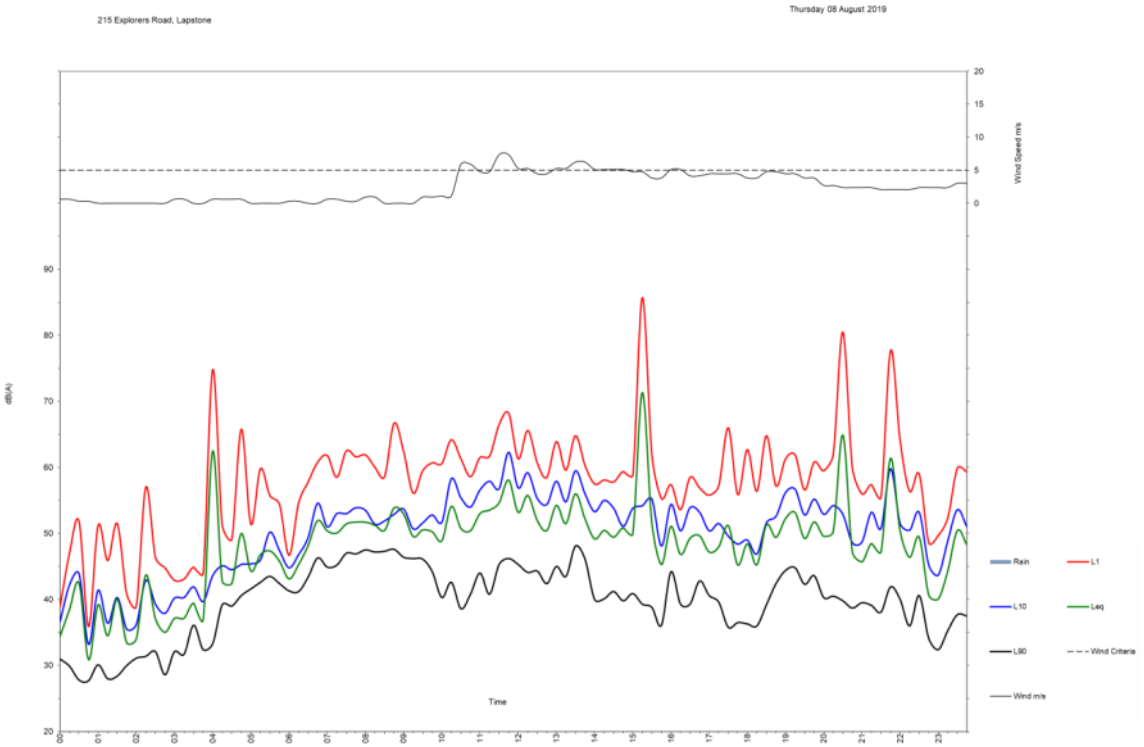
Human response and cosmetic damage from construction vibration may be avoided by observing the minimum distances listed in section 8.7 for selected equipment.

