Gunnedah Second Road Over Rail Bridge

Selected Preferred Design

Noise and Vibration Impact Assessment

Construction and Operations

Report Number 610.12027-R2

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KBR Pty Ltd
201 Kent Street
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Executive Summary

In September 2013, SLR Consulting Australia Pty Ltd (SLR) was engaged by KBR Pty Ltd (KBR) to assess the potential noise and vibration impacts of the construction and operation of the proposed Concept Design options for the Gunnedah Second Road Over Rail Bridge Project. This was required by the RMS Scope of Work and Technical Criteria document (RMS Contract No. 12.2547.2214). Six (6) concept design options were originally assessed (reported in SLR report 610.12027-R1 dated 2 October 2013). This option analysis assessment resulted in one preferred option being selected.

Design of the preferred alignment has progressed further and has been modified to incorporate the required connection at Barber Street, a reconfigured roundabout at Oxley Highway and a new roundabout to replace the existing intersection of Kimilaroi Highway and Warrabungle Street (see **Figure 1**). SLR has been engaged by KBR to assess the potential noise and vibration impacts associated with the operation and construction of this proposal.

Gunnedah is situated in northern NSW, 70 km northwest of Tamworth. The town is bisected by The Hunter Valley Rail Corridor, which separates the town centre and business district in the north from the growing residential areas in the south. The existing Abbott Street bridge, which is not suitable for use by wide or Higher Mass Limit vehicles, is currently the only local grade separated crossing of the railway line. Traffic congestion at the New Street level crossing is causing queuing through the intersection with the Oxley Highway and subsequent delays. These delays are expected to increase as the length and frequency of coal trains using the rail line increases to keep pace with continued development of the coal industry.

OPERATIONAL IMPACTS

The operational noise impact assessment has been undertaken in accordance with the *Road Noise Policy* (RNP) and *Environmental Noise Management Manual* (ENMM). The modelling and assessment considered the following assessment years:

- The At-Opening year is 2016.
- The Design Year is 2026.

Based on the predicted results, the following findings were made:

- The criteria for ‘new road’ (i.e. the proposed overpass) are applicable for most receivers apart from the receivers located directly adjacent to the proposed upgraded roundabout at Kimilaroi Highway, namely 33, 35 and 36 Conadilly Street.
- For receivers where the dominant noise impact was due to the proposed overpass (i.e. where the more stringent ‘new road’ criteria are applicable):
    - Two (2) selected representative receivers were predicted to exceed the $L_{Aeq(15hour)}$ (day time) base criterion. The levels of exceedance were predicted to be up to 2 dB.
    - All predicted relative increase in noise levels were less than the prescribed criterion of 12 dB.
- For receivers located adjacent to the proposed upgraded roundabout at Kimilaroi Highway (i.e. where the ‘redevelopment’ criteria are applicable):
    - Predicted noise levels at all three selected representative receivers were within the prescribed day and night time base criteria.
    - The proposed roundabout to replace the existing Kimilaroi Highway and Warrabungle Street intersection was not predicted to cause significant noise impact with the predicted relative increase in noise levels all less than 2.0 dB.

Executive Summary

- Based on the findings as presented above, it was determined that further consideration of mitigation measures is required for two properties, namely: 1/2-6 Warrabungle Street and 3 Warrabungle Street.

An assessment of feasible and reasonable mitigation options was undertaken. It was determined that the most reasonable and feasible mitigation option for the identified two (2) properties is considered to be localised property treatments.

CONSTRUCTION IMPACTS

The construction noise impact assessment has been undertaken in accordance with the *Interim Construction Noise Guideline* (ICNG). The following findings were made:

- The highest impacts are predicted during Stage 1 impact piling, with worst exceedances of the NMLs of up to 36 dB at Warrabungle Street. It is noted the use of auger or bored piling techniques would be expected to reduce these exceedances by up to 20 dB.
- For the construction stage when new kerbs and associated infrastructure are constructed at the new and reconfigured roundabouts, the worst exceedances of the NMLs of up to 29 dB and 18 dB were predicted at Warrabungle Street and Kimilaroi Highway roundabout respectively.
- For the remaining construction stages, the primary noise impacts are confined to the Warrabungle Street residences, with exceedances of up to 13 dB for precast placement, up to 17 dB for concreting and up to 28 dB during finishing.

These exceedances are a direct result of the close proximity of residences and the nature of the works.

Recommended construction noise mitigation measures are detailed within this report. These are particularly important and should be considered when receivers are highly affected (eg impact piling, new kerb construction and finishing operations).

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1 INTRODUCTION

1.1 Project Background

In September 2013, SLR Consulting Australia Pty Ltd (SLR Consulting) was engaged by KBR Pty Ltd (KBR) to assess the potential noise and vibration impacts of the construction and operation of the proposed Concept Design options for the Gunnedah Second Road Over Rail Bridge Project.

This was required by the RMS Scope of Work and Technical Criteria document (RMS Contract No. 12.2547.2214). Six (6) concept design options were originally assessed and reported in SLR Consulting report *'610.12027-R1 – Gunnedah Second Road Over Rail Bridge Project, Noise and Vibration Impact Assessment, Construction and Operations*, dated 2 October 2013. The Route Options analysis assessment resulted in the selection of the preferred alignment option.

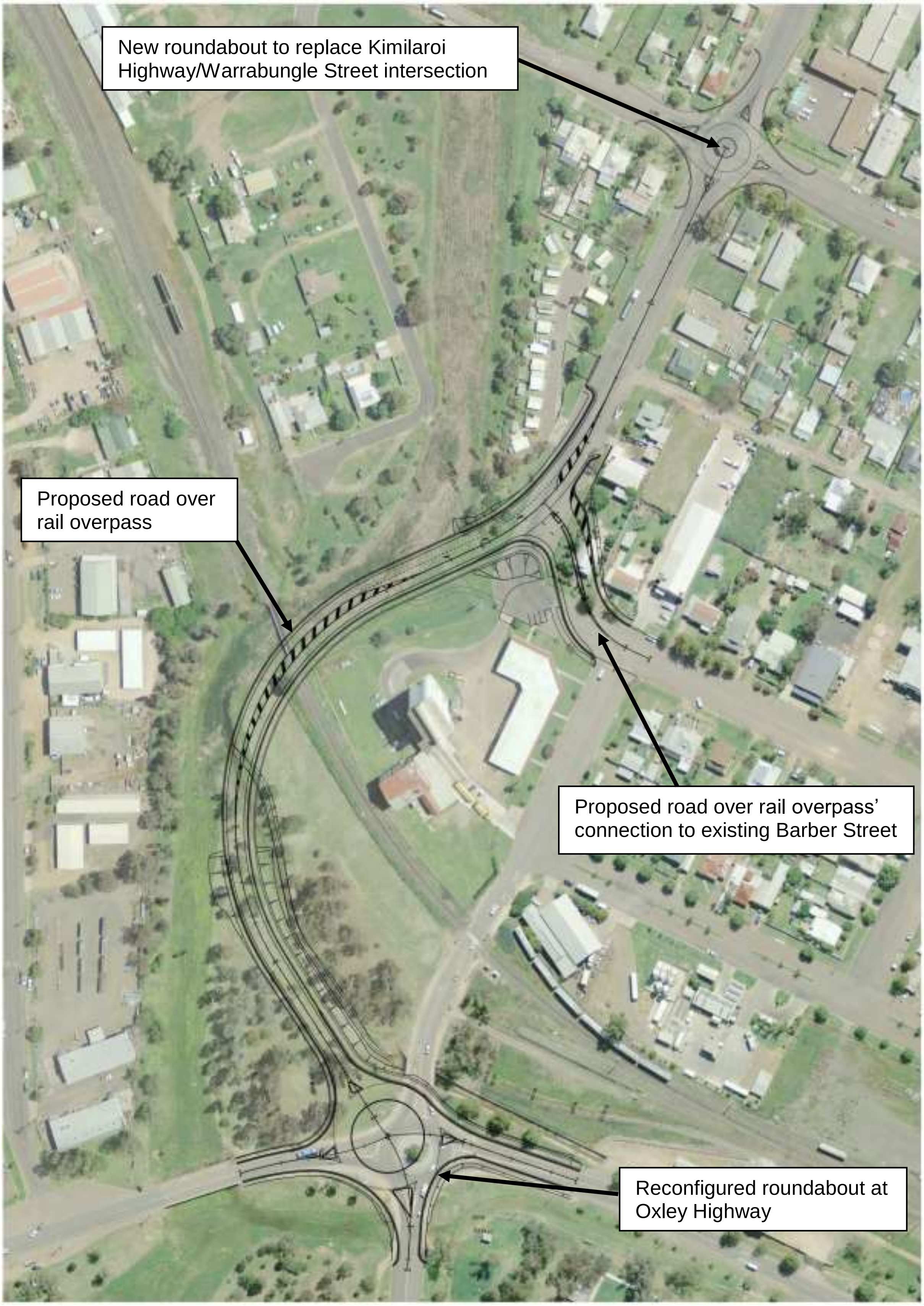
Design of the preferred alignment has now been progressed further to include the required connection at Barber Street, a reconfigured roundabout at Oxley Highway and a new roundabout to replace the existing intersection of Kimilaroi Highway and Warrabungle Street (see **Figure 1**).

SLR Consulting has been engaged by KBR to assess the potential noise and vibration impacts associated with the operation and construction of this proposal.

1.2 Terminology

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

Figure 1 Proposed Road over Rail Overpass and Associated Works



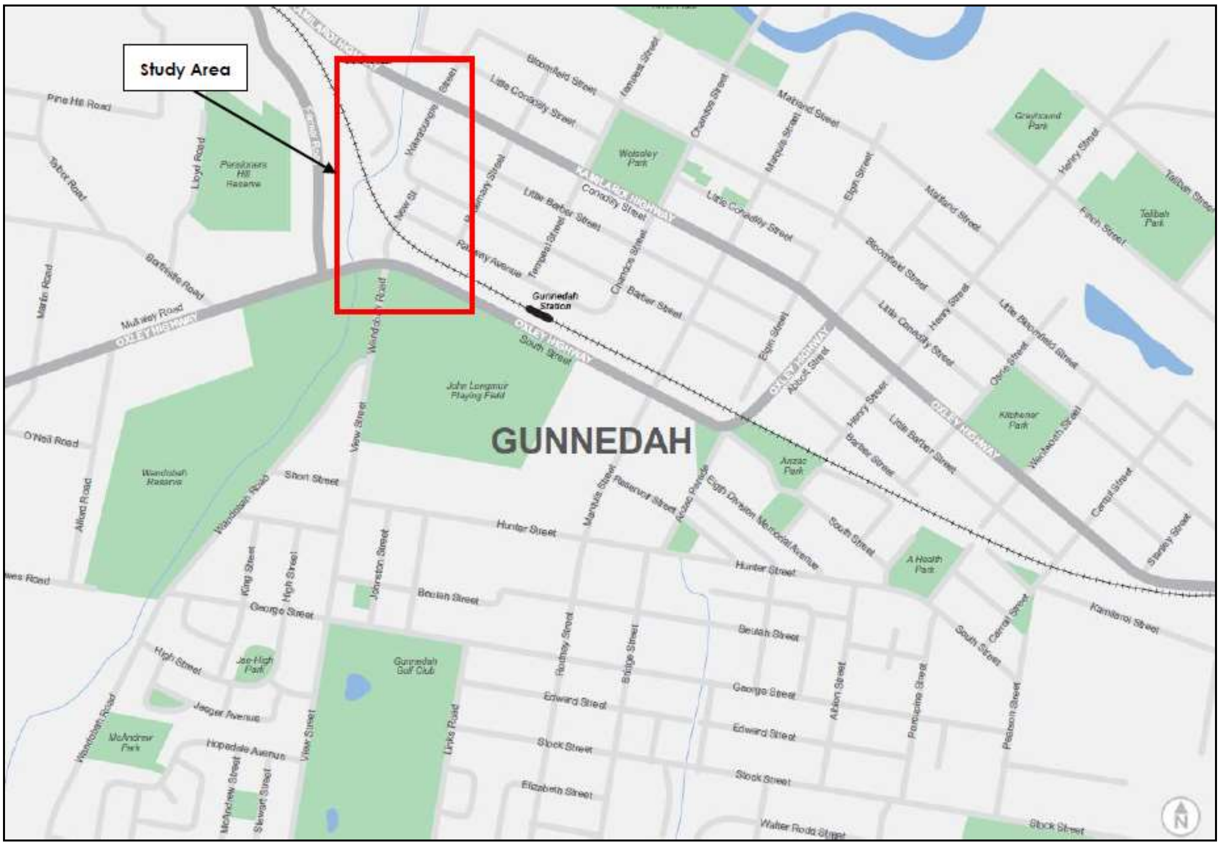
2 PROJECT DESCRIPTION

2.1 Project Area

Gunnedah is located in northern NSW, 70 km northwest of Tamworth. The Hunter Valley Rail Corridor runs through the middle of the town. Currently, there is only one grade separated crossing of the rail line at Abbot Street Bridge, which forms part of the Oxley Highway.

The study area for the project is illustrated in **Figure 2** below.

Figure 2 Project Area



2.2 Identification of Sensitive Receivers

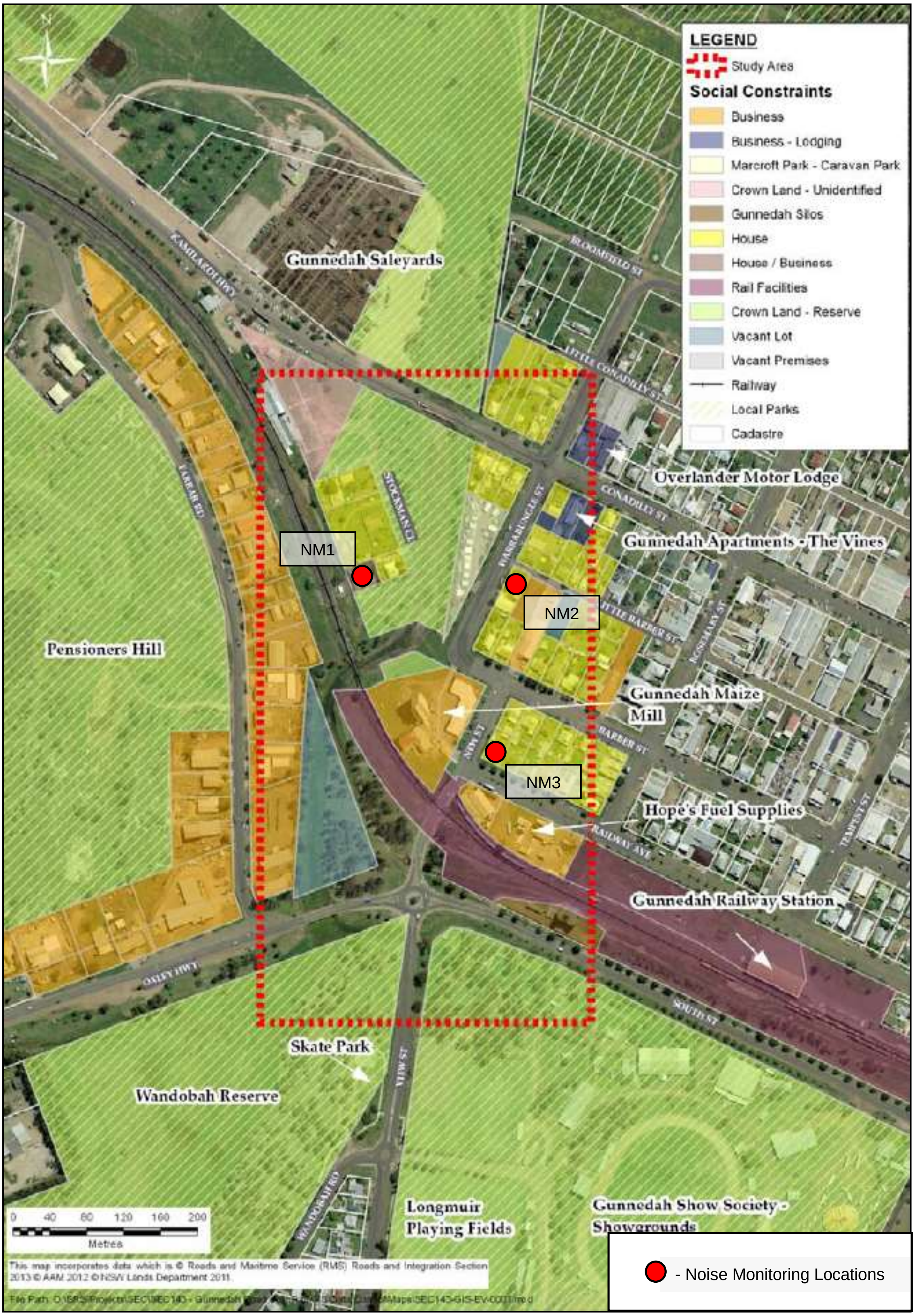
The Gunnedah project area consists of a variety of land uses in the immediate vicinity of the proposed new bridge location.

Land use on the western side of the project area, in the vicinity of Farrar Road, is typically industrial/commercial related,. The eastern side of the project area is generally a mix of residential and commercial land uses.

The heritage listed Gunnedah Maize Mill is located approximately in the centre of the project area.

The various land use and receiver types surrounding the project area are shown in **Figure 3**.

Figure 3 Project Area Overview and Receiver Types



3 EXISTING AMBIENT NOISE ENVIRONMENT

In order to characterise the noise environment across the project area (in relation to both construction and operation) and to establish existing ambient noise levels upon which to base the noise emission targets, environmental noise monitoring was performed at representative locations within the project area.

The noise monitoring locations were selected to be representative of receivers and communities potentially affected by the construction and operation of the proposal.

Noise monitoring equipment was deployed with consideration of other noise sources that may influence the measurements, accessibility and security, and with the consent of relevant land owners. The noise monitoring locations are indicated on the site plan in **Figure 3**.

3.1 Methodology for Unattended Noise Monitoring

To measure the prevailing levels of background and ambient noise, noise loggers were deployed adjacent to sensitive receptors over a minimum period of one week in April 2013.

The noise loggers continuously measured noise levels in 15 minute sampling periods to determine the existing L_{Aeq}, L_{A90} and other relevant statistical noise levels during the daytime, evening and night-time periods.

The noise measurements were carried out with Acoustic Research Laboratories Type EL 316 and EL 215 Environmental Noise Loggers and SVANTEK 957 Noise Loggers. The equipment was set up with microphones at 1.5 m above the ground level and, where possible, 1 m from the facade of the subject building. All microphones were fitted with wind shields.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of AS IEC 61672.1-2004 *"Electroacoustics - Sound Level Meters"* and carried appropriate and current NATA calibration certificates. The calibration of the loggers was checked both before and after each measurement survey and the variation in calibration at all locations was found to be within acceptable limits at all times.

The analysis of the measured noise levels has been carried out in accordance with the procedures contained in the ENMM and INP to establish representative ambient and background noise levels over relevant time periods. Consistent with recommendations contained in these documents, periods of unsatisfactory monitoring conditions of rain and wind speeds greater than 5 m/s have been filtered from the results. Reference is also made to the results off attended measurements and observations noted during the monitoring campaign.

Traffic counting on the surrounding road network was undertaken concurrently during the ambient noise logging survey period. This is discussed in greater detail in **Section 5.1**.

3.2 Unattended Noise Monitoring Results

The results of the unattended ambient noise surveys are presented in **Table 1** as the Rating Background Level (RBL) and L_{Aeq} (energy averaged) noise levels for the daytime, evening and night-time periods. The 24 hour daily noise levels at each monitoring location are graphically presented in **Appendix B**.

Table 1 Ambient Noise Logging Results

Location	Ambient Noise Logging Results				
NM1 - 9 Stockmen Close, Gunnedah	**INP/ICNG Defined Time Periods**				
	Monitoring Period	**Noise Level (dBA)**			
		RBL	**LAeq**	**L10**	**L1**
	Daytime	45	56	53	61
	Evening	42	55	52	63
	Night-time	38	56	49	58
	RNP Defined Time Periods				
	Monitoring Period[3]	**Noise Level (dBA) - LAeq(Period)**			
		Weekday	**Weekend**	**Weekly**	
	Daytime (7am-10pm) - LAeq(15hr)	56	54	55	
	Night-time (10pm-7am) - LAeq(9hr)	54	59	56	
NM2 - 1 Little Barber Street, Gunnedah	**INP/ICNG Defined Time Periods**				
	Monitoring Period	**Noise Level (dBA)**			
		RBL	**LAeq**	**L10**	**L1**
	Daytime	39	61	64	73
	Evening	39	59	57	69
	Night-time	33	54	49	64
	RNP Defined Time Periods				
	Monitoring Period	**Noise Level (dBA) - LAeq(Period)**			
		Weekday	**Weekend**	**Weekly**	
	Daytime (7am-10pm) - LAeq(15hr)	61	57	60	
	Night-time (10pm-7am) - LAeq(9hr)	55	51	54	
NM3 - 2 Railway Avenue, Gunnedah	**INP/ICNG Defined Time Periods**				
	Monitoring Period	**Noise Level (dBA)**			
		RBL	**LAeq**	**L10**	**L1**
	Daytime	52	61	64	70
	Evening	44	59	62	68
	Night-time	37	55	53	64
	RNP Defined Time Periods				
	Monitoring Period	**Noise Level (dBA) - LAeq(Period)**			
		Weekday	**Weekday**	**Weekday**	
	Daytime (7am-10pm) - LAeq(15hr)	61	59	61	
	Night-time (10pm-7am) - LAeq(9hr)	55	56	55	

Note 1: ICNG Governing Periods -Day: 7.00 am to 6.00 pm Monday to Saturday, 8.00 am to 6.00 pm Sunday; Evening: 6.00 pm to 10.00 pm; Night: 10.00 pm to 7.00 am Monday to Saturday, 10.00 pm to 8.00 am Sunday.

Note 2: RNP Governing Periods - Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am.

Note 3: Noise levels were found to not be road traffic noise dominated at this location.

The noise levels display a diurnal trend with noise levels during the night-time lower than the levels during the daytime and evening periods. This characteristic is typical of areas where the daytime and evening ambient noise levels are primarily influenced by road/rail traffic movements in the area, and from general ambient noise sources during the night-time.

3.3 Operator Attended Ambient Noise Measurements

3.3.1 Noise Measurement Procedure

Attended measurements of ambient noise have been used to determine the various sources that influence the existing noise environment. During each measurement the observer noted the various noise sources and the contributing noise level.

At each location the attended measurements were performed using a Brüel and Kjær Type 2270 sound level meter for a minimum period of 15 minutes. Wind speeds were less than 5 m/s at all times, and all measurements were performed at a height of 1.5 m above ground level.

Calibration of the sound level meter was checked before and after each measurement and the variation in calibration at all locations was found to be within acceptable limits at all times. The noise environment at the attended monitoring locations is described in **Table 2**.

Table 2 Operator-Attended Ambient Noise Survey at Noise Logging Location

Noise Survey Location	Measurement Details	Measured Noise Level (dBA)			Ambient Noise Sources - Typical Maximum Noise Levels LAmax (dBA)	SLM Serial Number
		LA90	LAeq	LAmax		
NM1 - 9 Stockmen Close, Gunnedah	19/03/2013 16:28 Wind calm Cloud 2/8	45	50	67	Residents: 48-67 Light road traffic: 48-60 Birds: 54-65 Rooster: 46 Industry: 53-55 Train horn: 59	2679354
NM2 - 1 Little Barber Street, Gunnedah	19/03/2013 16:00 Wind calm Cloud 2/8	42	59	77	Residents: 45 Light road traffic: 60-72 Lawn mower: 75 Birds: 65 Dogs: 48-59 Distance traffic: 49-59	2679354
NM3 - 2 Railway Avenue, Gunnedah	19/03/2013 15:28 Wind calm Cloud 2/8	52	60	76	New Street: 59-71 Birds: 55-62 Maize Mill: 52 Railway Road: 67-72 Other industry: 67	2679354

At location NM1 (9 Stockmen Close, Gunnedah) it was noted that the noise environment was typically influenced by other sources of ambient noise in the area (such as noise from fauna, train passbys and some industrial type noise), and was not necessarily dominated by road traffic.

This is likely due to this location being notably further away from the surrounding roads than either location NM2 or NM3.

4 NOISE AND VIBRATION GOALS

4.1 Operational Noise - NSW Road Noise Policy

4.1.1 Guideline Overview

For traffic operating on public roads, the NSW Government's *Road Noise Policy* (RNP) is appropriate for assessing potential road traffic noise impacts.

The NSW Government issued the RNP on 1 July 2011. The document identifies strategies that address the issue of road traffic noise from:

- Existing roads.
- New road projects.
- Road redevelopment projects.
- New traffic-generating developments.

The RNP noise criteria aim to protect amenity inside and immediately around permanent residences, schools, hospitals and other sensitive land uses, rather than at all points in a given locality, which would not be practical or possible. Although it is not mandatory to achieve the noise assessment criteria in the RNP, project proponents need to provide justification if it is not considered feasible or reasonable to achieve them.

The guideline recognises that there are generally more opportunities to minimise noise impacts from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impacts from existing roads and corridors is more limited.

The RNP criteria are applicable both at the time of project opening and also in a design year, typically taken to be ten years after project completion.

4.1.2 Noise Assessment Criteria - Residential Land Uses

Table 3 summarises the RNP 'redevelopment' and the 'new road' assessment criteria for residences, which are applicable for this project. Note that the proposed road over rail overpass is considered to be a new road while the proposed works at the Barber Street connection and the Kimilaroi Highway roundabout are considered to be redevelopment of existing roads.

These criteria are presented for assessment against facade noise levels as measured at the most affected point in front of a building.

Table 3 RNP Criteria - Residential Land Uses

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am – 10 pm)	**Night-time (10 pm - 7 am)**
Freeway/ arterial/ sub-arterial roads	1 Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	LAeq(15hour) 55 (external)	LAeq(9hour) 50 (external)
	2. Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	LAeq(15hour) 60 (external)	LAeq(9hour) 55 (external)

In addition to the noise criteria in **Table 3**, the RNP describes a "Relative Increase Criteria" of 12 dB above existing traffic noise. This criterion is primarily intended to protect existing quiet areas from excessive changes in amenity.

4.1.3 Sleep Disturbance

Guidance for the assessment of sleep disturbance given in the RNP is reproduced as follows:

> *"Triggers for, and effects of sleep disturbance from, exposure to intermittent noise such as noise from road traffic are still being studied. There appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. The NSW Roads and Traffic Authority's Practice Note 3 (NSW Roads and Traffic Authority 2008) outlines a protocol for assessing and reporting on maximum noise levels and the potential for sleep disturbance."*

NSW Roads and Traffic Authority's *Environmental Noise Management Manual* (ENMM) - Practice Note III protocol for assessing the potential for sleep disturbance is determined by performing L_{AFmax} - $L_{Aeq(1hr)}$ calculation on individual vehicle passby noise measurements. The number of night-time passby events where the L_{AFmax} - $L_{Aeq(1hr)}$ difference is greater than 15 dB is to be determined.

With regard to reaction to potential sleep disturbance events, the RNP gives the following guidance:

> *From the research on sleep disturbance to date it can be concluded that:*
>
> - *maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep*
> - *one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.*

It is generally accepted that internal noise levels in a dwelling, with the windows open are 10 dB lower than external noise levels. Based on a worst case minimum attenuation, with windows open, of 10 dB, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions.

The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA are not likely to affect health and wellbeing significantly.

4.2 Assessment Scenarios

The two RNP-related assessment years are described as follows:

- The At-Opening year is 2016.
- The Design year is 2026.

A third scenario was also modelled for the purposes of validating the existing noise model against the noise survey data:

- The Validation year is 2013.

4.3 Construction Noise Goals

4.3.1 Construction Noise Metrics

The noise metrics used to describe construction noise emissions in the modelling and assessments are:

$L_{A1(1minute)}$ The "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, the 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 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).

4.3.2 EPA's Interim Construction Noise Guideline

The EPA's *Interim Construction Noise Guideline*, 2009 (ICNG) sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses by presenting assessment approaches that are tailored to the scale of construction projects.

The main objectives of the ICNG are stated in Section 1.3 of the ICNG. The relevant items are presented below:

- Promote a clear understanding of ways to identify and minimise noise from construction works;
- Focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts;
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours;
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage; and
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

Whilst it is recognised the guideline is non-mandatory, SLR Consulting consider it applicable to the project and has adopted it for the purposes of assessing the potential for impacts during the construction works.

Guidance levels are given for airborne noise at sensitive land uses, including passive recreation, commercial and industrial premises. Guidance levels are also given for ground-borne noise and sleep disturbance. The assessment method involves predicting noise levels and comparing them with the guidance, or management levels. The 'management levels' will be referred to as 'Noise Management Levels' (NMLs). The NMLs have been reproduced from the guideline and are presented in **Table 4**.

The Project Specific Noise Level for each of the residential receptors in this study are presented in **Table 5**.

Specific sensitive land uses (eg active and passive recreation) and commercial premises in the vicinity of the works and their recommended noise levels are presented in **Table 6**.

Table 4 Guideline Management Levels for Construction Noise - ICNG

Time of day	Management level $L_{Aeq\ (15\ min)}$ [1]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 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: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Note 1 Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m 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

Table 5 ICNG Project Specific NML for Residential Assessment (dBA re 20 µPa)

	Project Specific NML $L_{Aeq(Period)}$ Assessment Criteria [1]		
	Day (7am to 6pm Monday to Friday, 8am to 1 pm Saturdays))	Evening (6pm to 10pm Monday to Friday)	Night (10pm to 7:00am Monday to Friday)
New Street, Barber Street	62	49	42
Warrabungle Street	49	44	38
Stockman Close	55	47	43

Table 6 NMLs at Sensitive Land Uses and Commercial and Industrial Premises (other than Residences) - ICNG

Receiver	$L_{Aeq(15minute)}$ Construction NML
Commercial (offices)	External noise level 70 dBA
Industrial	External noise level 75 dBA

4.4 Construction Vibration Goals

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 prejudiced.

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 works 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)*

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.
2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas.
Source: BS 6472–1992

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 BS7385 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 (BS7385)

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 Ground-Borne (Regenerated) Noise

Ground-borne (or regenerated) construction noise can be present on construction projects where vibration from activities such as rockbreaking, road heading, rotary cutting and rock drilling/sawing can be transmitted through the ground and into the habitable areas of nearby buildings. Ground-borne noise occurs when this vibration in the ground and/or building elements is regenerated as audible noise within areas of occupancy inside the building.

The NSW EPA's ICNG defines internal ground-borne noise goals for residential receivers of 40 dBA $L_{Aeq(15minute)}$ during the evening (6:00 pm to 10:00 pm) and 35 dBA $L_{Aeq(15minute)}$ during the night-time (10:00 pm to 7:00 am). The goals are only applicable when ground-borne noise levels are higher than airborne noise levels.

5 OPERATIONAL NOISE ASSESSMENT

5.1 Traffic Figures

5.1.1 Existing Situation

Traffic flow information for the existing situation was recorded for the roads within the project area during the noise monitoring period and is presented in **Table 9**. This information, in conjunction with the noise monitoring data as presented in **Section 3.2**, was used as the basis for the validation of the noise model.

Table 9 Existing Road Traffic Survey – Results Summary

Location	Direction	Speed (kph)	Traffic Volumes			
			15 Hour Day		9 Hour Night	
			Light	Heavy	Light	Heavy
Barber Street	Two Way	43	4416	404	202	22
Kimilaroi Highway	Two Way	47	2521	328	254	56
New Street	Two Way	35	5485	461	294	31
Oxley Highway	Two Way	55	2504	364	189	43
Warrabungle Street	Two Way	40	5485	461	294	31

Notes Daytime is from 7.00 am to 10.00 pm, Night-time is from 10.00 pm to 7.00 am.

5.1.2 At-Opening Situation

Traffic flow information for the At-Opening situation within the project area is presented in **Table 10**.

Table 10 At-Opening Road Traffic Data (Year 2016)

Location	Direction	Speed (kph)	Traffic Volumes			
			15 Hour Day		9 Hour Night	
			Light	Heavy	Light	Heavy
Kimilaroi Highway / Warrabungle Street Roundabout						
Kamilaroi Hwy (West of Warrabungle St)	Two Way	50	2334	385	266	44
Warrabungle St (North of Kamilaroi Hwy)	Two Way	50	467	141	54	16
Kamilaroi Hwy (East of Warrabungle St)	Two Way	50	1349	22	154	3
Warrabungle St (South of Kamilaroi Hwy)	Two Way	50	663	20	37	1
Oxley Highway / New Street / Proposed Overpass Roundabout						
Oxley Hwy (West of New St)	Two Way	50	2738	189	224	15
Proposed Overpass or existing New St (North of Oxley Hwy)	Two Way	50	3722	123	210	7
Oxley Hwy (East of New St)	Two Way	50	888	69	73	6
View St (South of Oxley Hwy)	Two Way	50	2085	71	118	4
Barber Street Connection						
Barber St (East of View St)	Two Way	50	5105	142	234	7

Notes Daytime is from 7.00 am to 10.00 pm, Night-time is from 10.00 pm to 7.00 am.

5.1.3 Design Year Situation

Traffic flow information for the Design Year situation within the project area is presented in **Table 11**.

Table 11 Design Year Road Traffic Data (Year 2026)

Location	Direction	Speed (kph)	Traffic Volumes			
			15 Hour Day		9 Hour Night	
			Light	Heavy	Light	Heavy
Kimilaroi Highway / Warrabungle Street Roundabout						
Kamilaroi Hwy (West of Warrabungle St)	Two Way	50	2536	415	289	47
Warrabungle St (North of Kamilaroi Hwy)	Two Way	50	491	148	56	17
Kamilaroi Hwy (East of Warrabungle St)	Two Way	50	1488	24	170	3
Warrabungle St (South of Kamilaroi Hwy)	Two Way	50	706	21	40	1
Oxley Highway / New Street / Proposed Overpass Roundabout						
Oxley Hwy (West of New St)	Two Way	50	2929	203	239	17
Proposed Overpass or existing New St (North of Oxley Hwy)	Two Way	50	3948	133	222	7
Oxley Hwy (East of New St)	Two Way	50	934	73	76	6
View St (South of Oxley Hwy)	Two Way	50	2192	75	124	4
Barber Street Connection						
Barber St (East of View St)	Two Way	50	5438	158	249	7

Notes Daytime is from 7.00 am to 10.00 pm, Night-time is from 10.00 pm to 7.00 am.

5.2 Assessment Methodology

A three-dimensional computer noise model was previously developed as part of the *Detailed Design Noise Assessment* for the project. Noise modelling of the project area was carried out using the UK Department of Transport, *Calculation of Road Traffic Noise* (CORTN 1988) algorithms incorporated in SoundPLAN noise software.

In the original UK version of the CORTN Model, all traffic noise 'sources' are located 0.5 m above the pavement surface. This approach is appropriate as a 'standard' calculation method and yields reasonable consistency from project to project. The predicted noise levels are also reasonably accurate for roadway conditions having a clear line-of-sight from receivers to the traffic.

Where noise barriers (including the edges of cuttings) are present however, the CORTN barrier reduction algorithm would tend to over-predict the reductions for truck engine and exhaust noise components, which have effective source heights considerably greater than 0.5 m above pavement level.

For this project, the SoundPLAN traffic noise source 'strings' have therefore been modified to incorporate four effective noise sources (and associated heights) in each carriageway. These comprise a '*CAR*' source with height of 0.5 m above pavement and three '*TRUCK*' sources at three separate heights representing the noise emission from truck tyres (0.5 m), truck engines (1.5 m) and truck exhausts (3.6 m).

The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical noise barriers. The CORTN single point receiver calculations include the standard CORTN +2.5 dB facade reflection and are adjusted by -1.7 dB for Australian Conditions in accordance with the ARRB recommendations.

It is noted that the CoRTN noise modelling algorithms do not take into account engine braking noise from trucks or the effect of vehicles accelerating away from an intersection.

5.3 Noise Model Validation

Reference to **Section 3** indicates that noise logging location NM1, 9 Stockmen Close, was influenced by extraneous sources of ambient noise and was not road traffic noise dominated. This is due to the location being around 100 m away from the nearest source of road traffic noise (Warrabungle Street), whereas locations NM2 and NM3 are immediately adjacent to roads.

Location NM1 has therefore been discounted from the following validation process.

The predicted operational noise levels for the existing scenario have been compared to the noise levels measured during the ambient noise survey, discussed in **Section 3**, for the purpose of model validation. This is shown in **Table 12**.

Table 12 Model Validation - Comparison of Predicted Noise Levels to Measured Noise Levels

Noise Logging Location	Noise Logging Address	Noise Levels (dBA)					
		Measured Existing		Predicted Existing		Comparison – Predicted Minus Measured	
		Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)
NM2	1 Little Barber Street	60	54	62	52	2	-2
NM3	2 Railway Avenue	61	55	62	53	1	-2

Reference to the above indicates that the correlation between measured noise levels and those predicted is within ±2 dBA. This is within the accepted limits of noise modelling, noting that the ENMM states that "*it should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dBA*". The noise model is therefore considered valid.

Reference to the noise logging data detailed in **Section 3** and illustrated in **Appendix B** indicates the night-time noise environment in the project area is not entirely road traffic noise dominated. The measured L_{Aeq} noise levels therefore include both the road traffic noise component together with other sources of extraneous ambient noise in the area, such as fauna noise and occasional rail passbys.

As such, the road traffic noise component alone would be expected to be slightly lower than the levels measured. On the basis of the comparison of the noise model predictions with the baseline measurement results, it is concluded that the noise model provides results which enable a reliable assessment of the project.

5.4 Predicted Operational Noise Levels

The predicted operational noise levels for the At-Opening and Design Year, together with the change in noise levels and the level above the RNP criteria at the representative sensitive receivers are shown in **Table 13** (refer to **Appendix C** for locations of representative receivers and **Appendix D** for the full results).

Table 13 Predicted Operational Noise Levels

Receiver Address[1]	Predicted Noise Levels (dBA)								RNP Criteria (dBA)				Are the RNP Criteria Exceeded?		Change in Noise Level[3]				Acute Level of Noise[4]		Consider Further Additional Noise Mitigation?[5]
	At-Opening				Design Year																
	'No Build' Scenario		'Build' Scenario		'No Build' Scenario		'Build' Scenario		At-Opening		Design Year				At-Opening		Design Year				
	Day[6]	Night[6]	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
2 Railway Avenue	59	49	49	39	59	49	49	39	55	50	55	50	No	No	-9.7	-9.8	-9.8	-10.0	No	No	No
5 Barber Street	59	50	54	44	60	50	55	44	55	50	55	50	No	No	-5.0	-5.6	-5.1	-5.6	No	No	No
1/2-6 Warrabungle	52	42	**57**	47	53	43	**57**	47	55	50	55	50	Yes	No	4.6	4.8	4.6	4.6	No	No	Yes
2/2-6 Warrabungle	53	43	55	45	53	44	55	45	55	50	55	50	No	No	1.6	1.5	1.6	1.5	No	No	No
3 Warrabungle Street	54	44	**57**	47	54	44	**57**	47	55	50	55	50	Yes	No	2.8	2.8	2.8	2.6	No	No	Yes
14/2-6 Warrabungle	53	44	53	45	53	44	54	45	55	50	55	50	No	No	0.7	0.9	0.6	0.8	No	No	No
1 Little Barber Street	52	42	53	44	52	43	53	44	55	50	55	50	No	No	1.0	1.1	0.8	1.0	No	No	No
7 Stockman Close	46	37	52	42	47	37	52	43	55	50	55	50	No	No	5.6	5.7	5.5	5.7	No	No	No
9 Stockman Close	46	36	52	42	46	36	52	43	55	50	55	50	No	No	6.1	6.2	6.1	6.2	No	No	No
33 Conadilly Street	58	51	59	52	58	51	60	53	60	55	60	55	No	No	1.7	1.7	1.6	1.7	No	No	No
35 Conadilly Street	56	49	57	50	56	49	58	51	60	55	60	55	No	No	1.6	1.7	1.5	1.6	No	No	No
36 Conadilly Street	59	52	60	53	59	53	60	54	60	55	60	55	No	No	0.9	0.9	0.9	0.9	No	No	No

Note 1: Receiver ID

Note 2: Investigation into noise treatment in accordance with RTA's RNP Implementation Flowchart required when the Target Noise Level is exceeded

Note 3: Change in noise level between 'build' and 'no build' scenarios for year of opening and the design year. A negative values implies a decrease in noise level and vice versa.

Note 4: Acute noise is defined as day $L_{Aeq(15hour)}$ 65dBA and night-time as $L_{Aeq(9hour)}$ 60dBA. In cases where the predicted 'No Build' noise level is deemed acute investigation into feasible and reasonable noise mitigation is required.

Note 5: For 'new road', this is required when the base criteria are exceeded. For 'redevelopment', this is required when change in noise levels exceed 2.0 dB or predicted design year levels are acute.

Note 6: Day = 7am - 10pm (15 hours); Night = 10pm - 7am (9 hours).

5.4.1 Summary of Results

Based on the predicted results presented in **Table 13**, the following findings were made:

- The criteria for 'new road' (i.e. the proposed overpass) are applicable for most receivers apart from the receivers located directly adjacent to the proposed upgraded roundabout at Kimilaroi Highway, namely 33, 35 and 36 Conadilly Street.
- For receivers where the dominant noise impact was due to the proposed overpass (i.e. where the more stringent 'new road' criteria are applicable):
    - Two (2) selected representative receivers were predicted to exceed the $L_{Aeq(15hour)}$ (day time) base criterion. The levels of exceedance were predicted to be up to 2 dB.
    - All predicted relative increase in noise levels were less than the prescribed criterion of 12 dB.
- For receivers located adjacent to the proposed upgraded roundabout at Kimilaroi Highway (i.e. where the 'redevelopment' criteria are applicable):
    - Predicted noise levels at all three selected representative receivers were within the prescribed day and night time base criteria.
    - The proposed roundabout to replace the existing Kimilaroi Highway and Warrabungle Street intersection was not predicted to cause significant noise impact with the predicted relative increase in noise levels all less than 2.0 dB.
- The predicted daytime and night-time L_{Aeq} noise levels show that no receivers are predicted to be subject to acute levels of noise.
- Based on the findings as presented above, it was determined that further consideration of mitigation measures is required for two properties, namely: 1/2-6 Warrabungle Street and 3 Warrabungle Street.

5.5 Assessment of Reasonable and Feasible Mitigation Measures

5.5.1 Procedure Overview

As highlighted in the RNP, the redevelopment of existing road corridors offers a more limited range of noise control measures because of likely limitations to using corridor route adjustment, the proximity of residents to the road and limited road re-design options.

For the situation where existing noise levels exceed the criteria, the RNP gives the following guidance:

> *"Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.*
>
> *In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person."*

Where exceedances of the noise criteria are identified, the RNP describes noise mitigation measures to be considered in order of priority:

1 Road design and traffic management

2 Quieter pavement surfaces

3 In corridor noise barriers/mounds

4 At property treatments or localised barriers/mounds

The priority of mitigation measures recognises that noise control at the source is preferable over noise path control and noise mitigation at the receiver.

The RNP notes that it is not mandatory to achieve the noise assessment criteria, and that noise mitigation measures should be both feasible and reasonable. Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the abatement measure. To make such a judgement, consideration may be given to noise impacts, noise mitigation benefits, the cost effectiveness of noise mitigation and community views.

5.5.2 Reasonable and Feasible Definition

Where the noise goals in the design year 'build' scenario are found to be exceeded as a result of a project, the RNP and the ENMM require the project to adopt "reasonable and feasible" mitigation measures to meet the targets.

Practice Note IV of the ENMM defines what "reasonable and feasible" factors may be considered when investigating noise mitigation measures.