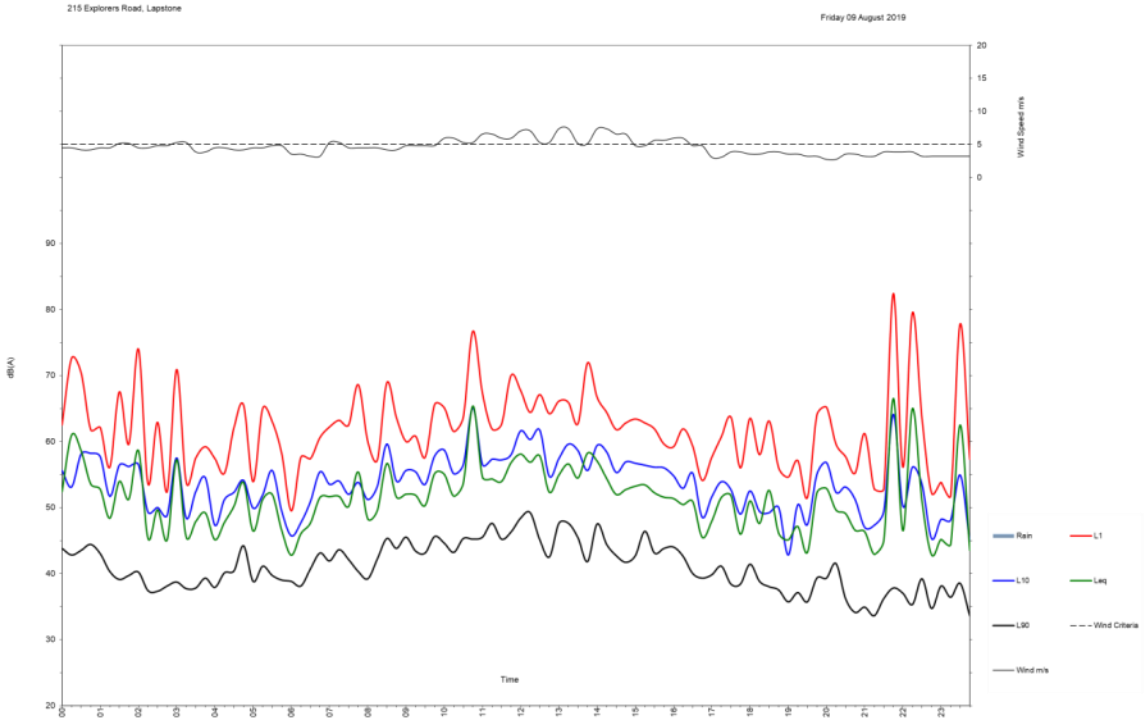
APPENDIX A: ACOUSTIC GLOSSARY

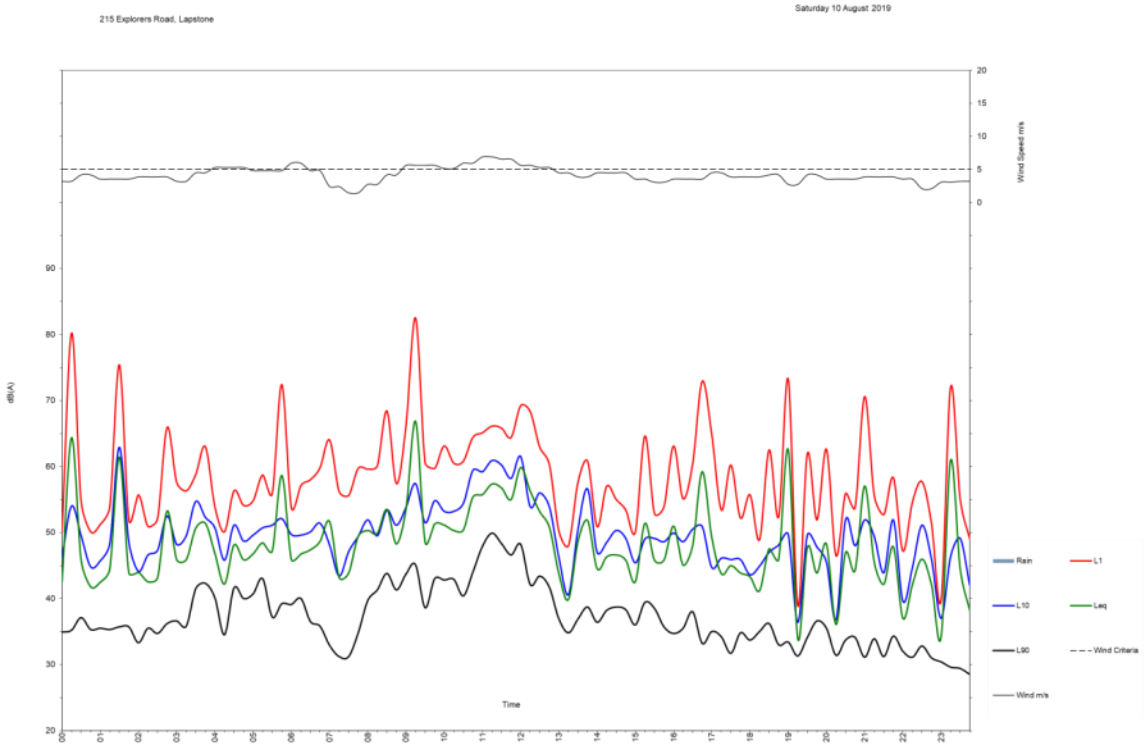
Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dBA the faintest sound we can hear 30dBA a quiet library or in a quiet location in the country 45dBA typical office space. Ambience in the city at night 60dBA Martin Place at lunch time 70dBA the sound of a car passing on the street 80dBA loud music played at home 90dBA the sound of a truck passing on the street 100dBA the sound of a rock band 115dBA limit of sound permitted in industry 120dBA deafening
dB(A)	*A-weighted decibels*The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
LMax	The maximum sound pressure level measured over a given period.
LMin	The minimum sound pressure level measured over a given period.
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Background Sound Level	The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted, external ambient noise sources. Usually taken to mean the LA90 value
Sound Isolation	A reference to the degree of acoustical separation between any two areas. Sound isolation may refer to sound transmission loss of a partition or to noise reduction from any unwanted noise source. The term "sound isolation" does not specify any grade or performance quality and requires the units to be specified for any contractual condition
Sound Pressure Level, LP dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, Lw dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt

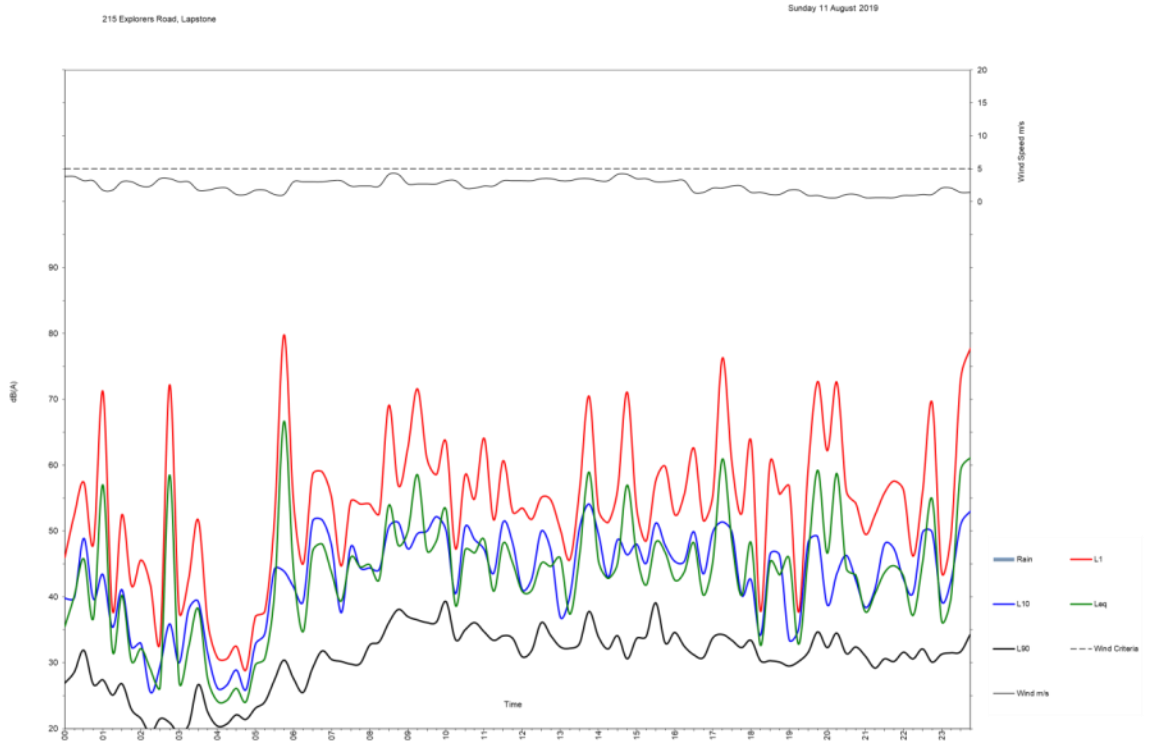
APPENDIX B: LOGGER DATA CHARTS

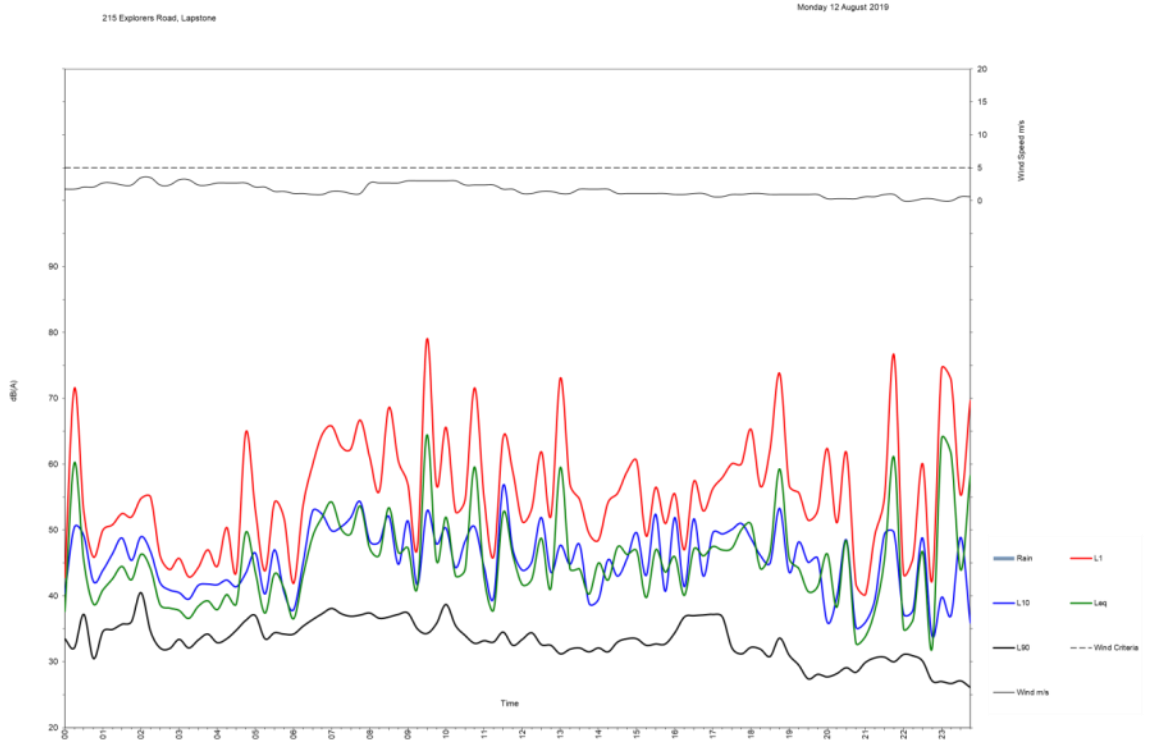


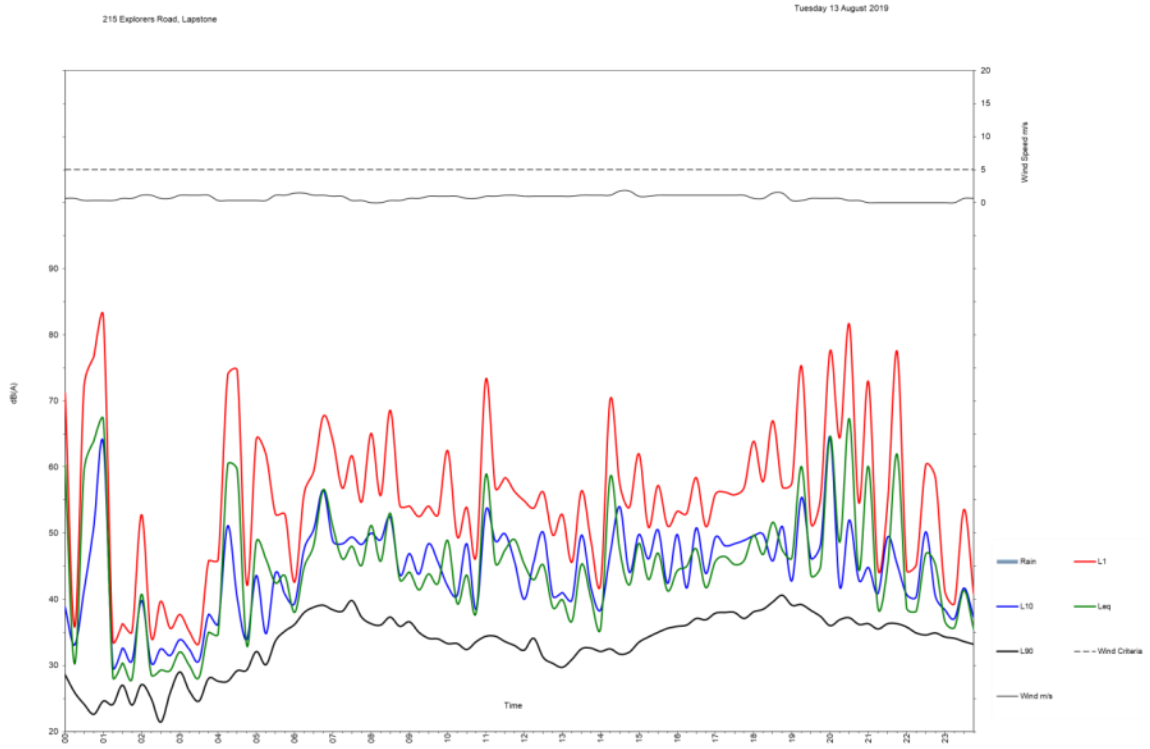


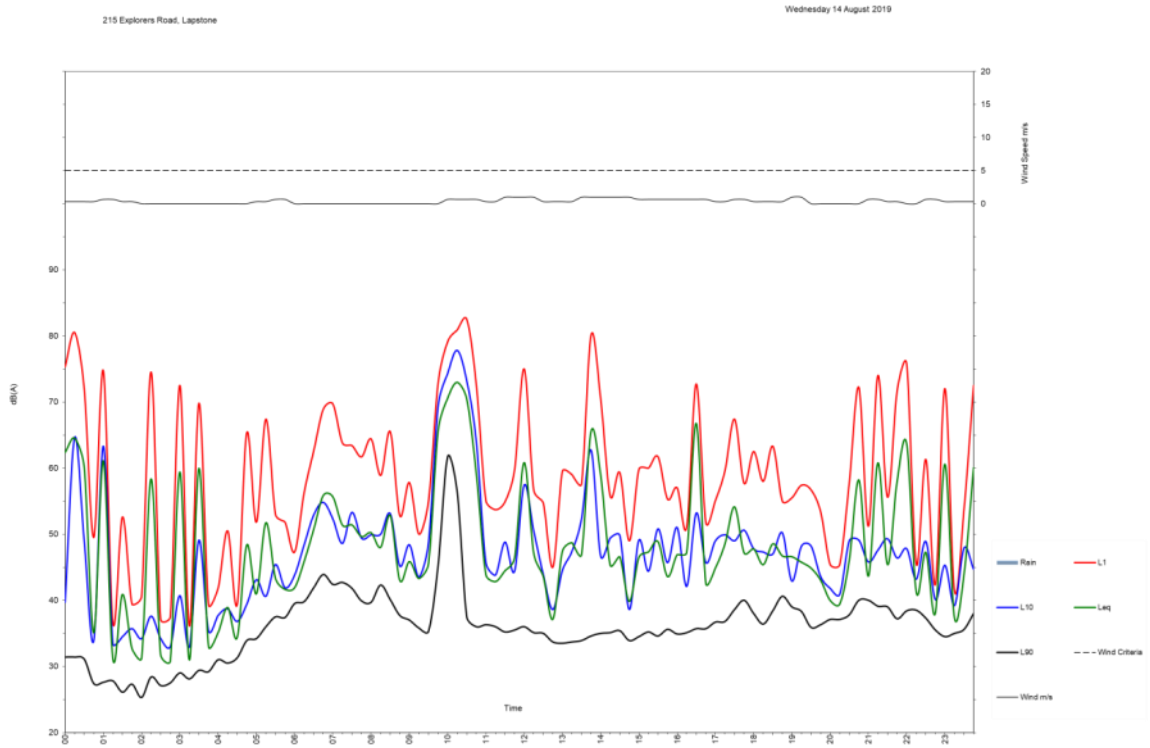

215 Explorers Road, Lapstone
Friday 09 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