"**Reasonableness**" relates to the application of wider judgements. The factors to be considered are:

- The noise reduction provided and the number of people protected
- The cost of mitigation, including the total cost and cost variations with different benefits provided
- Community views and wishes
- Visual impacts
- Existing and future noise levels, including changes in noise levels
- The benefits arising from the proposed road or road development

"**Feasibility**" relates to engineering considerations (what can be practically built) and may include:

- The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources
- Safety issues, such as restrictions on road vision
- Road corridor site constraints such as space limitations
- Floodway and stormwater flow obstruction
- Access requirements
- Maintenance requirements

5.5.3 ENMM Exemptions

For receivers where the increase due to the proposed "redevelopment" is below 2 dB, practice Note IV of the ENMM outlines two situations where the assessment is exempt from consideration of noise mitigation (such as noise barriers/mounds, architectural treatments and quieter pavement surfaces) beyond the adoption of all "feasible and reasonable" traffic management and other road design measures. The relevant section is reproduced as follows:

> *There are two situations in which the RTA believes it is generally not "reasonable" to take action to reduce predicted noise levels through the adoption of measures (such as noise barriers/mounds, architectural treatments and quieter pavement surfaces) beyond the adoption of all "feasible and reasonable" traffic management and other road design measures:*

(1) For proposed "new" roads and road "redevelopments" (see Practice Note I), the RTA believes it is generally not "reasonable" to take action to reduce predicted noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:

- *Within 2 dB(A) of "future existing" noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), and*
- *No more than 2 dB(A) above the target noise levels set out in columns 2 and 3 of Table 1 in the ECRTN.*

This approach is based on the insignificance of the changes in noise levels involved and the insignificant exceedances of the target noise levels.

It applies only if it can be demonstrated that all "feasible and reasonable" traffic management and other road design opportunities for reducing traffic noise have been exhausted.

(2) For proposed "redevelopments" of roads where existing noise levels already exceed the ECRTN target noise levels, and all "feasible and reasonable" traffic management and noise-reducing design opportunities have been incorporated into the road design, the RTA believes it is generally not "reasonable" to apply additional treatments such as noise barriers/mounds, quieter pavement surfaces and architectural treatment of private dwellings if the predicted design year noise levels:

- *Do not exceed the ECRTN allowances (in column 4 of Table 1 in the ECRTN) over the "future existing" noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), and*
- *Will not be acute (i.e. the noise levels are predicted to be less than 65 dB(A) Leq(15hr) (day) and 60 dB(A) Leq(9hr) (night)).*

Again, this approach is based on the insignificance of the change in noise levels involved, but recognises the increased importance of reducing noise levels where existing or predicted road traffic noise impacts are acute.

If either of these two "exceptions" applies, no further investigation of noise controls is required.

In the application of the above ENMM exemptions, the target noise levels contained in the RNP are used instead of those of the repealed ECRTN.

5.5.4 Consideration of Noise Mitigation

Consideration of mitigation (beyond the adoption of traffic management and other road design measures) was identified in **Section 5.4** to be required at two (2) properties within the defined project area. These properties (refer to **Figure 4**) were identified to be:

- 1/2-6 Warrabungle Street
- 3 Warrabungle Street

Figure 4 Sensitive Receivers Requiring Consideration of Noise Mitigation

5.5.5 Pavement Surface

The receivers which are eligible for consideration of noise mitigation are located at the intersection of the future overpass and the southern end of Warrabungle Street. The use of a quieter pavement surface is therefore unlikely to be a feasible option due to the durability constraints of the pavement materials due to frequent braking that occurs at intersections.

5.5.6 Noise Barriers/Mounds

The RTA's *Environmental Noise Management Manual* (ENMM) states that noise barriers are not considered cost-effective:

> *If residences are closely grouped in numbers of three or less, architectural treatments are preferred over roadside barriers, as it is likely that the cost per residence for barriers will be at least twice that for architectural treatments.*

Based on the above, noise barriers are not considered to be a reasonable option. In addition, the receivers requiring consideration are located at the future intersection, this location is not considered to be suitable for construction of noise barriers due to access requirements.

5.5.7 Residual Architectural Property Treatments

Treatments to buildings usually involve higher performance windows, doors and seals to prevent noise ingress to internal spaces. Building treatments effectively require occupants to keep their windows and doors closed and hence alternative ventilation is usually required to maintain adequate air flow.

An obvious disadvantage is that building treatments would not have any effect on the noise levels outside the dwelling in their front or back yards.

Where source control measures such as low noise pavements and noise barriers are found to not be feasible or reasonable, architectural treatment of individual dwellings should be considered, noting that:

- It may not be effective for lightweight buildings.
- It provides no protection to outdoor areas.
- Mechanical ventilation and/or air-conditioning is required, which can result in higher energy consumption.

Based on past experience, the following procedure is recommended to determine the extent of the specific treatment required:

- Inspect the relevant properties and determine the status of the dwelling, noting including and not limited to the type of construction, type of interior spaces most impacted by road noise, window sizes, glazing type etc.
- If deemed necessary, conduct sound insulation testing to determine the existing noise reduction that can be provided by the existing construction.
- Determine whether any changes/modification/upgrade of the facade element is required based on existing sound insulation properties and type of spaces affected. Typically, if applicable, the weakest elements on the façade are the windows'/sliding doors' frames and glazing.
- Consult with relevant property owner/occupants in relation to specific personal preferences.
- Determine the most appropriate/preferred method of providing alternative means of ventilation. Examples of suitable products/method include Acoustica Aeropac Ventilator or similar, or an in-ceiling ducted system to draw fresh air from the quiet side of the house to the rooms in concern.

5.5.8 Signage

Due to the potential for significant noise exposure from engine braking from trucks as they make their way through the intersections associated with this development, we recommend that signage be considered indicating that "engine brake usage is to be minimised".

5.5.9 Summary

The most reasonable and feasible mitigation option for the two identified residences is likely to be the provision of alternative ventilation (where currently not existing) to allow residents to close windows to prevent noise ingress, while maintaining adequate air flow.

It is noted that the requirements of the specific residential buildings may benefit from different acoustic treatments which should be considered in consultation with the owners.

6 CONSTRUCTION NOISE ASSESSMENT

6.1 Construction Noise and Vibration Modelling

6.1.1 Overview

In order to determine the acoustical impact of the proposed construction activities the 3 dimensional noise model used for the traffic noise assessment was developed to incorporate the significant noise sources and the intervening terrain and buildings to the residences.

The noise model was analysed using the CONCAWE noise prediction algorithm and is a suitable procedure to predict the noise emissions from the operation of various components that comprise the various elements of the project.

The noise modelling takes into account source sound level emissions and locations, screening effects, receiver locations, reflections off nearby buildings and structures, ground topography and noise attenuation due to spherical spreading and atmospheric absorption. Ground topography was digitised from spot height topographical data obtained from Google aerial and ground based survey data surrounding the site.

6.1.2 Modelling Scenarios and Sound Power Levels

It is understood that construction activities will be conducted during standard construction hours, and the proposed construction programme is as follows:

- Construct temporary access road off existing road network.
- Precast deck girders (offsite activity).
- Piling operations (approximately one impacted pile per day including concreting operations, assume four piles per pier).
- At completion of piling operations, start preparation for pile cap inc. excavation, casting of blinding layer, breaking back of pile reinforcement (if required), placing of reinforcement and formwork, completion of concreting, curing time and stripping of formwork (allow approximately 15 days per pier).
- Seven days after construction of pilecap, start erecting formwork and placing reinforcement for Piers. Complete concreting, curing and stripping of formwork (allow 21 days).
- 14 days after final construction of consecutive piers, land precast concrete girders. Assume four girders per day (with 7-9 girders per span), depending on site access and ability to deliver four girders in a day from the precaster.
- Construct diaphragms (at the end of each span) – small hand tools, and concreting operations (one week each diaphragm) to be cast span by span before deck concreting works.
- Install reinforcement, and pour concrete for decks span by span. (allow 10 days per deck to complete concreting operations).
- Construction of new kerbs and associated infrastructure (particularly at the Kimilaroi Highway roundabout and Oxley Highway roundabout).
- Finishing operations including bitumen laying, line marking, barrier installation and screen installation.

Based on the proposed construction program, scenarios have been developed for the typical noisier activities, which include:

1 Impact piling
2 Placement of precast beams
3 Concreting
4 Construction of new kerbs and associated infrastructure
5 Finishing

The typical worst case has been modelled for these scenarios as provided in **Appendix E**.

Receivers have been grouped together based on their distance from the activities and noise levels predicted. The highest noise level (the nearest receiver in the group) is presented in the Tables of results in **Section 6.2.1**. The grouping is as follows:

- Kimilaroi Highway / Conadilly Street roundabout - residences
- New Street - two residences
- Railway Avenue North - residences
- Barber Street - residences
- Warrabungle East - residences
- Warrabungle West - residences
- Stockman Close - two residences
- Mill Buildings - commercial/industrial
- Railway Avenue South - industrial
- Farrah Street - industrial

6.1.3 Vibration Modelling

Vibration impacts were assessed in accordance with minimum distance guidelines in the standards based on the type of equipment used and SLR Consulting's previous experience with vibration assessments of similar operations.

6.2 Construction Noise and Vibration Assessment

6.2.1 Construction Noise Impact

Construction works will be conducted during normal daytime working hours which are 7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm Saturday.

Based on the scenarios and the sound power levels outlined in **Appendices E and F**, construction noise levels have been predicted at the nearest receivers. The resultant daytime $L_{Aeq(15minute)}$ noise level predictions, where appropriate, in addition to the properties with NML exceedances, are presented in **Table 14.**

The tables present the various scenarios, NMLs and exceedances. The predictions in the tables are representative of the worst-case scenario with all equipment listed in **Appendix E** operating simultaneously.

In practice, noise levels will depend on the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. Noise levels will vary due to the movement of plant and equipment about the worksites and the concurrent operation of plant. In some cases, reductions in noise levels will occur when plant are located in cuttings or behind embankments, buildings or other items of equipment.

Table 14 Predicted Daytime Construction Noise Levels

Construction Stage	Receiver	Project Specific NML	Predicted LAeq Noise Level	Exceedance
1 – Piling	Kimilaroi Highway roundabout	62	68	6
	New Street	62	73	11
	Railway Avenue North	62	76	14
	Barber Street	62	79	17
	Warrabungle East	49	83	34
	Warrabungle West	49	85	36
	Stockman Close	55	85	30
	Mill Buildings	70	92	22
	Railway Avenue South	75	81	6
	Farrah Street	75	90	15
2 – Placement of precast beams	Kimilaroi Highway roundabout	62	46	-
	New Street	62	53	-
	Railway Avenue North	62	47	-
	Barber Street	62	59	-
	Warrabungle East	49	62	13
	Warrabungle West	49	62	13
	Stockman Close	55	56	1
	Mill Buildings	70	65	-
	Railway Avenue South	75	50	-
	Farrah Street	75	60	-
3 – Concreting	Kimilaroi Highway roundabout	62	50	-
	New Street	62	57	-
	Railway Avenue North	62	51	-
	Barber Street	62	63	1
	Warrabungle East	49	66	17
	Warrabungle West	49	66	17
	Stockman Close	55	60	5
	Mill Buildings	70	69	-
	Railway Avenue South	75	54	-
	Farrah Street	75	64	-

Construction Stage	Receiver	Project Specific NML	Predicted LAeq Noise Level	Exceedance
4 – Construction of new kerbs and associated infrastructure	Kimilaroi Highway roundabout	62	80	18
	New Street	62	66	4
	Railway Avenue North	62	54	-
	Barber Street	62	68	6
	Warrabungle East	49	74	25
	Warrabungle West	49	78	29
	Stockman Close	55	63	8
	Mill Buildings	70	68	-
	Railway Avenue South	75	59	-
	Farrah Street	75	65	-
5 – Finishing	Kimilaroi Highway roundabout	62	72	10
	New Street	62	53	-
	Railway Avenue North	62	49	-
	Barber Street	62	59	-
	Warrabungle East	49	77	28
	Warrabungle West	49	77	28
	Stockman Close	55	56	1
	Mill Buildings	70	65	-
	Railway Avenue South	75	53	-
	Farrah Street	75	61	-

6.2.2 Discussion

With reference to the above tables the construction noise impacts are summarised as follows:

- The highest impacts are predicted during Stage 1 impact piling, with worst exceedances of the NMLs of up to 36 dB at Warrabungle Street. It is noted the use of auger or bored piling techniques would be expected to reduce these exceedances by up to 20 dB.
- For the construction stage when new kerbs and associated infrastructure are constructed at the new and reconfigured roundabouts, the worst exceedances of the NMLs of up to 29 dB and 18 dB were predicted at Warrabungle Street and Kimilaroi Highway roundabout respectively.
- For the remaining construction stages, the primary noise impacts are confined to the Warrabungle Street residences, with exceedances of up to 13 dB for precast placement, up to 17 dB for concreting and up to 28 dB during finishing.

6.2.3 Highly Noise Affected Receivers

Predicted noise levels at the identified noise-sensitive receivers during the proposed construction scenarios exceed 75 dBA $L_{Aeq(15minute)}$ during impact piling, construction of new kerbs and finishing. The use of bored piling techniques is likely to result in reductions in predicted noise levels of up to 20 dB during piling operations.

6.3 Mitigation Measures

6.3.1 Recommended Noise Mitigation

The expected noise management level exceedances are likely to be concerning for surrounding residents and particular effort should be directed towards the implementation of all reasonable noise mitigation and management strategies.

The standard suite of mitigation measures includes management measures such as community consultation, site inductions (with guidance on how to minimise noise and vibration) and the preparation of site specific construction noise and vibration management plans. The strategy also includes several recommendations for reducing the source noise levels of construction equipment via good planning and equipment selection.

Examples of mitigation measures which may be considered appropriate for these works are:

- Use of localised acoustic hoarding around significantly noisy items of plant (eg jackhammer), where practicable. This would be expected to provide between 5 dB and 10 dB of additional noise attenuation provided the line-of-sight between all receivers and the construction equipment is broken. The barrier is most affective when it is located either close to the noise source or the receiver.
- Scheduling of the higher NML exceedance activities/locations to be undertaken predominantly during less noise-sensitive periods, where available and possible. The community should be consulted to assist in identifying less noise sensitive periods.
- Briefing of the work team in order to create awareness of the locality of sensitive receivers and the importance of minimising noise emissions.
- Consideration of the use of bored piling techniques.
- Ensuring any spoil is placed and not dropped into awaiting trucks.
- Establishing load points as far as practicable from sensitive receivers.
- Use of less noise-intensive equipment, where reasonable and feasible.
- Non-tonal reversing alarms fitted to all construction vehicles.

6.4 Construction Vibration Assessment

6.4.1 Vibration Intensive Equipment

The major potential sources of vibration from the proposed construction activities are pile driving and vibratory rolling.

All other proposed activities are considered to either contain plant items that are not significantly vibration intensive or the separation distance from the nearest receivers is sufficient to mitigate the potential impacts.

The propagation of vibration through the ground is a complex phenomenon. Even for a simple source, the received vibration at any point may include the arrival of several different wave types and depend on other effects such as material damping, reflection, and impedance mismatch caused by changes in ground conditions along the propagation path.

It is useful to note that predictions of vibration normally involve a combination of empirical and analytical methods as the various characteristics are normally not sufficiently defined to enable full analytical modelling.

6.4.2 Guideline Safe Working Distances

As a guide, safe working distances for typical items of vibration intensive plant are listed in **Table 15**. The safe working distances 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*) and human comfort (refer to EPA's *Assessing Vibration: a technical guideline*). The safe working distances for building damage must be complied with at all times, unless otherwise approved by the relevant authority.

Table 15 Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (EPA Vibration Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	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
Impact Pile Driver (18 tonne)	Driven piles	10 m	? m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note 1: More stringent conditions may apply to heritage or other sensitive structures.

The safe working distances presented in **Table 15** are indicative only and will vary depending on the particular item of plant and local geotechnical conditions. They apply to typical buildings under typical geotechnical conditions. Based on a preliminary review of the proposed work areas, the following findings were made:

- The proposed impact piling is generally more than 20 m from any existing building structures. Therefore, based on the above, the proposed impact piling is not likely to cause cosmetic damage.
- Some existing residential buildings are likely to be less than 12 m from the proposed alignment work areas. Therefore, the allowable ratings for vibratory roller and hydraulic hammer should be ≤200 kN and ≤900 kg respectively.

6.4.3 Ground-borne Vibration Impacts

Structural Damage Assessment

The separation distance(s) between the proposed works and the nearest receivers will typically be sufficient to ensure that the criterion given in British Standard BS 7385 Part 2-1993 for transient vibration for minimal risk of cosmetic damage to residential and industrial buildings, as shown in **Table 8**, will be satisfied.

Attended vibration monitoring should be undertaken when works are in the vicinity of the most affected receivers to ensure that levels remain below the criterion. Building condition surveys should also be completed both before and after the works at all affected properties to ensure no damage occurs as a result of the project.

Human Comfort Vibration Assessment

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

In relation to human comfort (response), the safe 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.

In general, for the proposed works scenarios where rockbreaking and/or jackhammering is undertaken, the separation distance from the nearest receivers is sufficient to mitigate the potential impacts. However the use of a vibratory roller when operating adjacent to the nearest sensitive receivers may result in vibration levels that exceed the recommended levels with respect to human response, especially if used in conjunction with rockbreaking equipment.

At locations where the works would be in close proximity to buildings and other sensitive structures, judicious selection of plant and equipment would be necessary for vibration intensive activities. Vibration monitoring is also recommended to confirm the safe working distances.

6.4.4 Ground-borne Construction Noise

The nature of the works (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible. This is because the airborne noise emissions in most circumstances are much higher than ground-borne noise levels. For this reason ground-borne noise is not anticipated to be the controlling factor for this project and further assessment is not warranted.

7 CONCLUSION

7.1 Operation

The operational noise impact assessment has been undertaken in accordance with the *Road Noise Policy* (RNP) and *Environmental Noise Management Manual* (ENMM). Based on the results of the noise modelling of the proposed overpass and roundabouts, the following findings were made:

- The criteria for 'new road' (i.e. the proposed overpass) are applicable for most receivers apart from the receivers located directly adjacent to the proposed upgraded roundabout at Kimilaroi Highway, namely 33, 35 and 36 Conadilly Street.
- For receivers where the dominant noise impact was due to the proposed overpass (i.e. where the more stringent 'new road' criteria are applicable):
  - Two (2) selected representative receivers were predicted to exceed the $L_{Aeq(15hour)}$ (day time) base criterion. The levels of exceedance were predicted to be up to 2 dB.
  - All predicted relative increase in noise levels were less than the prescribed criterion of 12 dB.
- For receivers located adjacent to the proposed upgraded roundabout at Kimilaroi Highway (i.e. where the 'redevelopment' criteria are applicable):
  - Predicted noise levels at all three selected representative receivers were within the prescribed day and night time base criteria.
  - The proposed roundabout to replace the existing Kimilaroi Highway and Warrabungle Street intersection was not predicted to cause significant noise impact with the predicted relative increase in noise levels all less than 2.0 dB.
- Based on the findings as presented above, it was determined that further consideration of mitigation measures is required for two properties, namely: 1/2-6 Warrabungle Street and 3 Warrabungle Street.

The most reasonable and feasible mitigation option for the identified two (2) properties is considered to be property treatments as outlined in **Section 5.5**.

7.2 Construction

The construction noise impact assessment has been undertaken in accordance with the *Interim Construction Noise Guideline* (ICNG). The following findings were made:

- The highest impacts are predicted during Stage 1 impact piling, with worst exceedances of the NMLs of up to 36 dB at Warrabungle Street. It is noted the use of auger or bored piling techniques would be expected to reduce these exceedances by up to 20 dB.
- For the construction stage when new kerbs and associated infrastructure are constructed at the new and reconfigured roundabouts, the worst exceedances of the NMLs of up to 29 dB and 18 dB were predicted at Warrabungle Street and Kimilaroi Highway roundabout respectively.
- For the remaining construction stages, the primary noise impacts are confined to the Warrabungle Street residences, with exceedances of up to 13 dB for precast placement, up to 17 dB for concreting and up to 28 dB during finishing.

These exceedances are a direct result of the close proximity of residences and the nature of the works.

Recommended construction noise mitigation measures are detailed within this report. These are particularly important and should be considered when receivers are highly affected (eg impact piling, new kerbs construction and finishing operations).

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is 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 L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-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 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA 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

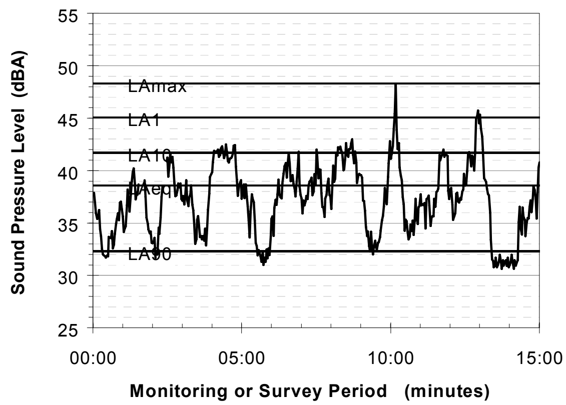
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to 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 L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} 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:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} 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.

L_{Aeq} 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.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

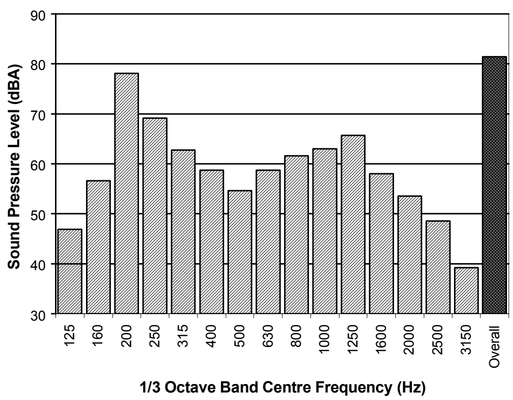
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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 (3 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.



8 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. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) 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/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 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.

10 Over-Pressure

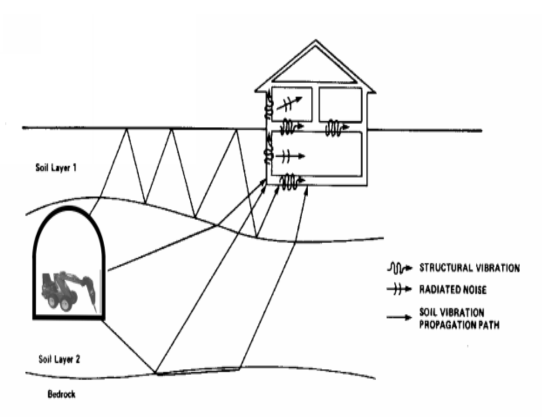
The term ‘over-pressure’ is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 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.

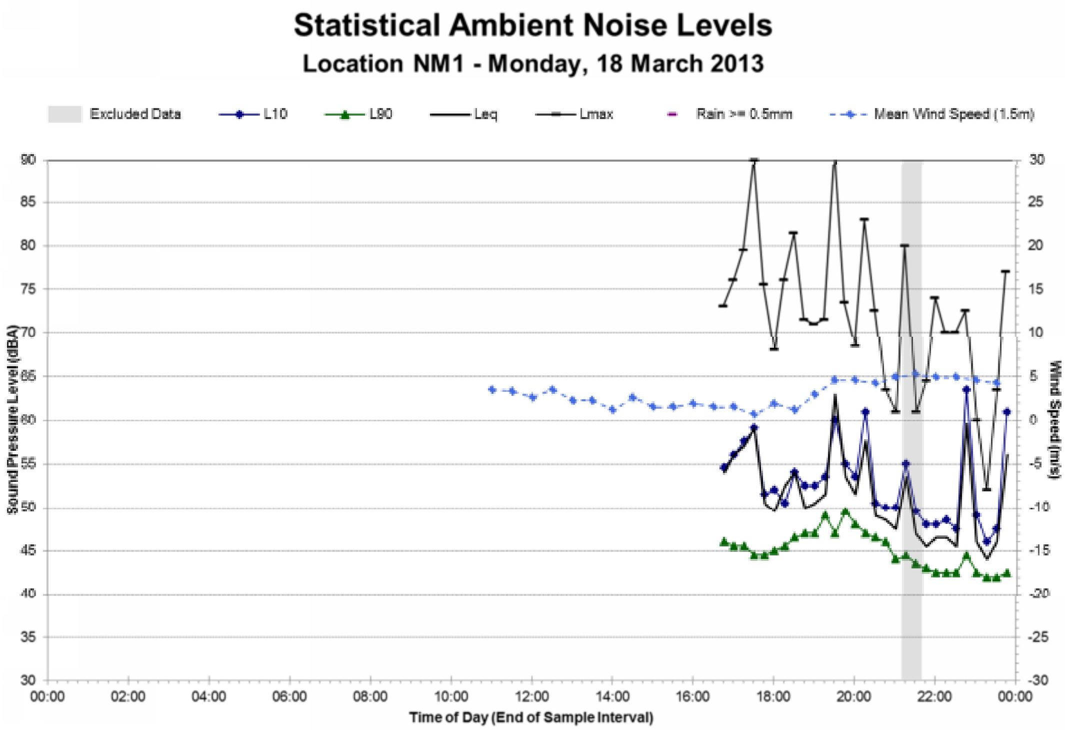
Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

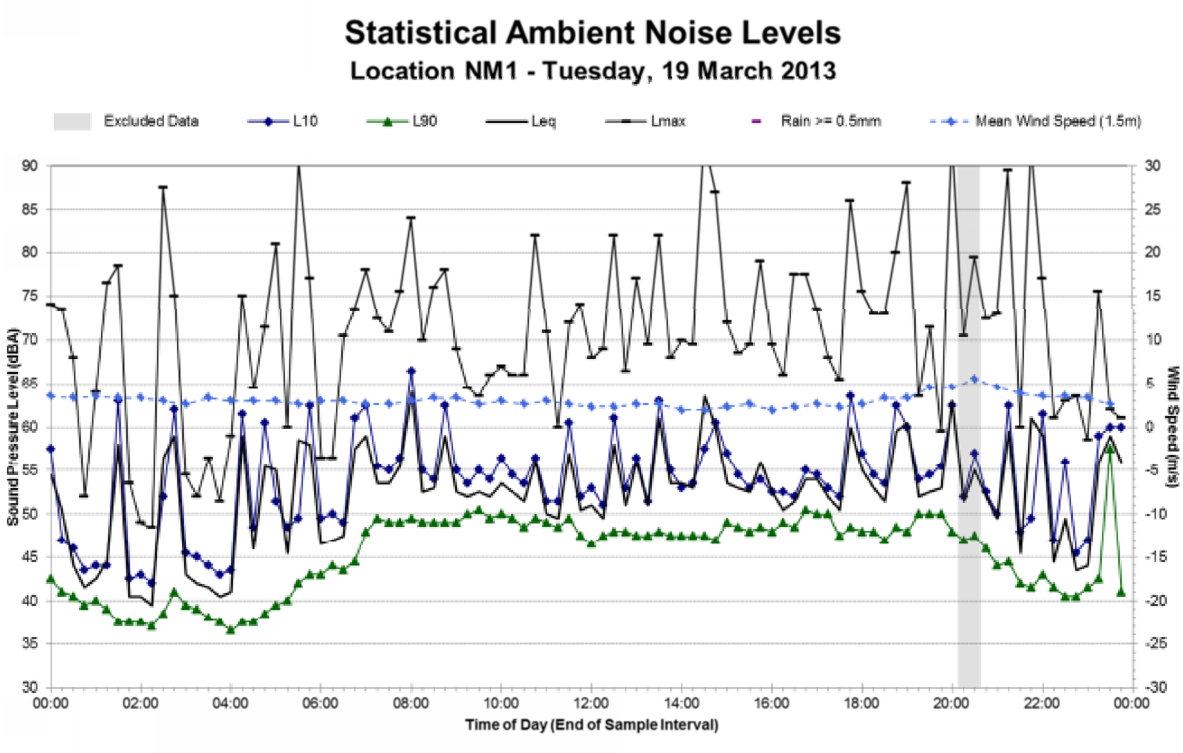
The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



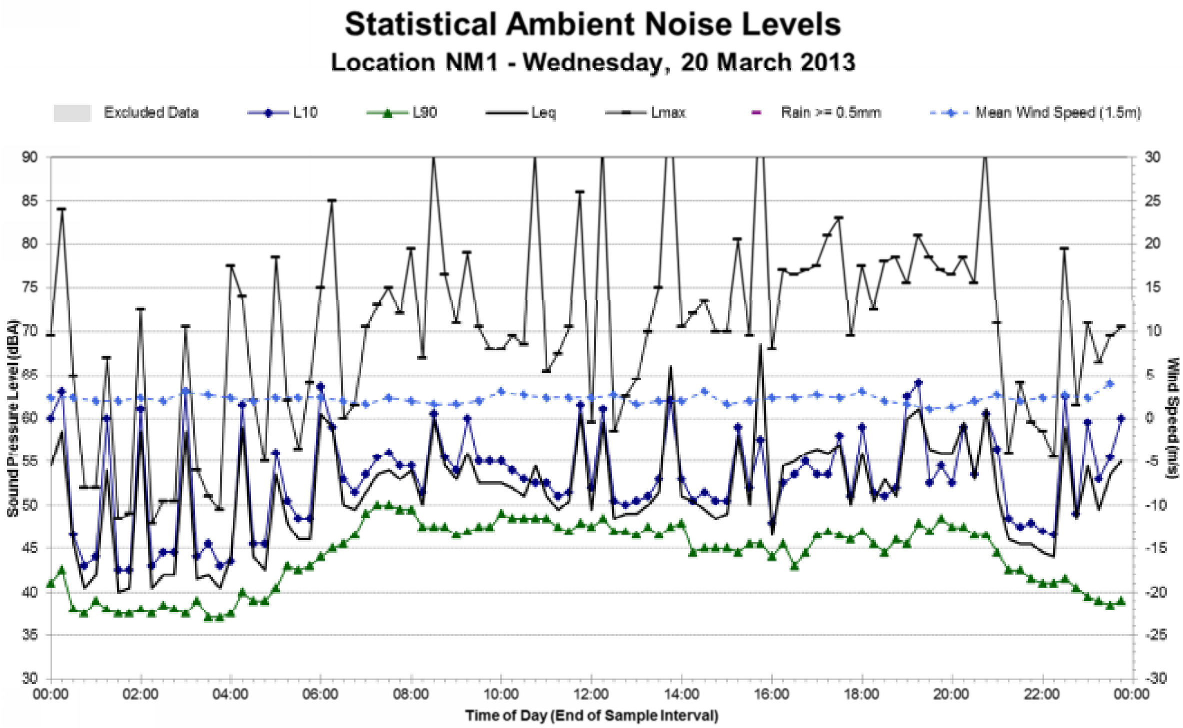
The term ‘regenerated noise’ is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect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