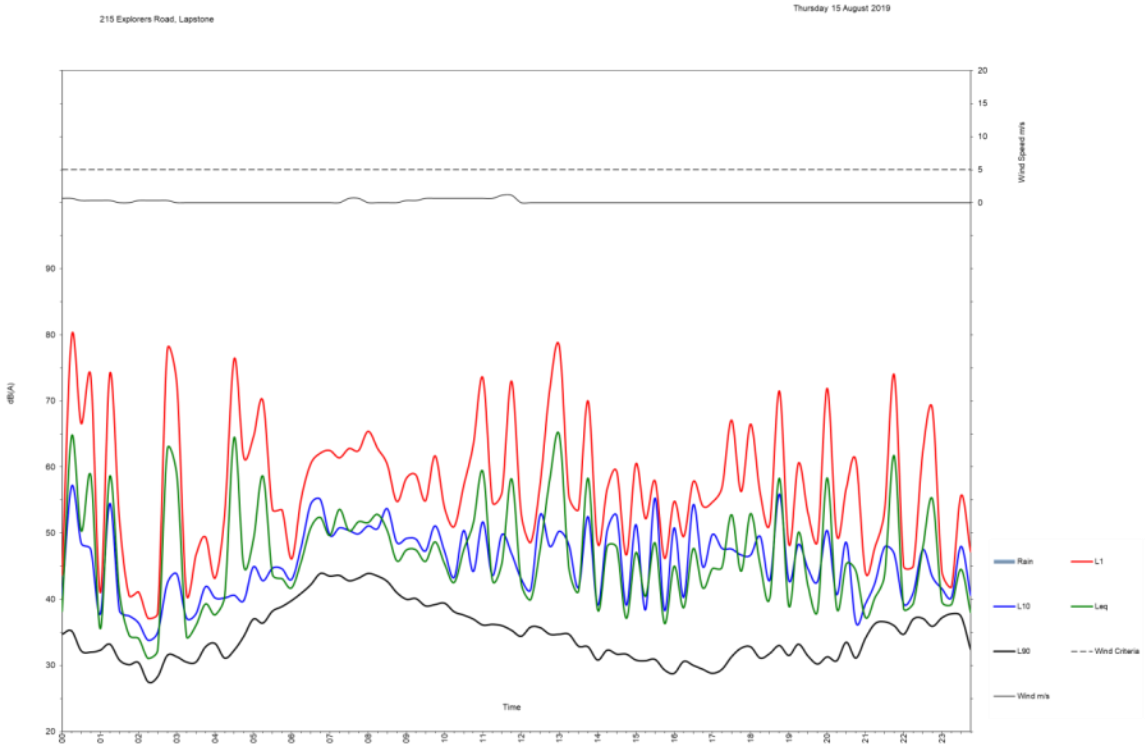

215 Explorers Road, Lapstone
Saturday 10 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

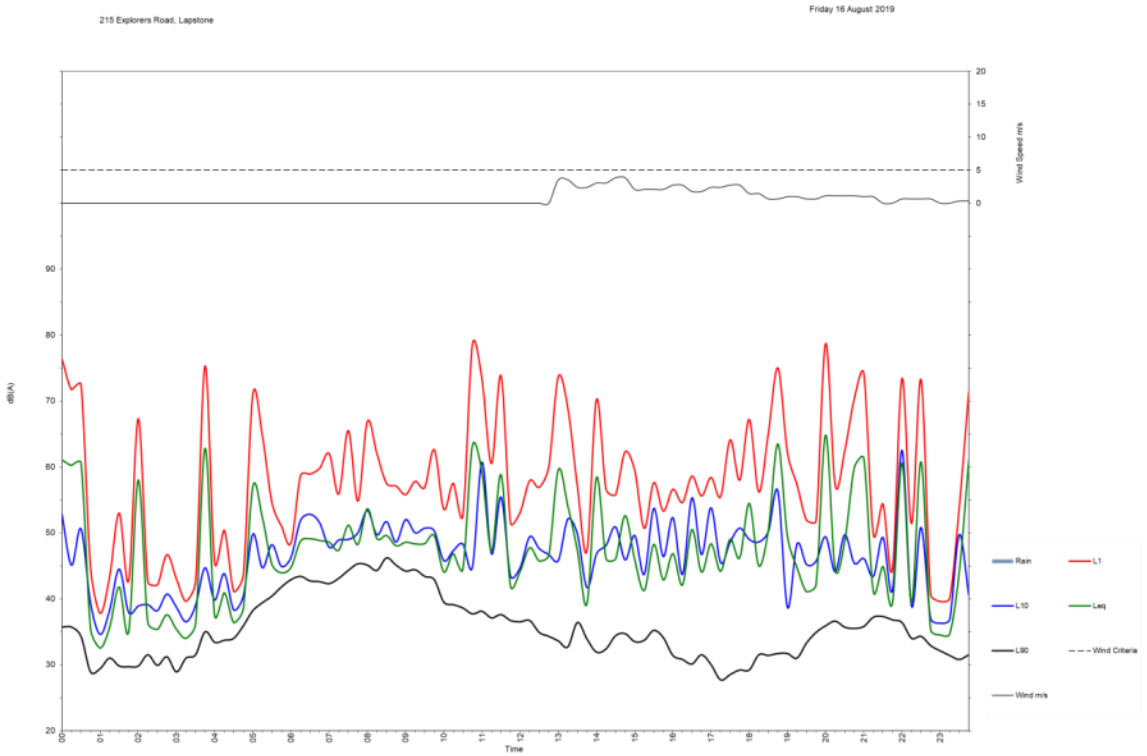

215 Explorers Road, Lapstone