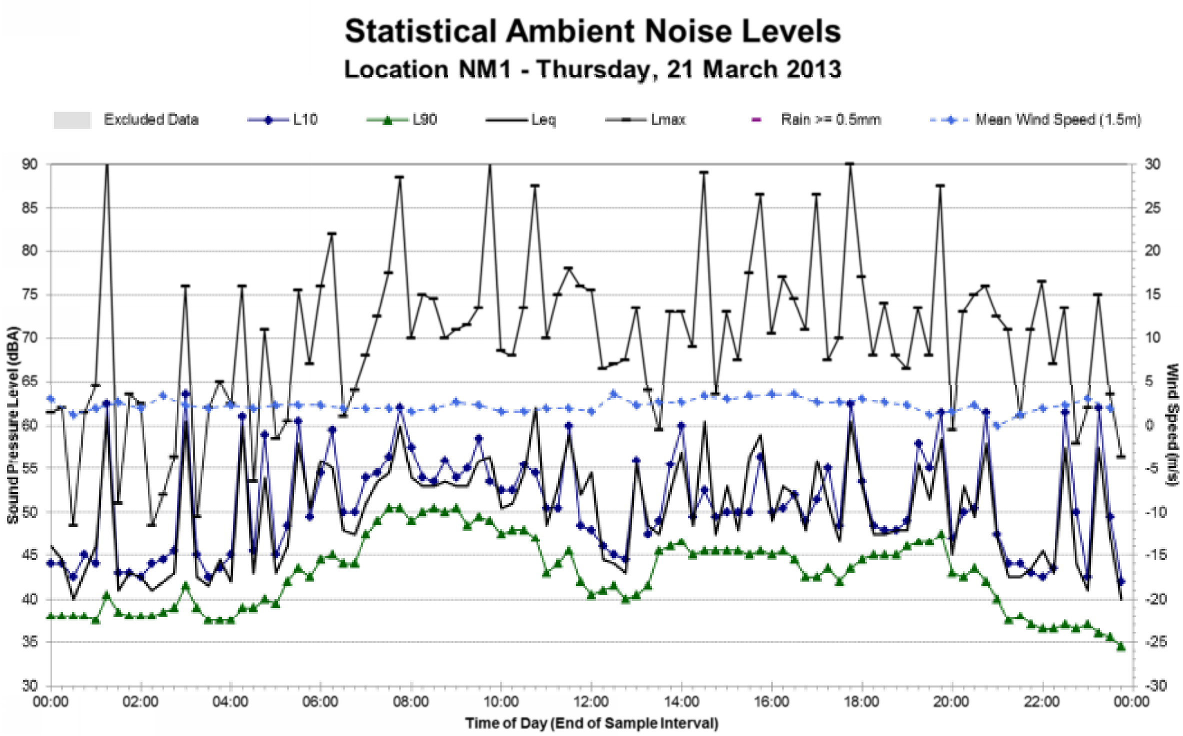
NM1 – 9 STOCKMEN CLOSE





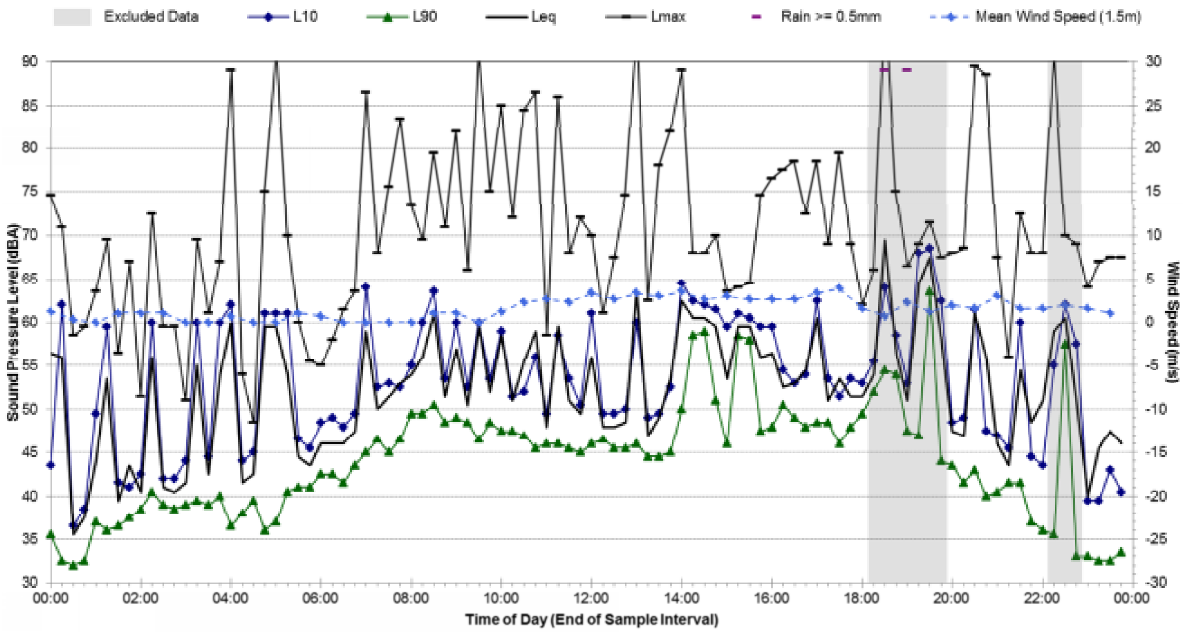
Ambient Noise Monitoring Results





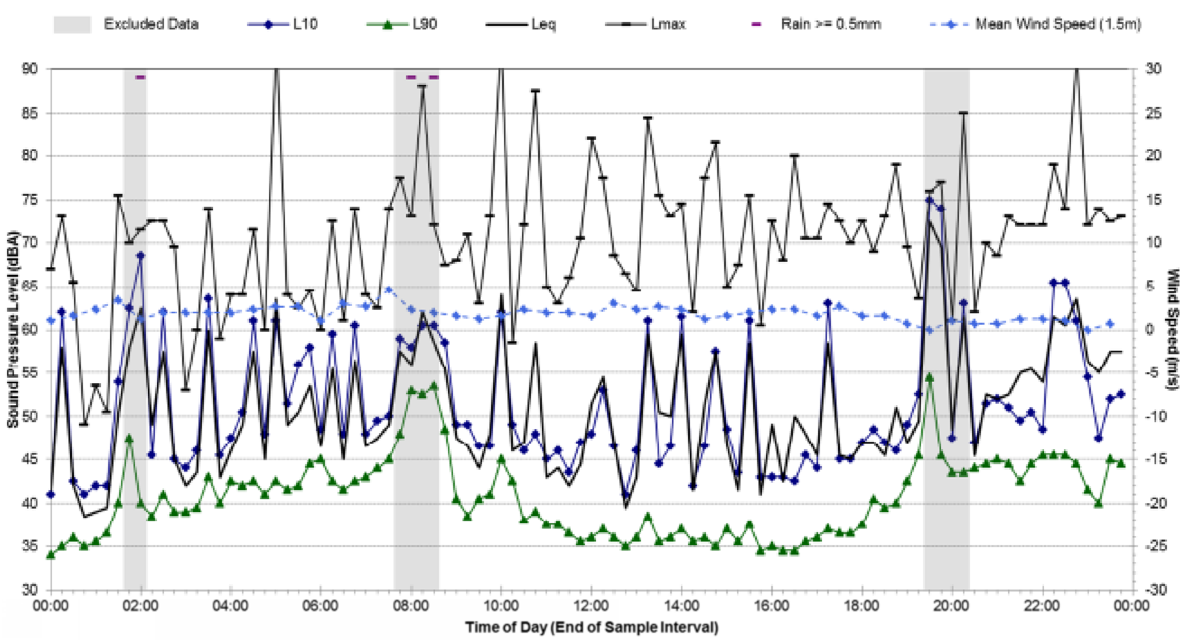
Statistical Ambient Noise Levels

Location NM1 - Friday, 22 March 2013

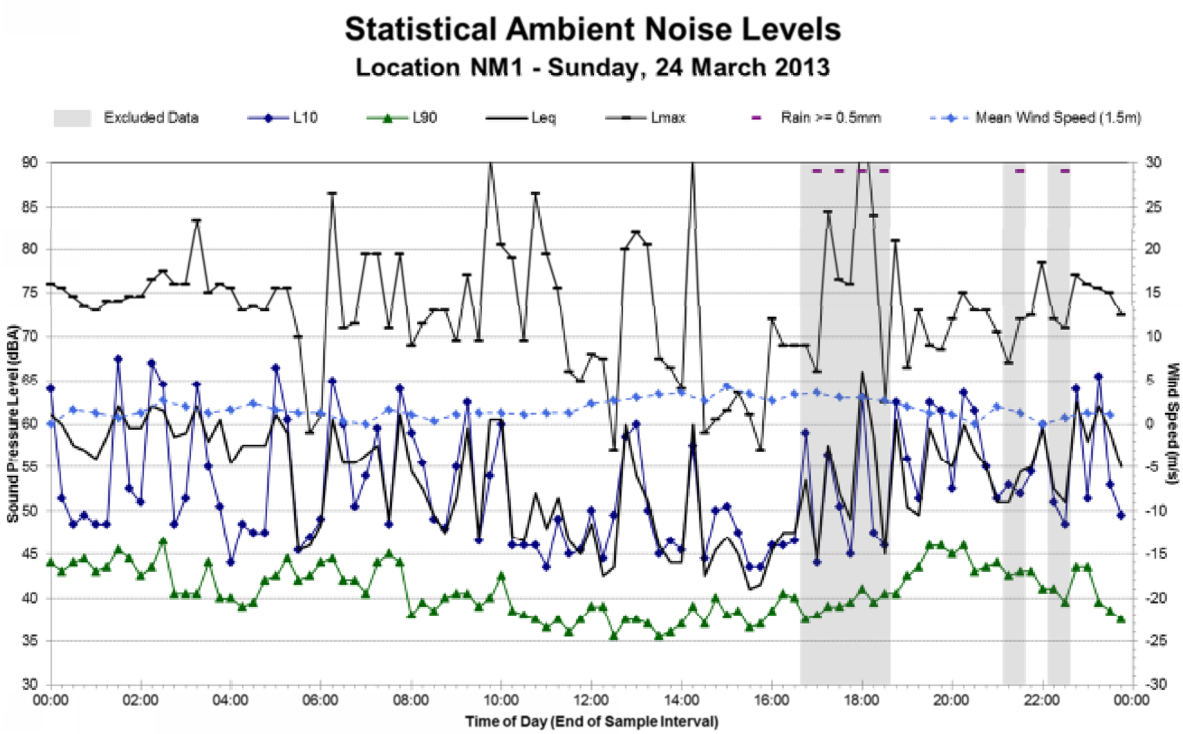


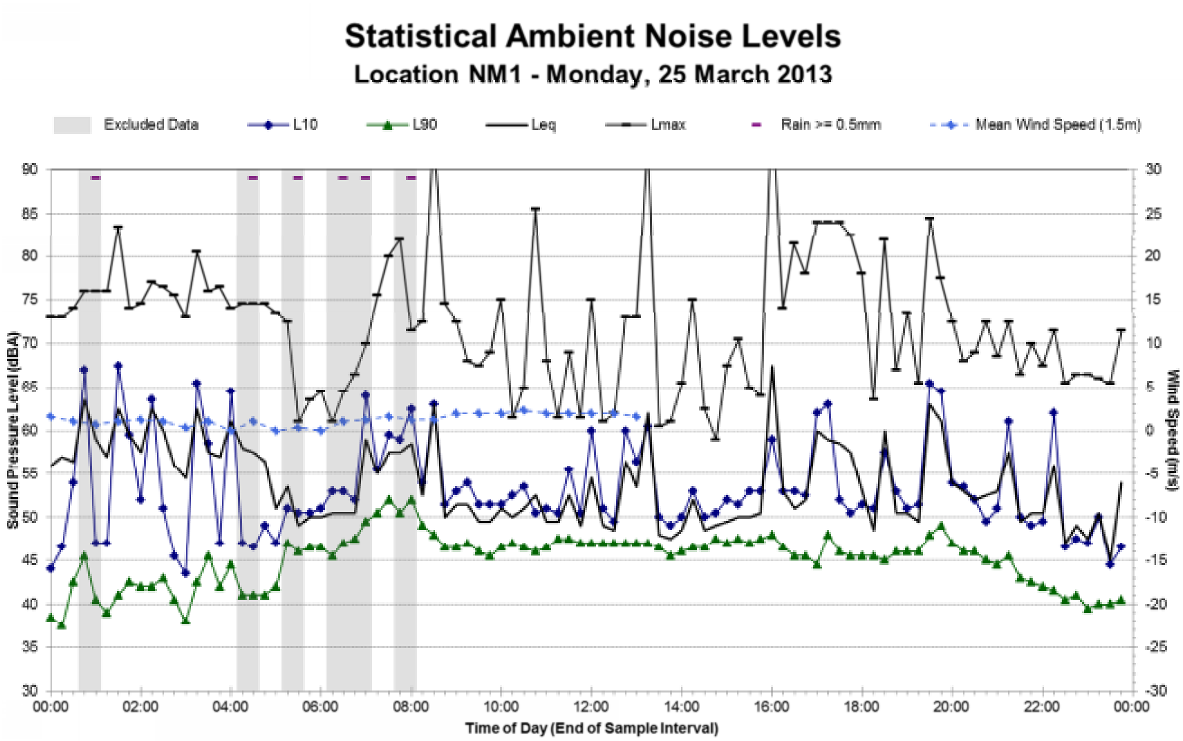
Statistical Ambient Noise Levels

Location NM1 - Saturday, 23 March 2013

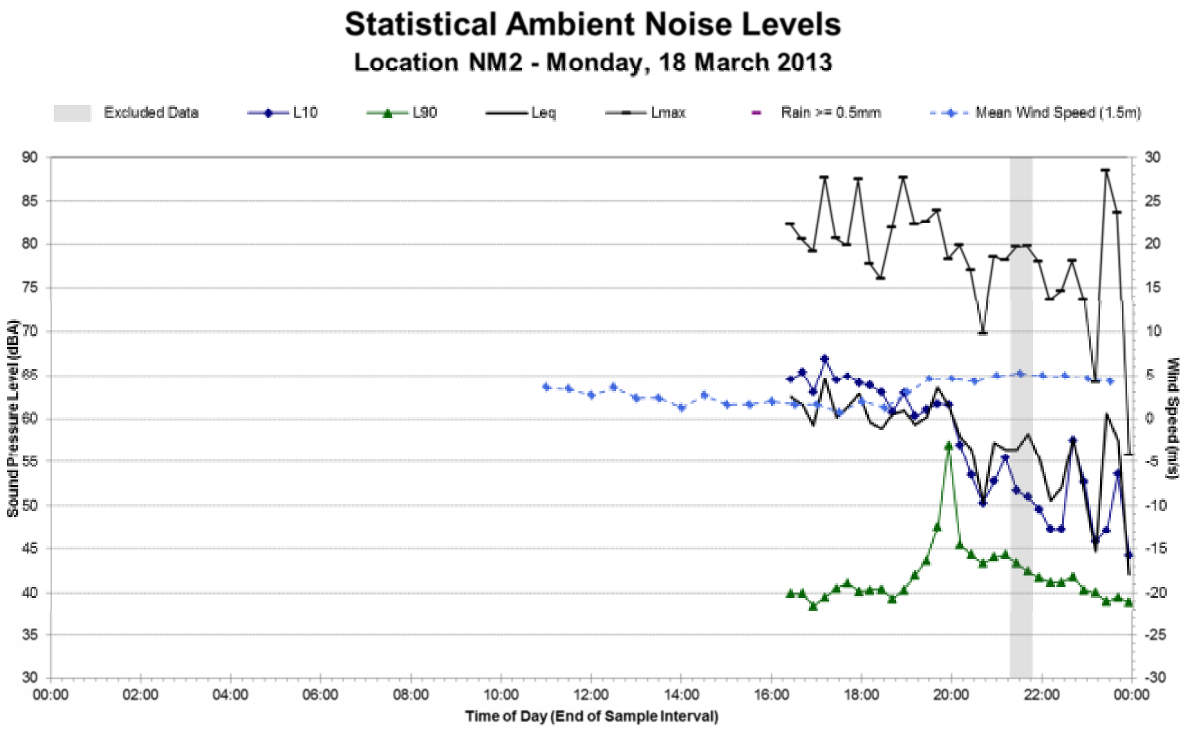


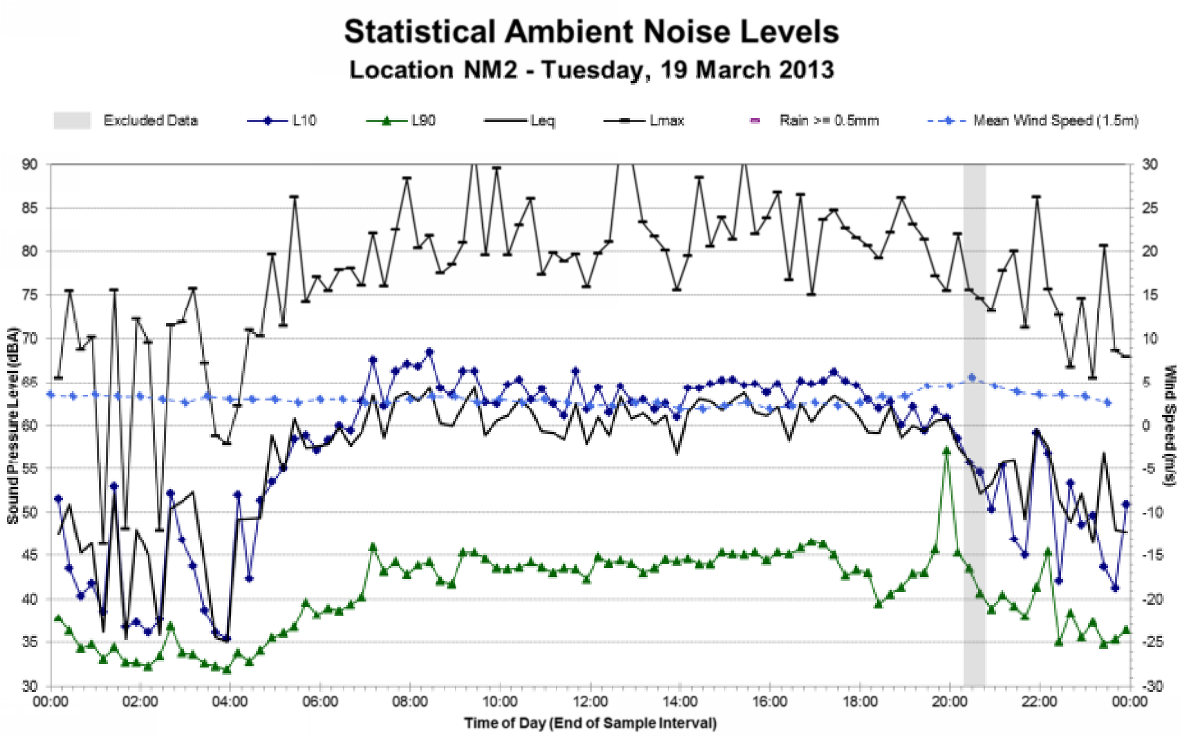
Ambient Noise Monitoring Results

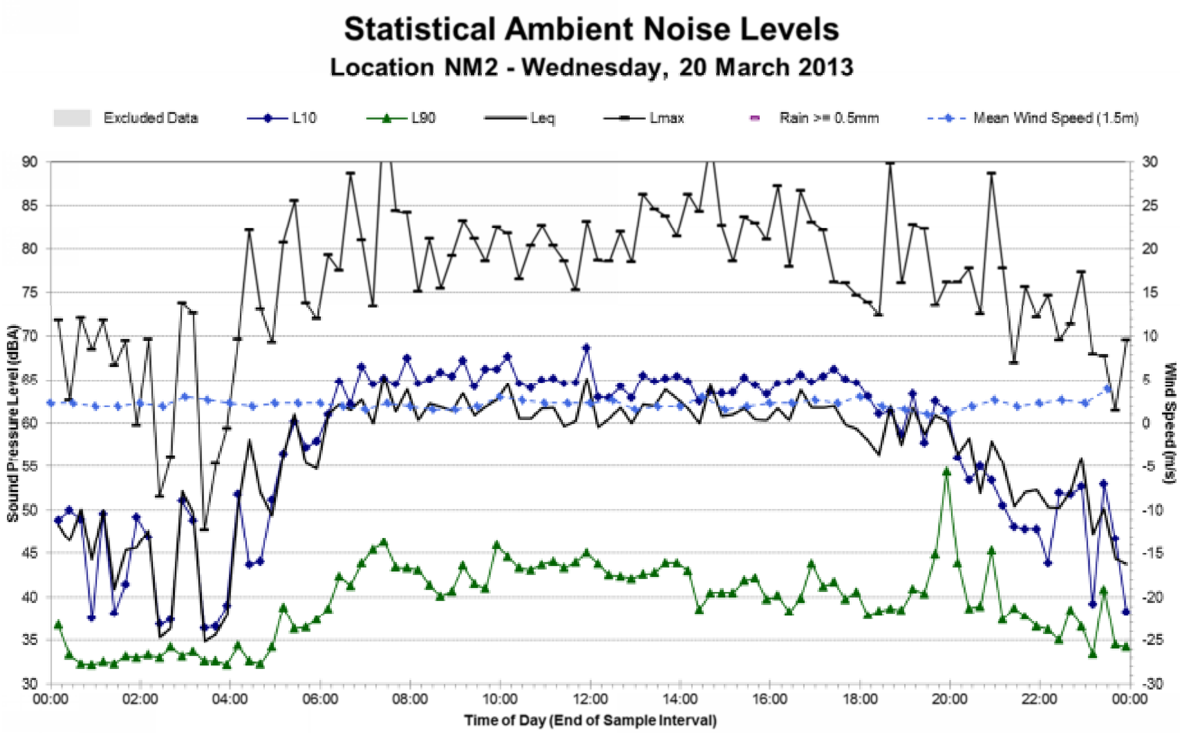




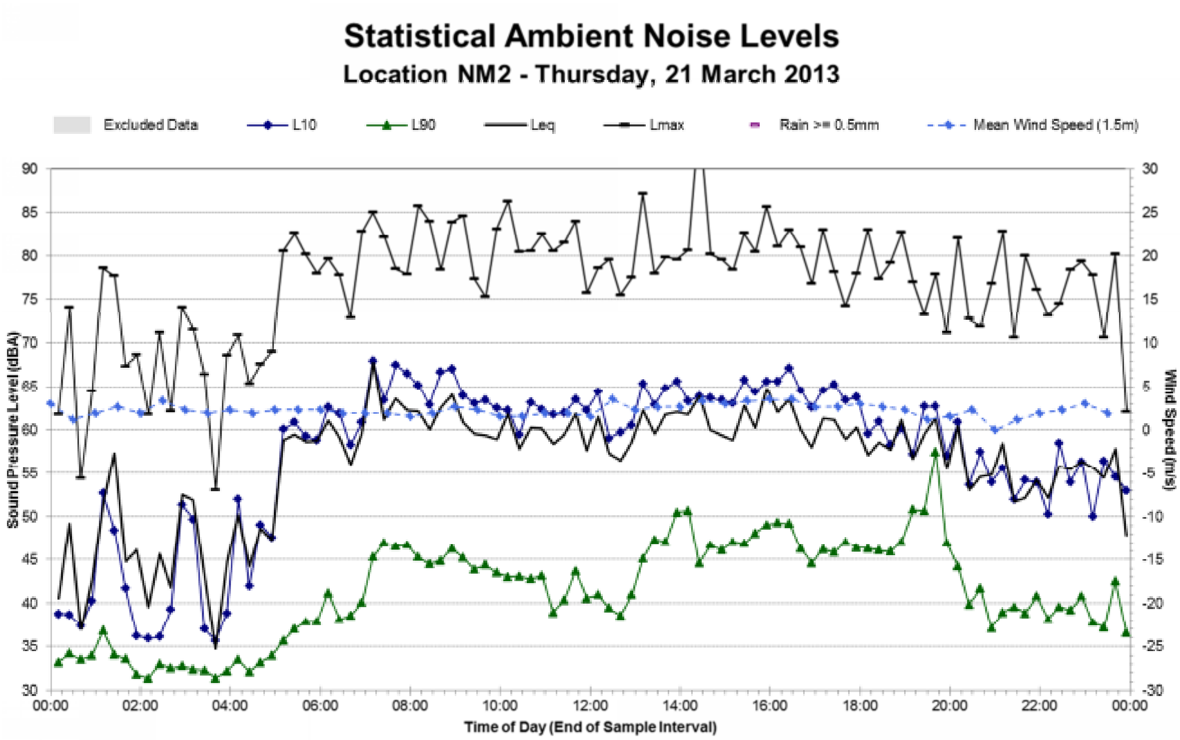
NM2 – 1 LITTLE BARBER STREET





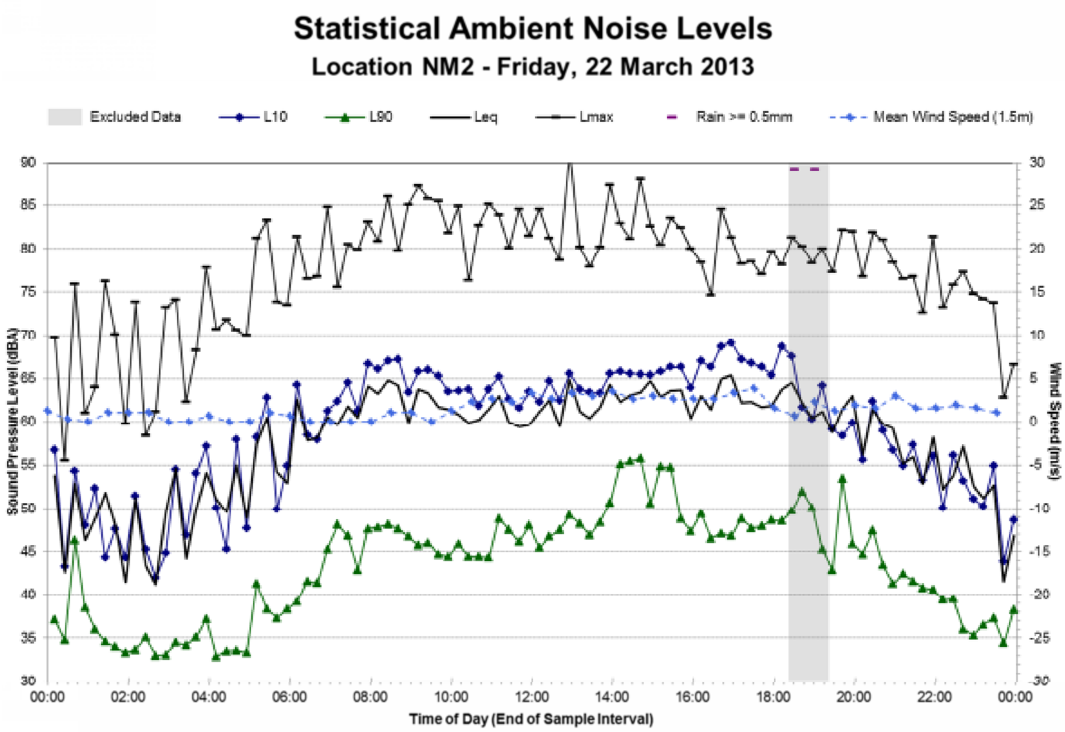


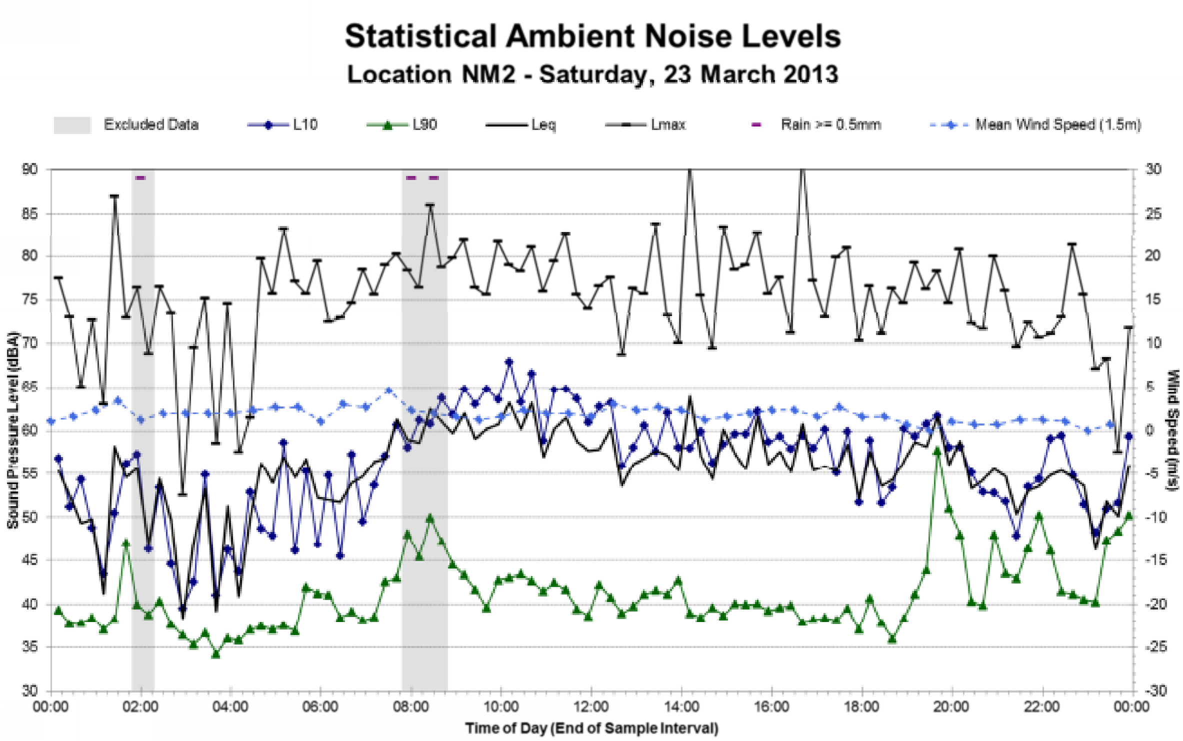
Statistical Ambient Noise Levels
Location NM2 - Wednesday, 20 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



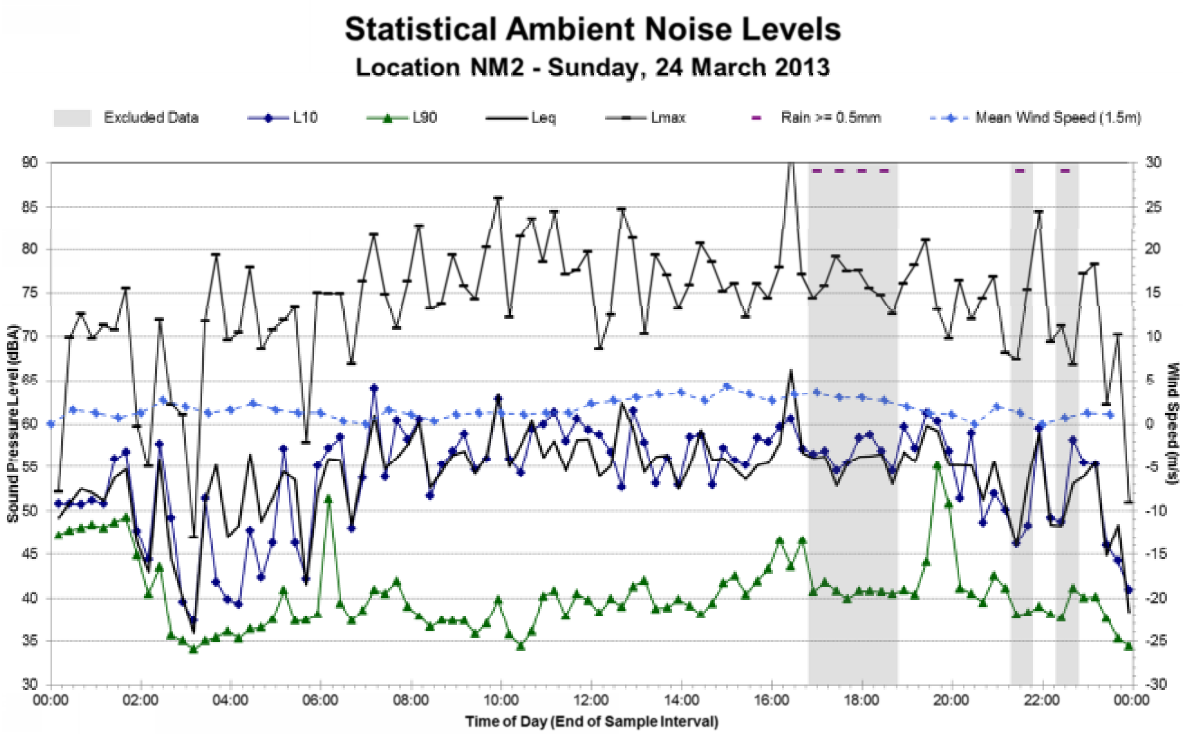
Statistical Ambient Noise Levels
Location NM2 - Thursday, 21 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

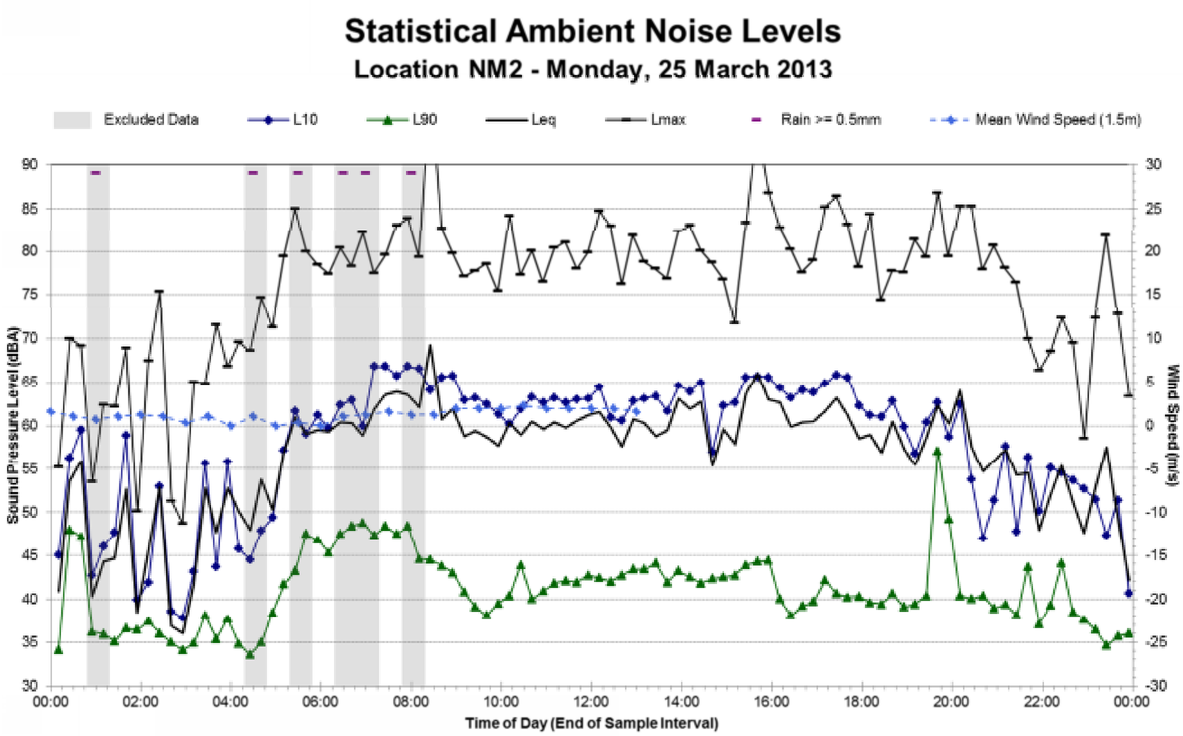
Ambient Noise Monitoring Results

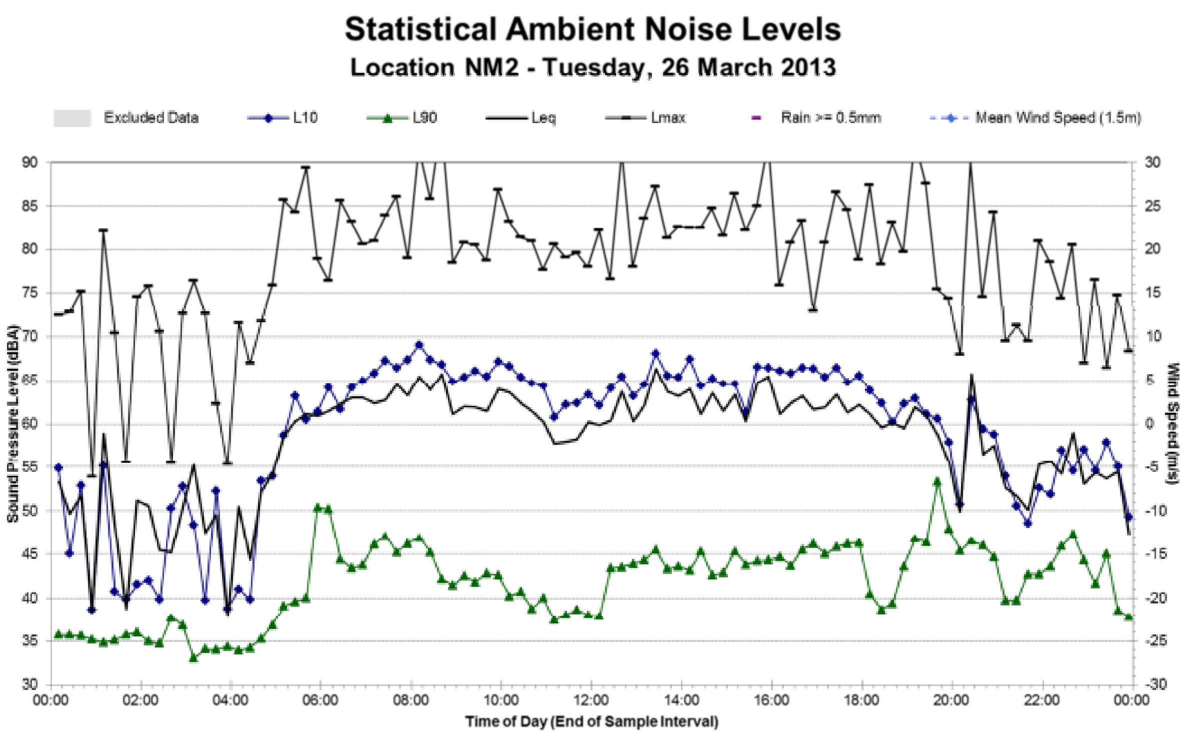


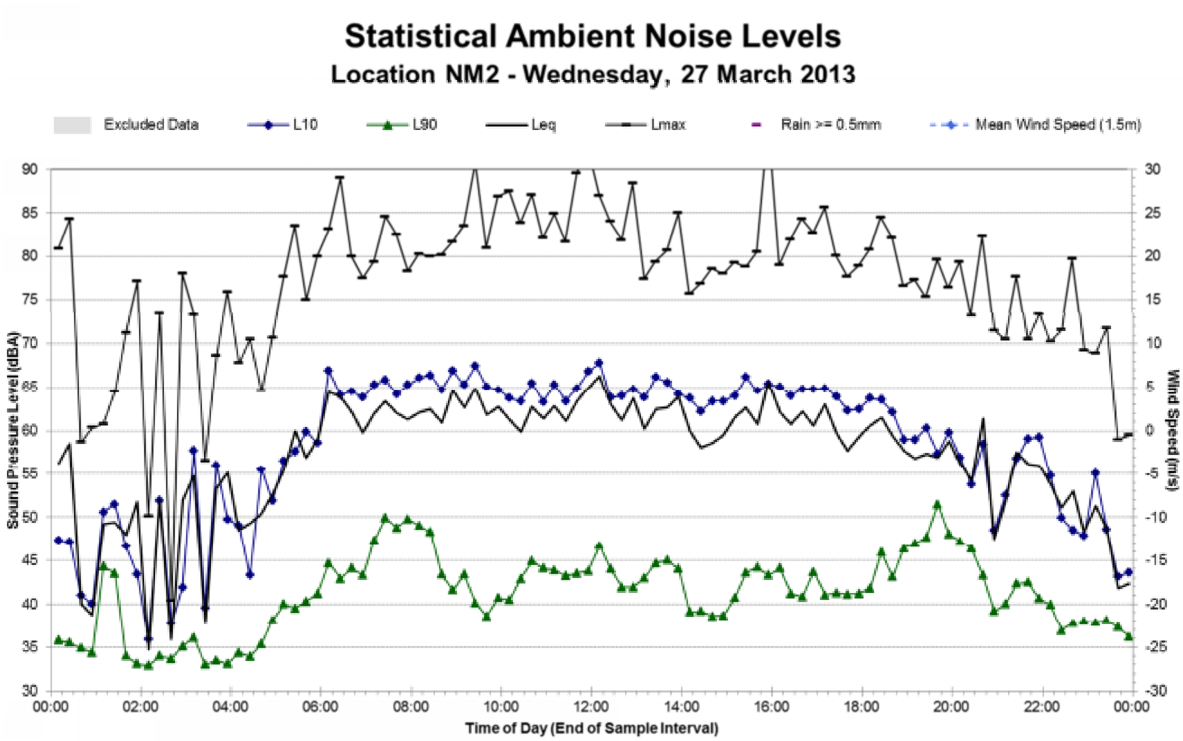


Ambient Noise Monitoring Results

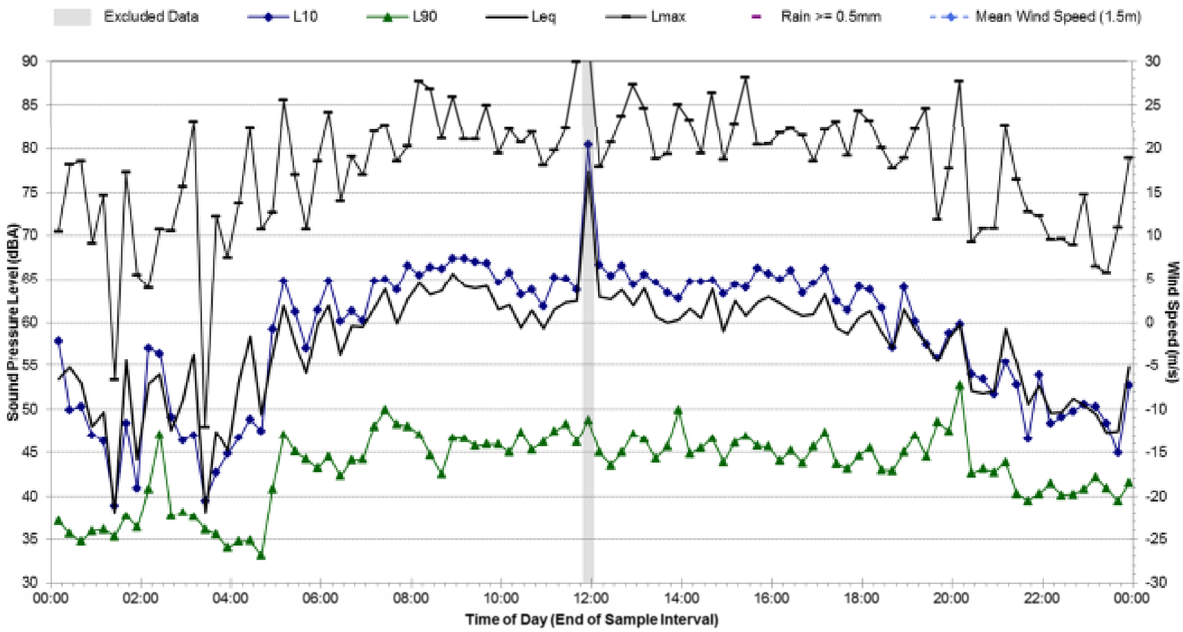




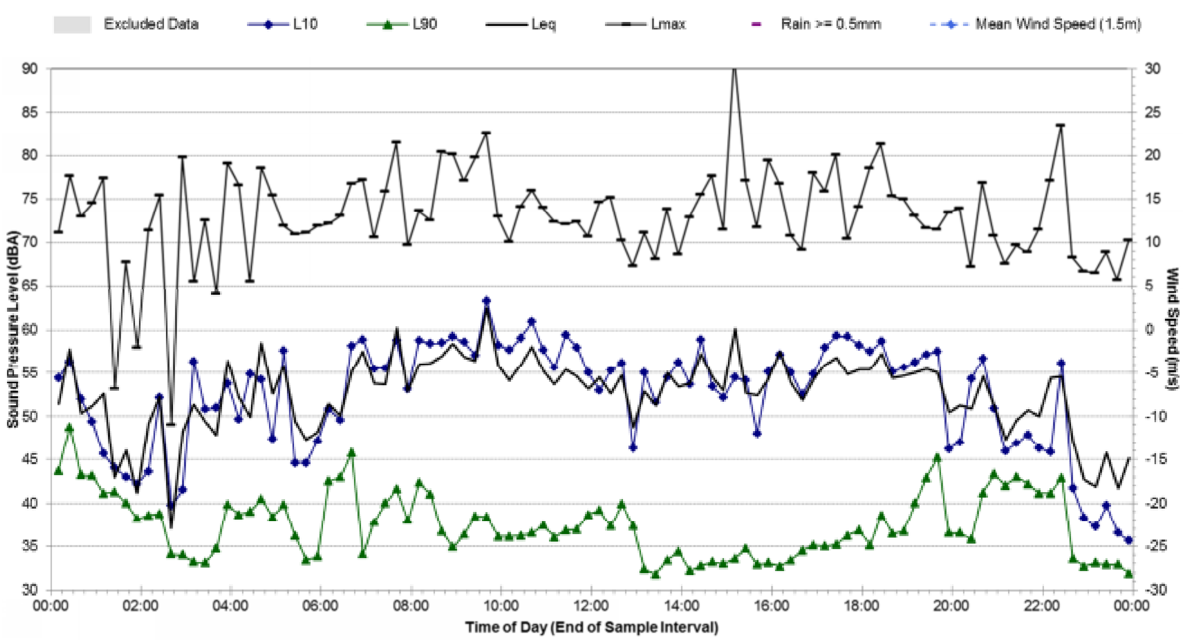

Statistical Ambient Noise Levels
Location NM2 - Tuesday, 26 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

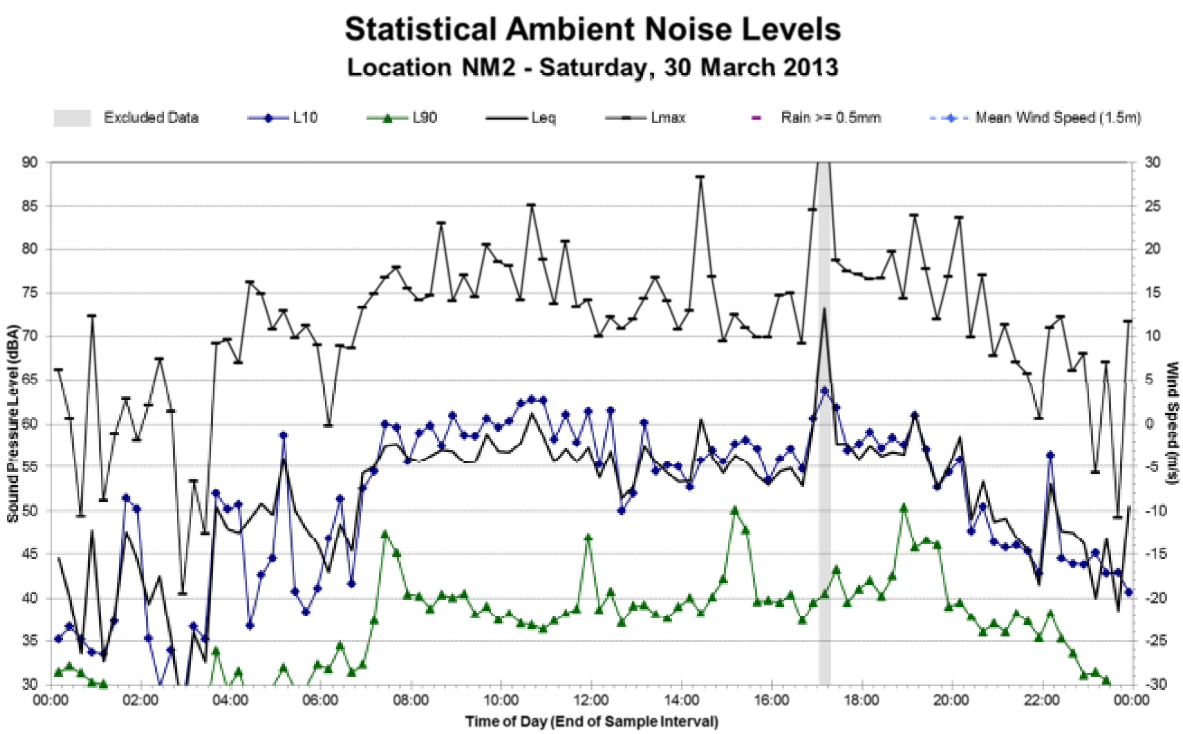

Statistical Ambient Noise Levels
Location NM2 - Wednesday, 27 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

Statistical Ambient Noise Levels
Location NM2 - Thursday, 28 March 2013



Statistical Ambient Noise Levels
Location NM2 - Friday, 29 March 2013




Statistical Ambient Noise Levels
Location NM2 - Saturday, 30 March 2013
Excluded Data
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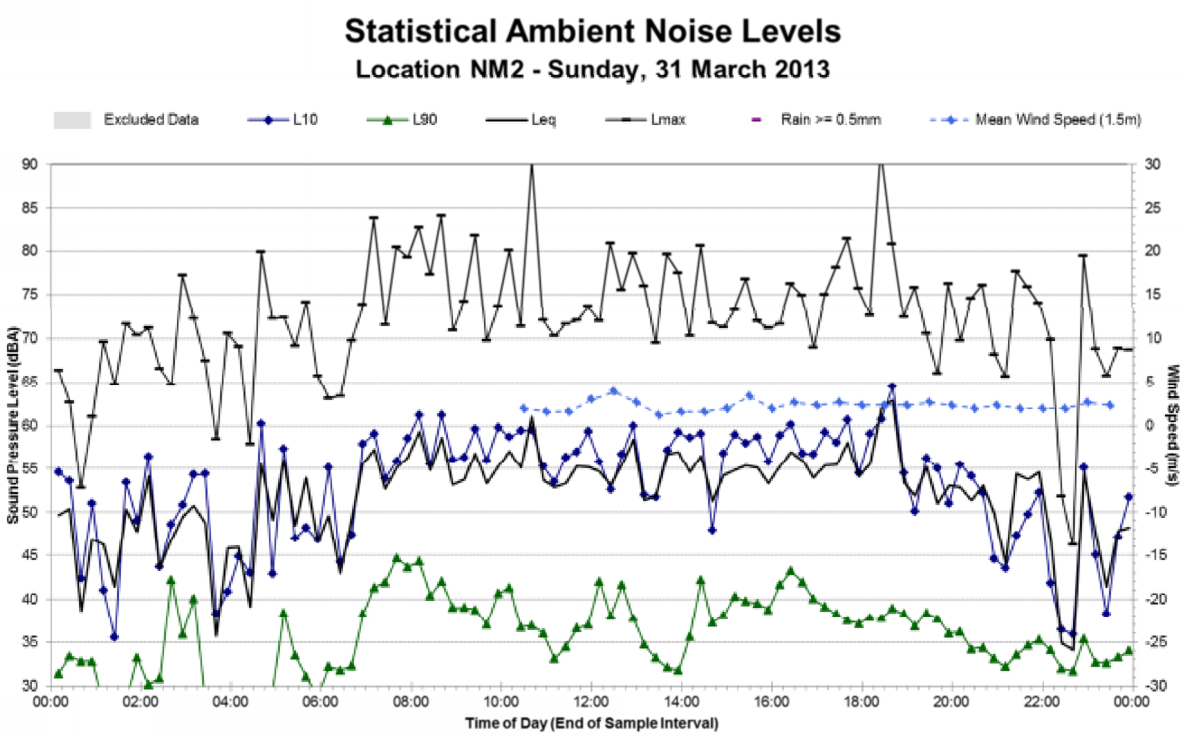
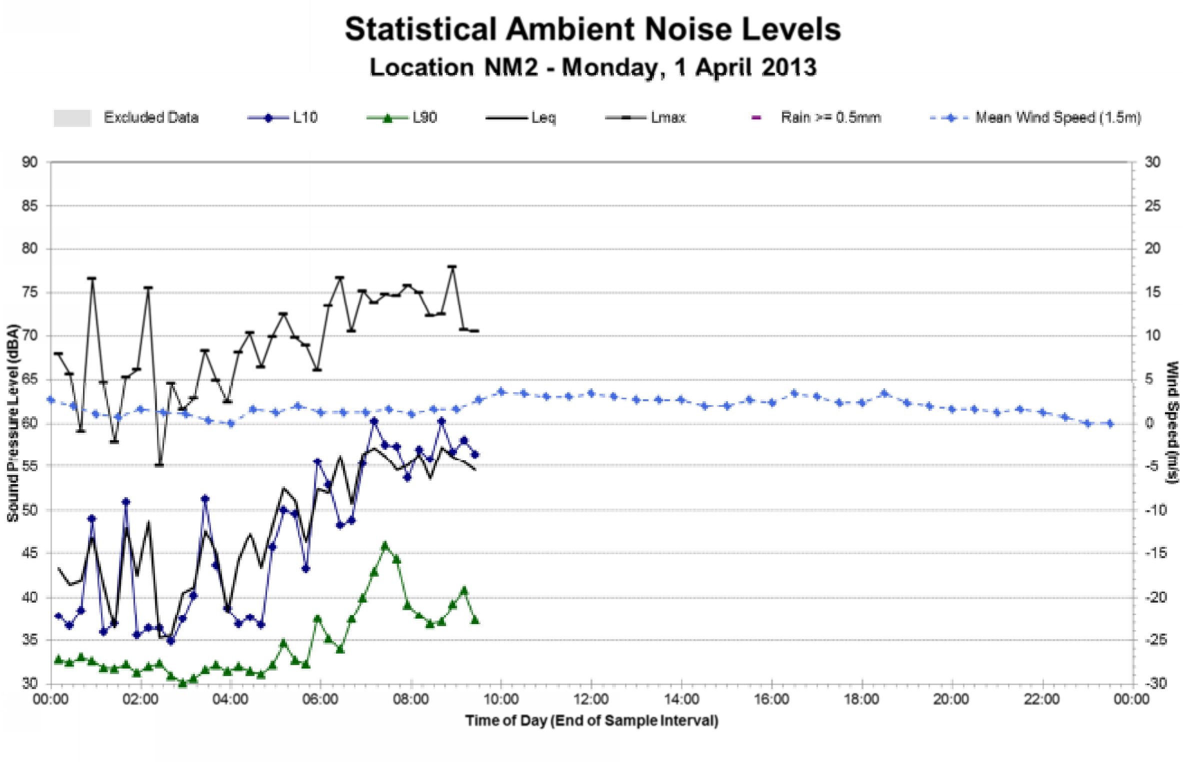
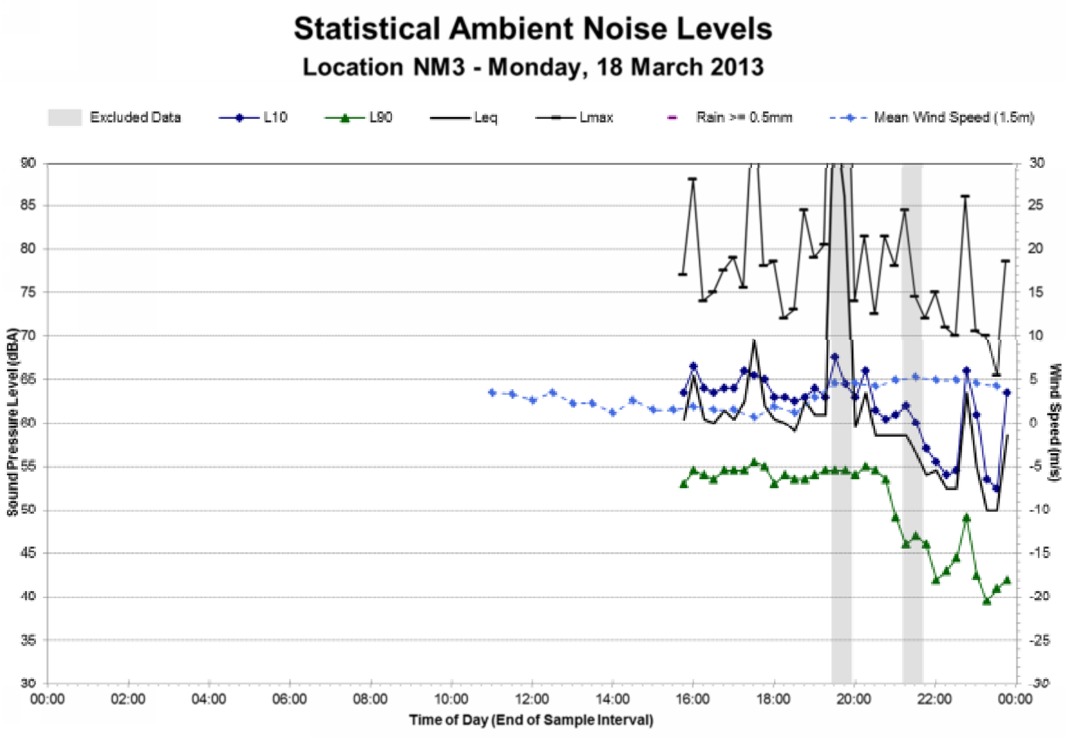
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