Sunday 11 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

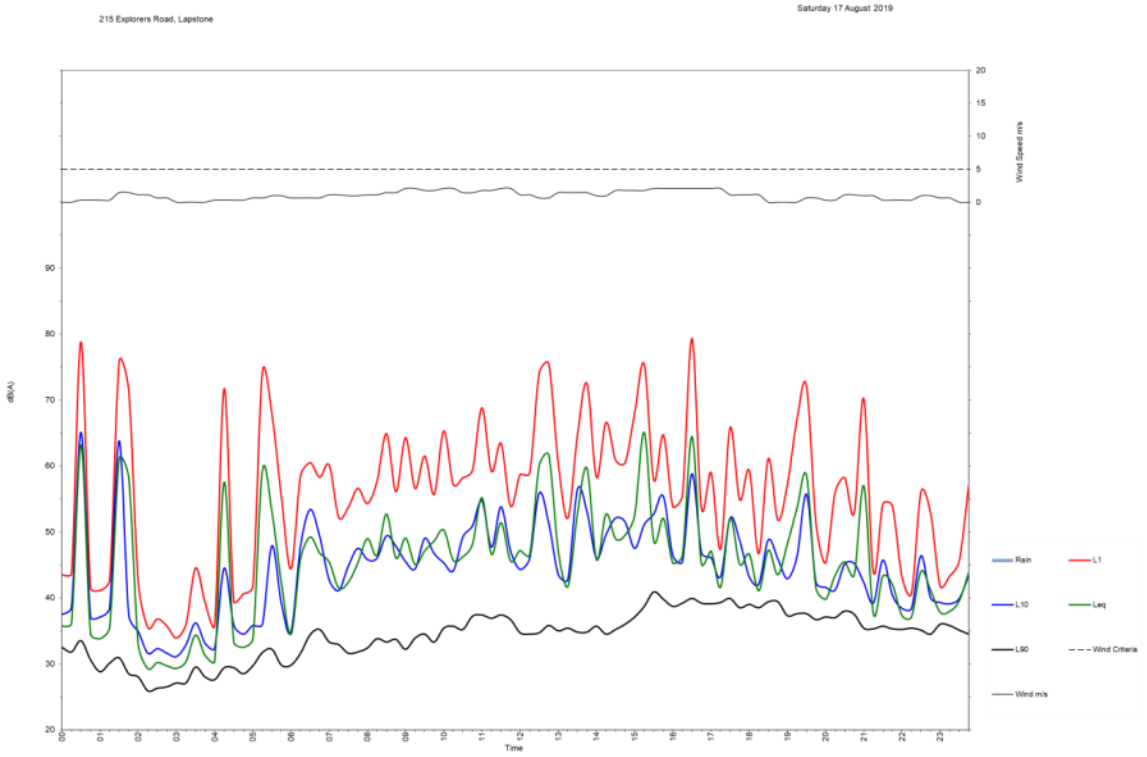

215 Explorers Road, Lapstone
Monday 12 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

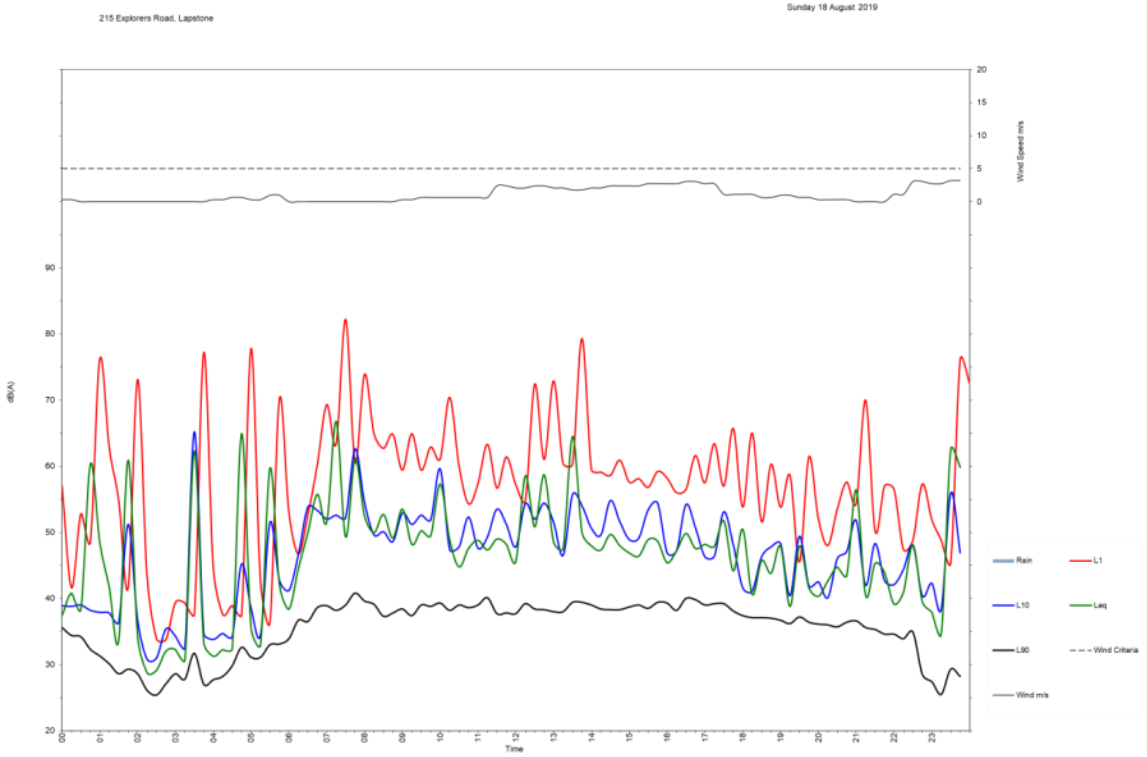

215 Explorers Road, Lapstone