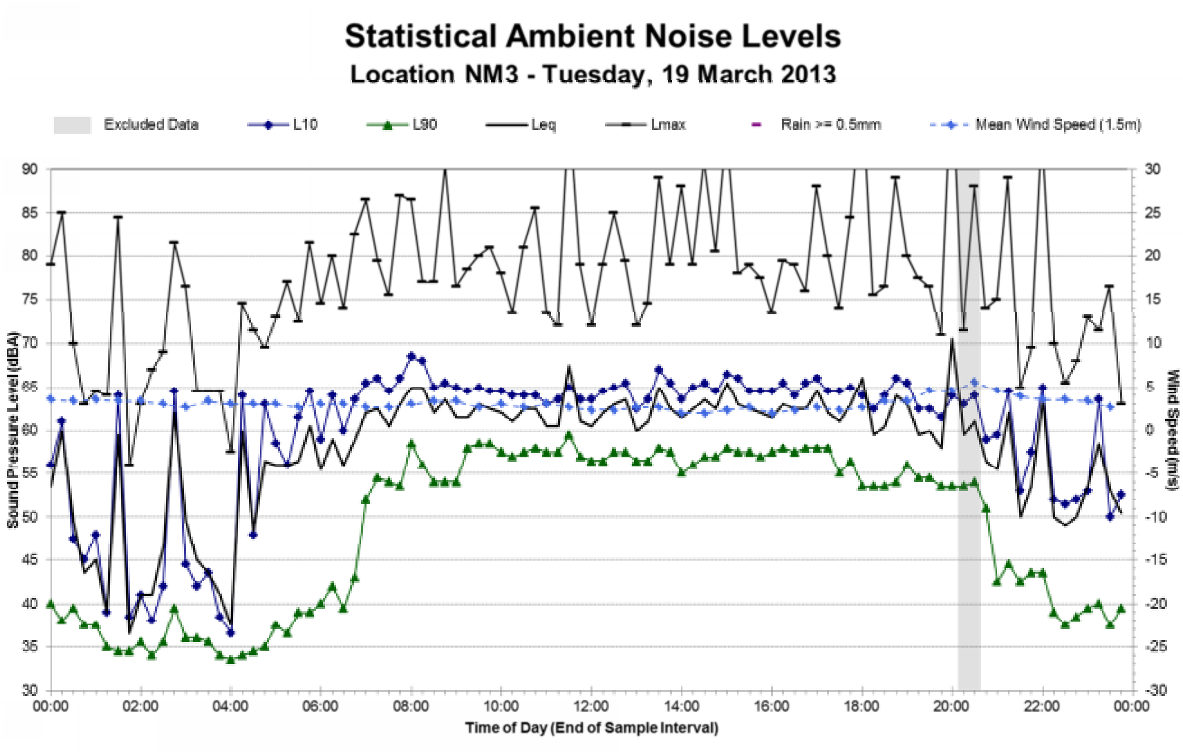

Statistical Ambient Noise Levels
Location NM2 - Sunday, 31 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

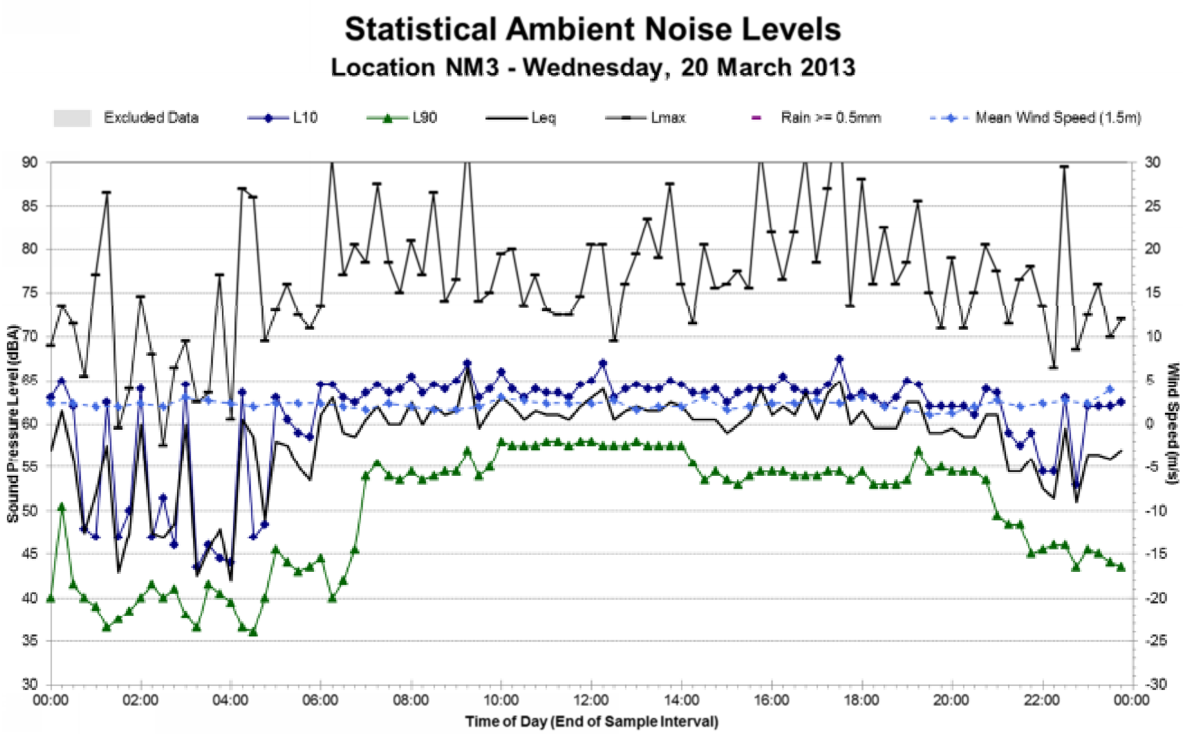
Ambient Noise Monitoring Results



NM3 – 2 RAILWAY AVENUE






Statistical Ambient Noise Levels
Location NM3 - Wednesday, 20 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
00:00
02:00
04:00
06:00
08:00
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12:00
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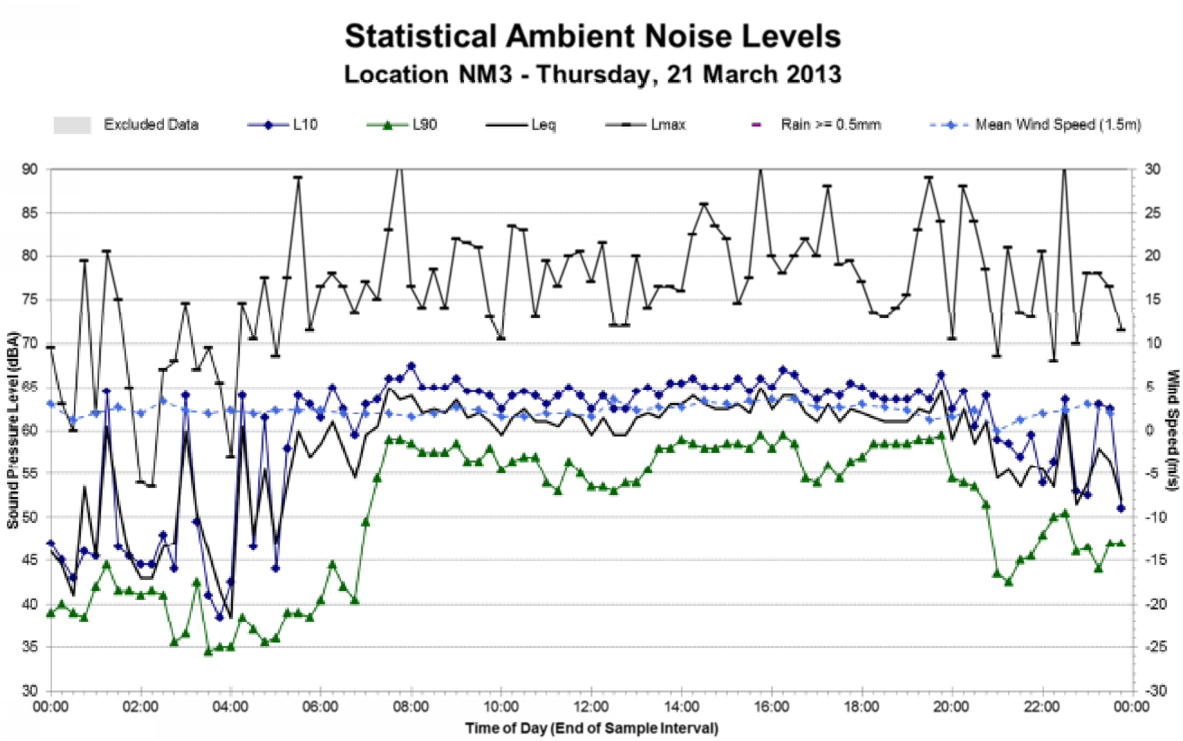
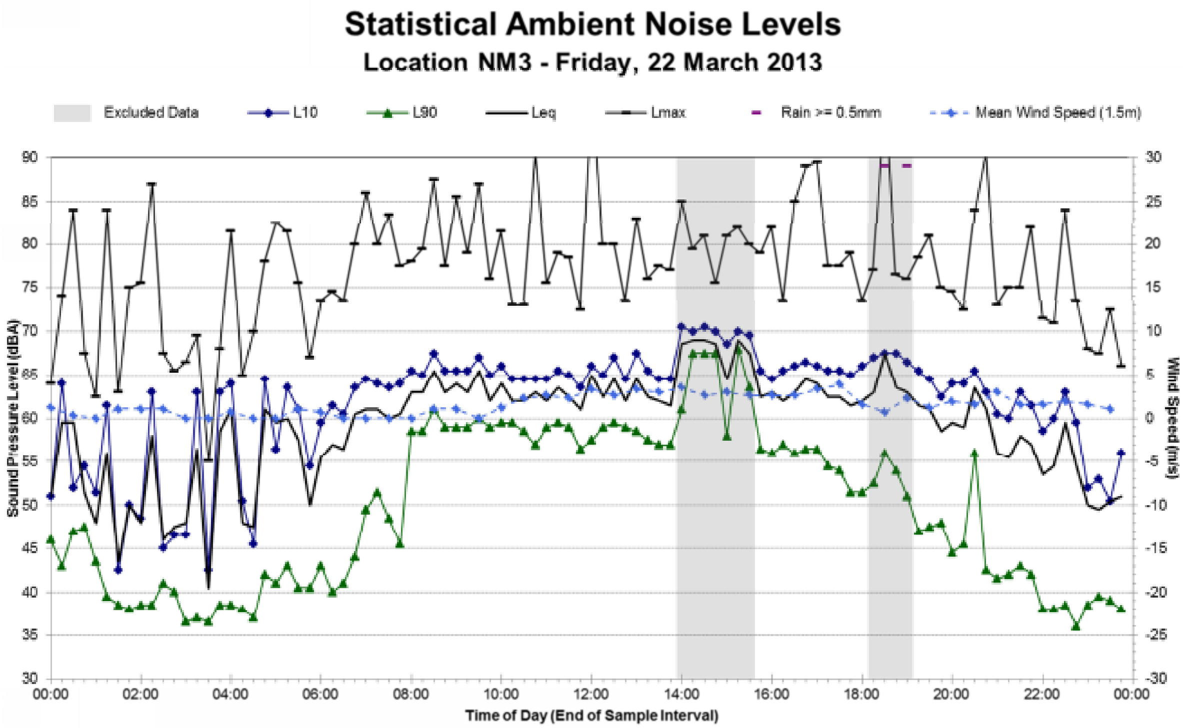
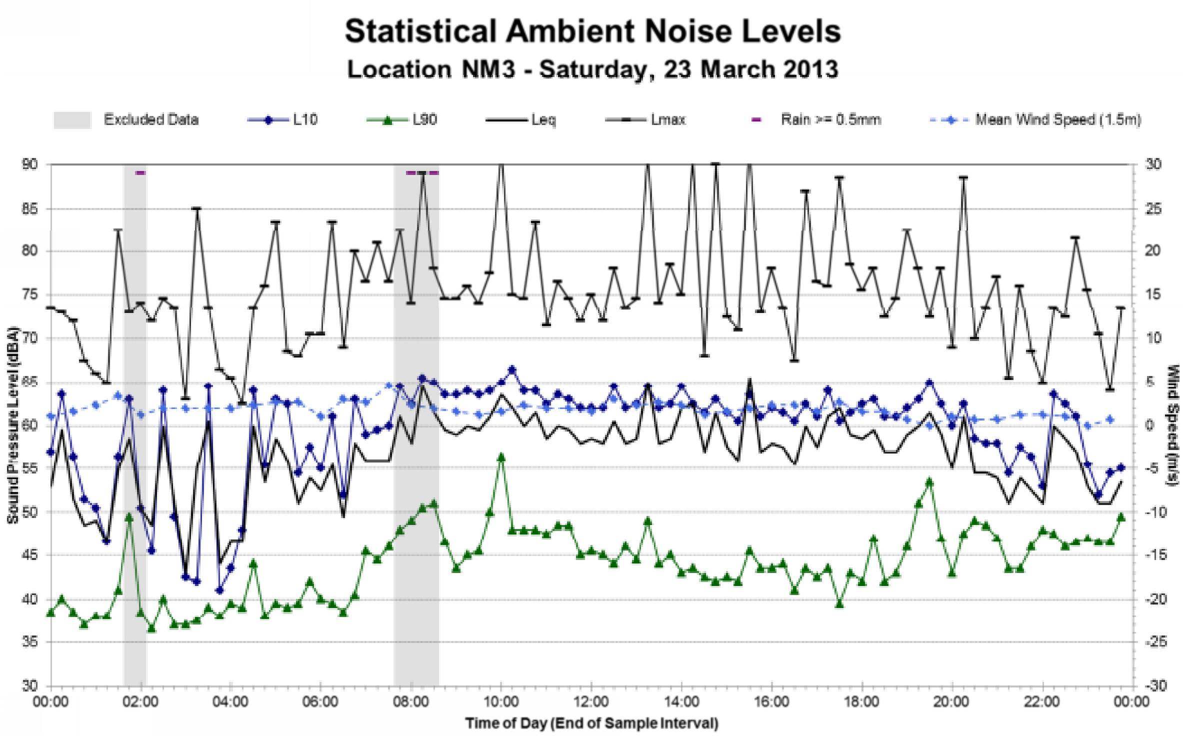
16:00
18:00
20:00
22:00
00:00


Statistical Ambient Noise Levels
Location NM3 - Thursday, 21 March 2013
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