Tuesday 13 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

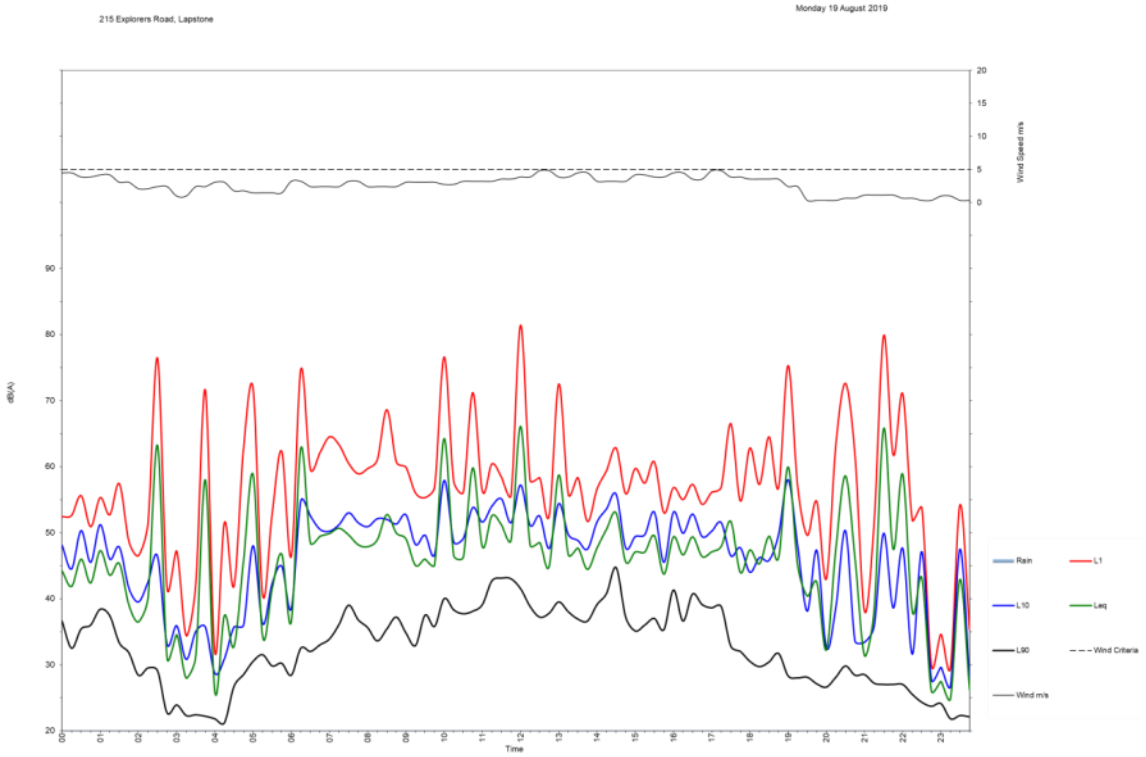

215 Explorers Road, Lapstone
Wednesday 14 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

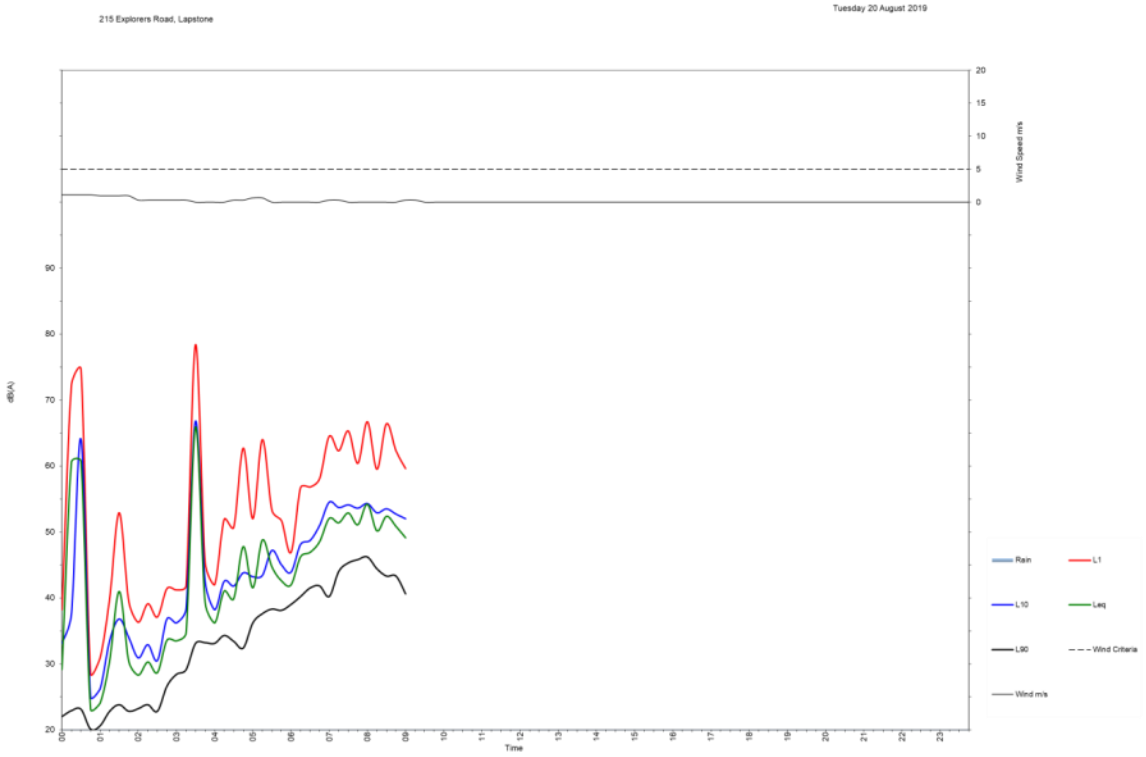

215 Explorers Road, Lapstone
Thursday 15 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


215 Explorers Road, Lapstone
Friday 16 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


215 Explorers Road, Lapstone
Saturday 17 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


215 Explorers Road, Lapstone
Sunday 18 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


215 Explorers Road, Lapstone
Monday 19 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


215 Explorers Road, Lapstone
Tuesday 20 August 2019
dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s