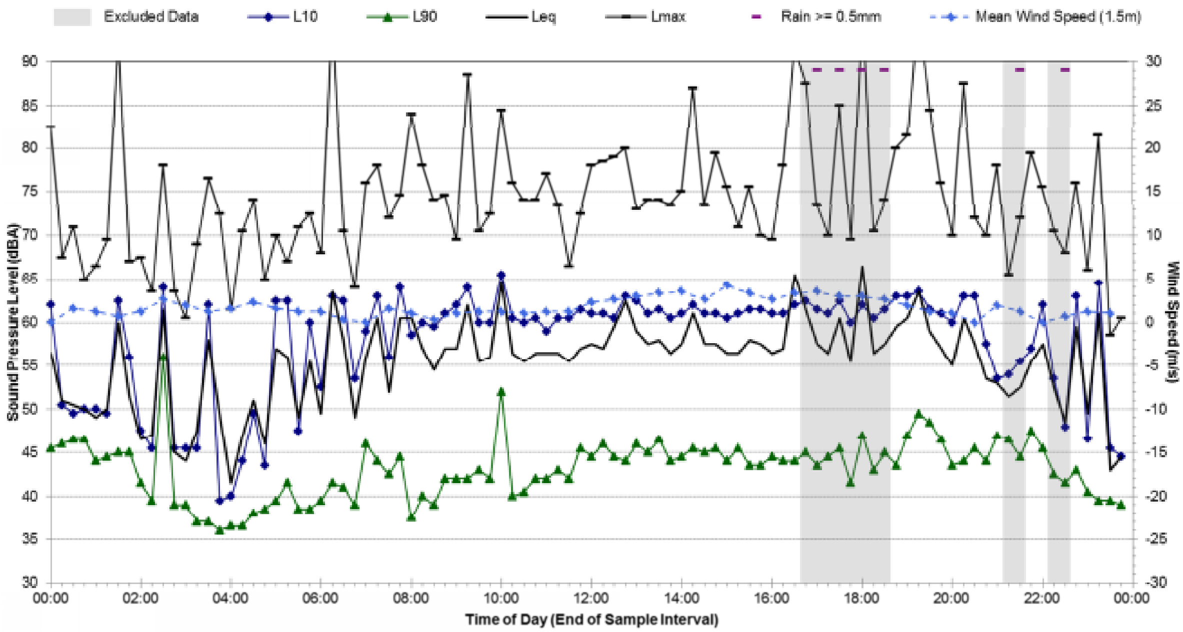
Ambient Noise Monitoring Results





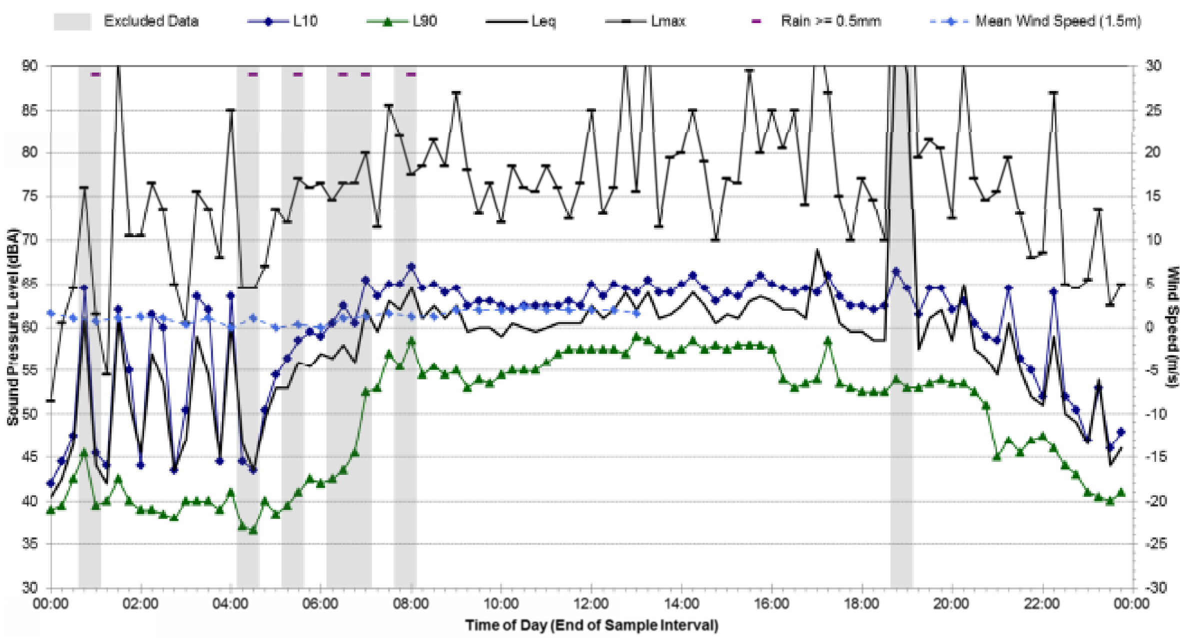
Statistical Ambient Noise Levels

Location NM3 - Sunday, 24 March 2013

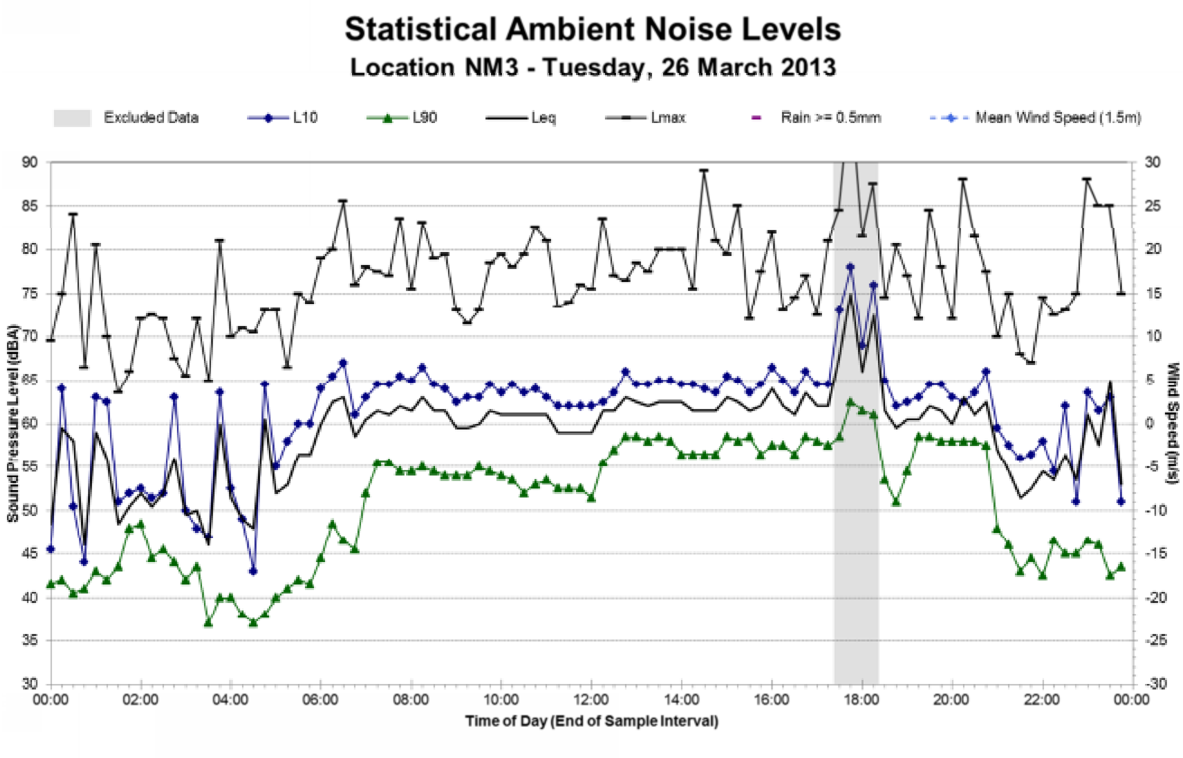


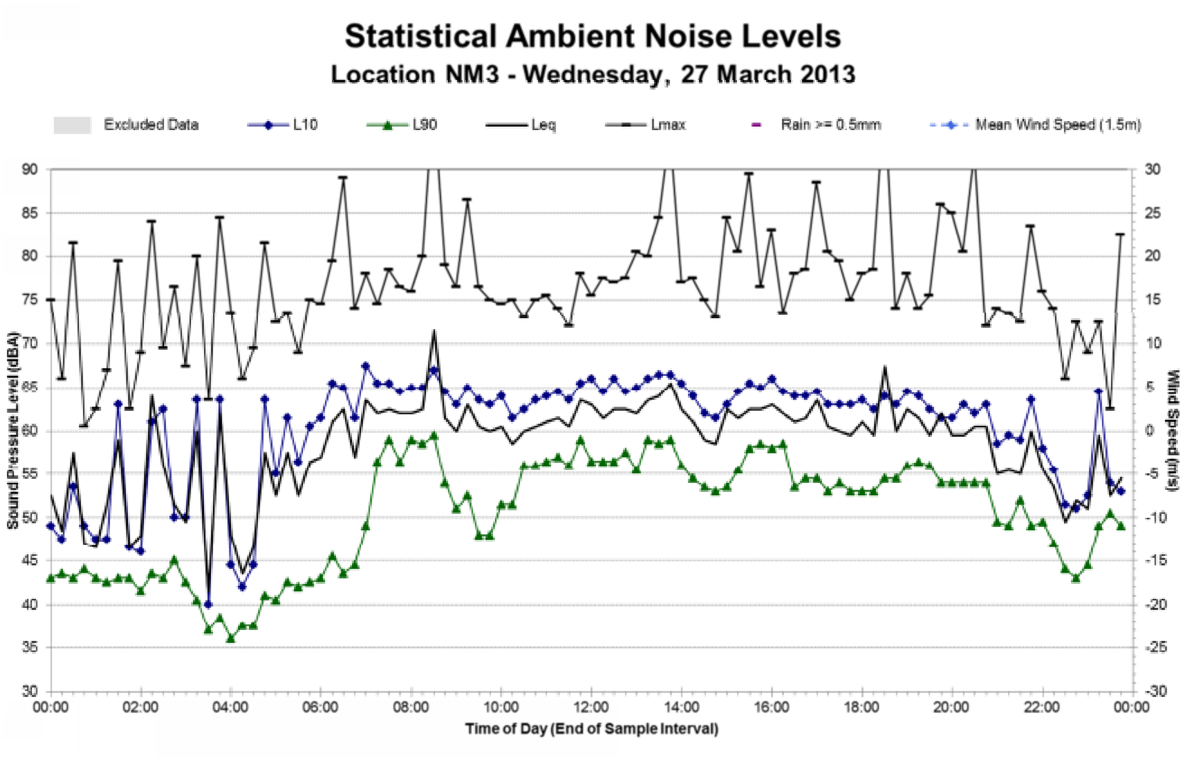
Statistical Ambient Noise Levels

Location NM3 - Monday, 25 March 2013

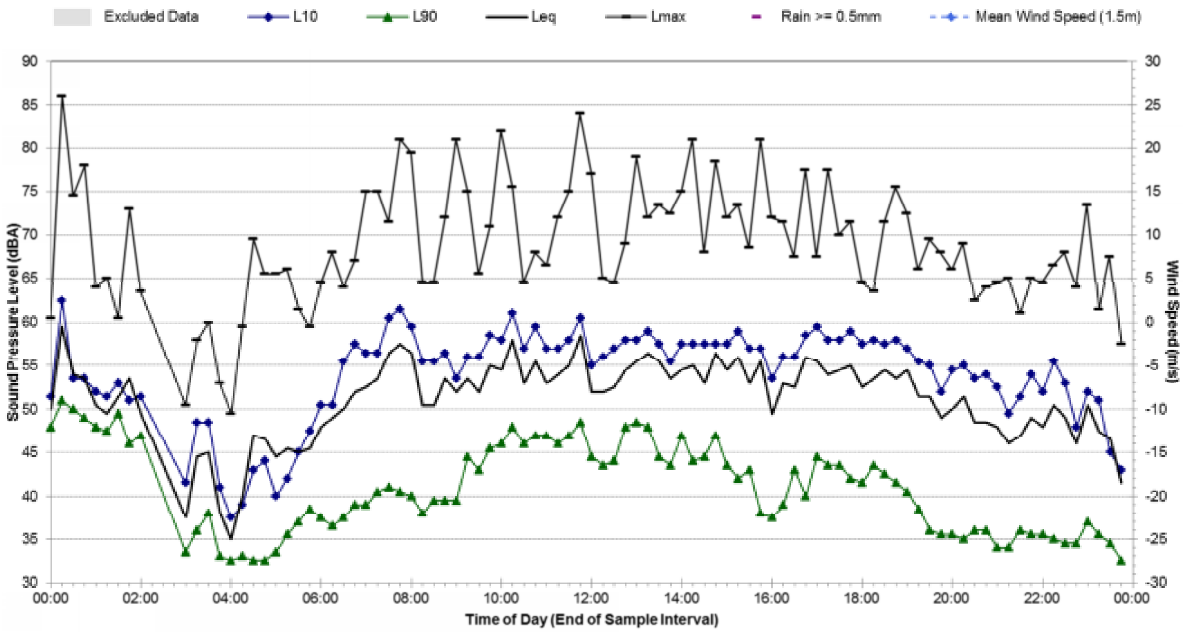


Ambient Noise Monitoring Results

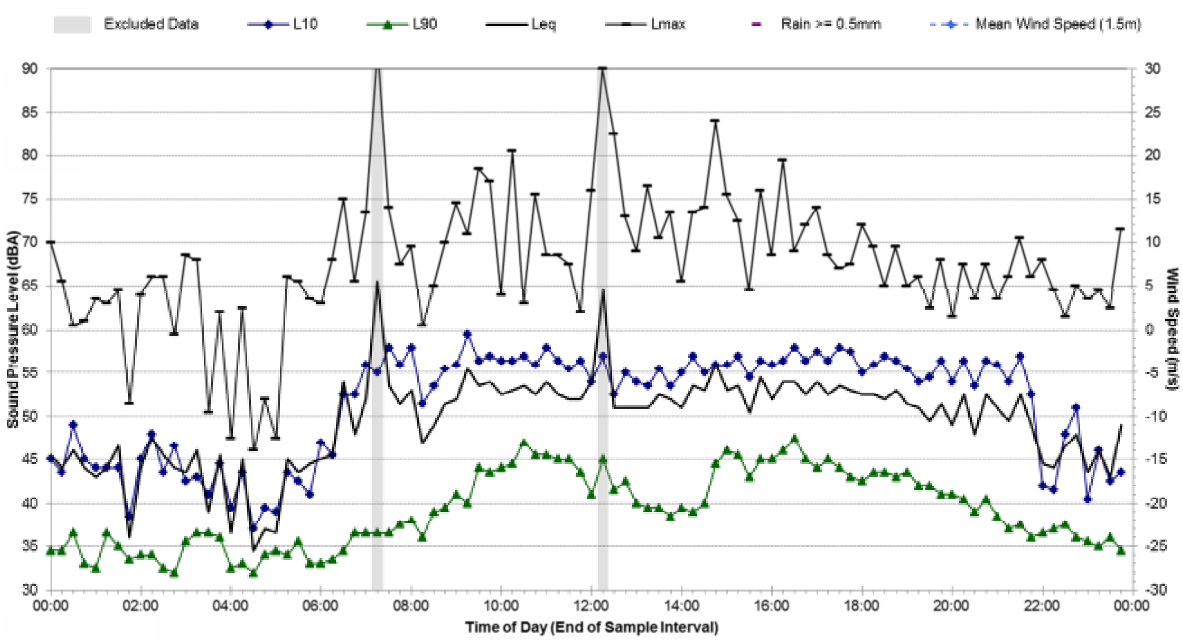




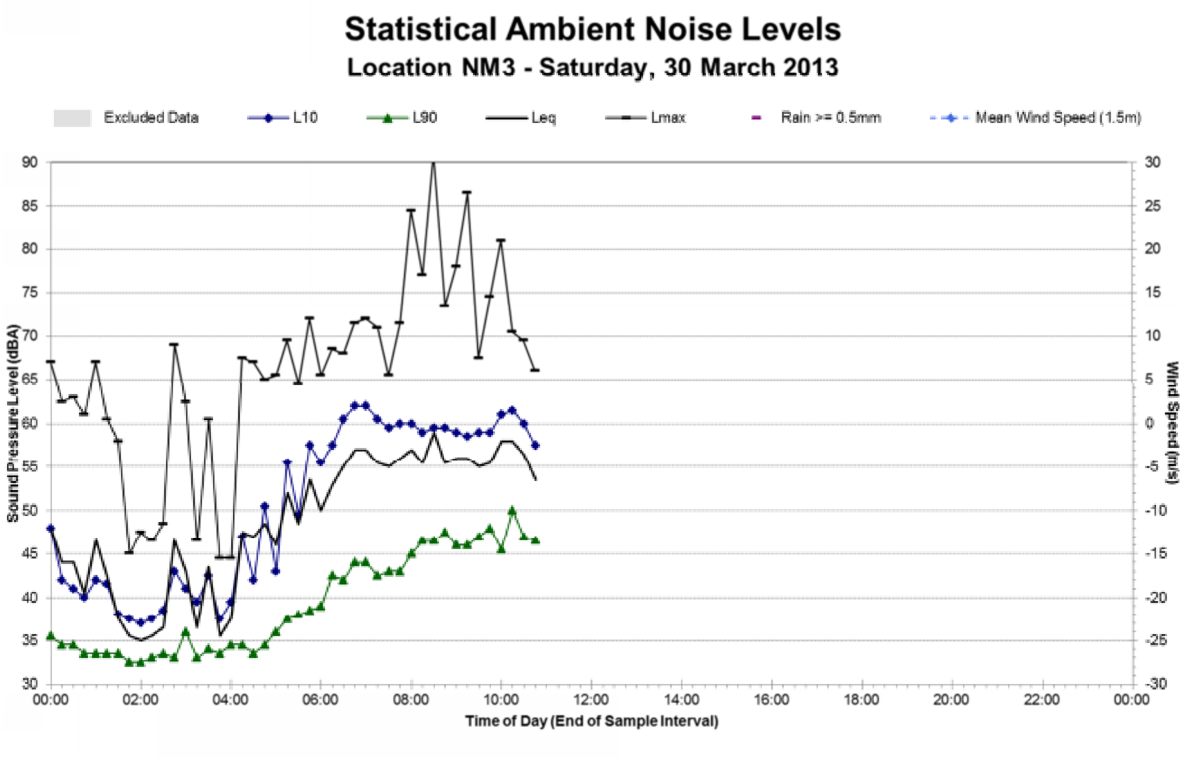
Statistical Ambient Noise Levels
Location NM3 - Thursday, 28 March 2013



Statistical Ambient Noise Levels
Location NM3 - Friday, 29 March 2013



Ambient Noise Monitoring Results



Representative Sensitive Receiver Locations

Predicted Operational Noise Levels – Full Table

Receiver Address[1]	Predicted Noise Levels (dBA)								RNP Criteria (dBA)				Are the RNP Criteria Exceeded?		Change in Noise Level[3]				Acute Level of Noise[4]		Consider Further Additional Noise Mitigation?[5]
	At-Opening				Design Year																
	'No Build' Scenario		'Build' Scenario		'No Build' Scenario		'Build' Scenario		At-Opening		Design Year				At-Opening		Design Year				
	Day[6]	Night[6]	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
2 Railway Avenue	58.6	48.9	48.9	39.1	58.9	49.3	49.1	39.3	55	50	55	50	No	No	-9.7	-9.8	-9.8	-10.0	No	No	No
4 Railway Avenue	50.4	40.8	44.6	35.2	50.6	41.1	44.7	35.4	55	50	55	50	No	No	-5.8	-5.6	-5.9	-5.7	No	No	No
8 Railway Avenue	48.1	38.6	44.3	34.9	48.4	38.9	44.4	35.0	55	50	55	50	No	No	-3.8	-3.7	-4.0	-3.9	No	No	No
10 Railway Avenue	46.7	37.2	44.1	34.8	47.0	37.5	44.2	34.9	55	50	55	50	No	No	-2.6	-2.4	-2.8	-2.6	No	No	No
12 Railway Avenue	46.2	36.9	44.6	35.5	46.5	37.2	44.7	35.6	55	50	55	50	No	No	-1.6	-1.4	-1.8	-1.6	No	No	No
5 Barber Street	59.5	49.7	54.5	44.1	59.9	50.0	54.8	44.4	55	50	55	50	No	No	-5.0	-5.6	-5.1	-5.6	No	No	No
6 Barber Street	56.3	46.1	56.4	45.9	56.6	46.4	56.7	46.3	55	50	55	50	Yes	No	0.1	-0.2	0.1	-0.1	No	No	No
7 Barber Street	58.9	48.4	58.7	48.2	59.2	48.7	59.1	48.5	55	50	55	50	Yes	No	-0.2	-0.2	-0.1	-0.2	No	No	No
8 Barber Street	57.9	47.5	57.5	47.0	58.2	47.8	57.8	47.3	55	50	55	50	Yes	No	-0.4	-0.5	-0.4	-0.5	No	No	No
9 Barber Street	59.3	48.8	59.3	48.7	59.7	49.1	59.6	49.1	55	50	55	50	Yes	No	0.0	-0.1	-0.1	0.0	No	No	No
10 Barber Street	58.9	48.4	58.7	48.2	59.2	48.7	59.1	48.5	55	50	55	50	Yes	No	-0.2	-0.2	-0.1	-0.2	No	No	No
11 Barber Street	59.3	48.7	59.3	48.7	59.7	49.1	59.7	49.1	55	50	55	50	Yes	No	0.0	0.0	0.0	0.0	No	No	No
12 Barber Street	58.2	47.6	58.1	47.5	58.5	48.0	58.4	47.9	55	50	55	50	Yes	No	-0.1	-0.1	-0.1	-0.1	No	No	No
14-16 Barber Street	59.1	48.6	59.1	48.5	59.5	48.9	59.5	48.9	55	50	55	50	Yes	No	0.0	-0.1	0.0	0.0	No	No	No
15 Barber Street	60.3	49.7	60.3	49.7	60.6	50.0	60.6	50.0	55	50	55	50	Yes	No	0.0	0.0	0.0	0.0	No	No	No
1/2-6 Warrabungle Street	52.5	42.4	57.1	47.2	52.8	42.8	57.4	47.4	55	50	55	50	Yes	No	4.6	4.8	4.6	4.6	No	No	Yes
2/2-6 Warrabungle Street	53.0	43.3	54.6	44.8	53.3	43.6	54.9	45.1	55	50	55	50	No	No	1.6	1.5	1.6	1.5	No	No	No
3 Warrabungle Street	53.9	44.2	56.7	47.0	54.1	44.5	56.9	47.1	55	50	55	50	Yes	No	2.8	2.8	2.8	2.6	No	No	Yes
3/2-6 Warrabungle Street	51.9	42.3	52.8	43.1	52.2	42.6	53.0	43.3	55	50	55	50	No	No	0.9	0.8	0.8	0.7	No	No	No
4/2-6 Warrabungle Street	50.9	41.4	51.9	42.4	51.2	41.7	52.2	42.7	55	50	55	50	No	No	1.0	1.0	1.0	1.0	No	No	No

Predicted Operational Noise Levels – Full Table

Receiver Address[1]	Predicted Noise Levels (dBA)								RNP Criteria (dBA)				Are the RNP Criteria Exceeded?		Change in Noise Level[3]				Acute Level of Noise[4]		Consider Further Additional Noise Mitigation?[5]
	At-Opening				Design Year																
	'No Build' Scenario		'Build' Scenario		'No Build' Scenario		'Build' Scenario		At-Opening		Design Year				At-Opening		Design Year				
	Day[6]	Night[6]	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
5/2-6 Warrabungle Street	50.2	40.8	51.0	41.6	50.5	41.1	51.2	41.8	55	50	55	50	No	No	0.8	0.8	0.7	0.7	No	No	No
6/2-6 Warrabungle Street	49.4	40.2	50.2	40.8	49.7	40.5	50.4	41.1	55	50	55	50	No	No	0.8	0.6	0.7	0.6	No	No	No
7/2-6 Warrabungle Street	48.7	39.6	49.5	40.3	48.9	40.0	49.7	40.6	55	50	55	50	No	No	0.8	0.7	0.8	0.6	No	No	No
8/2-6 Warrabungle Street	48.1	39.3	49.1	40.4	48.4	39.6	49.3	40.7	55	50	55	50	No	No	1.0	1.1	0.9	1.1	No	No	No
9/2-6 Warrabungle Street	47.8	39.3	48.5	39.9	48.1	39.6	48.7	40.2	55	50	55	50	No	No	0.7	0.6	0.6	0.6	No	No	No
10/2-6 Warrabungle Street	47.6	39.3	48.6	40.4	47.9	39.6	48.9	40.7	55	50	55	50	No	No	1.0	1.1	1.0	1.1	No	No	No
13/2-6 Warrabungle Street	50.1	41.2	50.9	42.6	50.3	41.5	51.1	42.8	55	50	55	50	No	No	0.8	1.4	0.8	1.3	No	No	No
14/2-6 Warrabungle Street	52.7	43.7	53.4	44.6	53.0	44.0	53.6	44.8	55	50	55	50	No	No	0.7	0.9	0.6	0.8	No	No	No
15/2-6 Warrabungle Street	51.6	42.1	52.2	42.9	51.8	42.4	52.3	43.0	55	50	55	50	No	No	0.6	0.8	0.5	0.6	No	No	No
5 Warrabungle Street	51.2	42.1	52.7	43.7	51.4	42.5	52.9	43.9	55	50	55	50	No	No	1.5	1.6	1.5	1.4	No	No	No
7 Warrabungle Street	53.2	44.4	54.3	45.7	53.5	44.8	54.4	45.9	55	50	55	50	No	No	1.1	1.3	0.9	1.1	No	No	No
1 Little Barber Street	51.6	42.5	52.6	43.6	51.9	42.8	52.7	43.8	55	50	55	50	No	No	1.0	1.1	0.8	1.0	No	No	No
7 Stockman Close	46.5	36.7	52.1	42.4	46.9	37.0	52.4	42.7	55	50	55	50	No	No	5.6	5.7	5.5	5.7	No	No	Yes
9 Stockman Close	46.1	36.2	52.2	42.4	46.4	36.5	52.5	42.7	55	50	55	50	No	No	6.1	6.2	6.1	6.2	No	No	Yes
27 Conadilly Street	59.1	52.5	59.4	52.7	59.4	52.8	59.7	53.1	55	50	55	50	Yes	Yes	0.3	0.2	0.3	0.3	No	No	No
28 Conadilly Street	60.3	53.6	60.4	53.7	60.6	54.0	60.7	54.1	55	50	55	50	Yes	Yes	0.1	0.1	0.1	0.1	No	No	No
31 Conadilly Street	59.1	52.4	59.8	53.2	59.4	52.8	60.1	53.5	55	50	55	50	Yes	Yes	0.7	0.8	0.7	0.7	No	No	No

Predicted Operational Noise Levels – Full Table

Receiver Address[1]	Predicted Noise Levels (dBA)								RNP Criteria (dBA)				Are the RNP Criteria Exceeded?		Change in Noise Level[3]				Acute Level of Noise[4]		Consider Further Additional Noise Mitigation?[5]
	At-Opening				Design Year																
	'No Build' Scenario		'Build' Scenario		'No Build' Scenario		'Build' Scenario		At-Opening		Design Year				At-Opening		Design Year				
	Day[6]	Night[6]	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
32 Conadilly Street	60.3	53.6	60.6	54.0	60.6	53.9	61.0	54.3	55	50	55	50	Yes	Yes	0.3	0.4	0.4	0.4	No	No	No
33 Conadilly Street	56.1	48.9	57.8	50.6	56.5	49.2	58.1	50.9	55	50	55	50	Yes	Yes	1.7	1.7	1.6	1.7	No	No	No
34 Conadilly Street	60.6	54.0	61.5	54.9	61.0	54.3	61.9	55.2	55	50	55	50	Yes	Yes	0.9	0.9	0.9	0.9	No	No	No
35 Conadilly Street	55.2	48.0	56.8	49.6	55.6	48.3	57.1	49.9	55	50	55	50	Yes	No	1.6	1.6	1.5	1.6	No	No	No
36 Conadilly Street	60.9	54.3	61.8	55.2	61.3	54.6	62.2	55.5	55	50	55	50	Yes	Yes	0.9	0.9	0.9	0.9	No	No	No
37 Conadilly Street	54.0	47.3	55.2	48.5	54.4	47.7	55.6	48.9	55	50	55	50	Yes	No	1.2	1.2	1.2	1.2	No	No	No
41 Conadilly Street	55.0	48.3	55.3	48.6	55.4	48.8	55.7	49.0	55	50	55	50	Yes	No	0.3	0.3	0.3	0.2	No	No	No

Note 1: Receiver ID: Black = meets RNP Criteria; Blue = exceeds RNP Criteria; Red = Acute level of noise.

Note 2: Investigation into noise treatment in accordance with RTA's RNP Implementation Flowchart required when the Target Noise Level is exceeded

Note 3: Change in noise level between 'build' and 'no build' scenarios for year of opening and the design year.

Note 4: Acute noise is defined as day LAeq(15hour) 65dBA and night-time as LAeq(9hour) 60dBA. In cases where the predicted future existing noise level is deemed acute investigation into feasible and reasonable noise mitigation is required.

Note 5: Where either change in noise levels exceed 2 dB or predicted design year levels are acute consideration of additional mitigation is required.

Note 6: 6 Day = 7am – 10pm (15 hours); Night = 10pm – 7am (9 hours).

CONSTRUCTION NOISE MODELLING SCENARIOS

Construction Component	Equipment Involved (at each location)	
	Equipment Type	**Number of Equipment**
Stage 1 – Piling		
Bridge supports	Impact Piling Rig	1
Stage 2 – Precast Placement		
Placement of precast beams	Mobile Crane	2
	Truck	1
Stage 2 – Concreting		
Construct diaphrams, pour concrete for decks	Concrete truck	2
	Concrete pump	2
	Delivery trucks	1
Stage 4 – Construction of New Kerbs		
Construction of New Kerbs and associated infrastructure (roundabouts and road connections)	Excavator (20T)	1
	Truck	1
	Jackhammer	1
	Excavator (breaker)	1
	Concrete truck / Agitator	1
	Concrete pump	1
	Vibratory roller	1
Stage 5 – Finishing		
Finishing works	Bitumen Paver	1
	Line marking machine	1
	Hand tools	1
	Roller	1

Equipment Sound Power Levels (SWLs)

Source Item	Overall SWL (dBA)
Excavator	99
Excavator (breaker)	121
Asphalt Paving Machine	104
Concrete Pump	106
Concrete Truck / Agitator	106
Hand Tools	94
Jackhammer *	108 [1]
Line Marking Plant	98
Mobile Crane	101
Piling Rig (impact)	128 [1]
Piling Rig (Bored)	108
Roller (non-vibratory)	100
Truck (12-15 tonne)	103
Truck (10 tonne)	98

Notes 1. The SWL includes a 5 dB impulsive penalty.