Appendix K

Noise and vibration assessment

Roads & Maritime

Noise and Vibration Assessment

Barham-Koondrook Bridge Restoration Work

September 2015

Barham Bridge Rehabilitation

Noise and Vibration Assessment

Report Number 640.10996-R1

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Barham Bridge Rehabilitation

Noise and Vibration Assessment

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EXECUTIVE SUMMARY

The bridge across the Murray River between the towns of Barham NSW and Koondrook VIC will be repaired and refurbished. The project is expected to last 12 months and during this time traffic will be diverted from the existing bridge to a temporary bridge.

SLR Consulting Australia Pty Ltd (SLR) conducted a noise assessment of two elements of the project, the noise generated by traffic diversion and the noise from the construction activities. There are three options for where the traffic can be diverted to while the bridge is being worked on. They are:

1. Divert traffic along Murray Parade to a temporary bridge at Vine Street, re-joining Thule Street at Whymoul Street.
2. Divert traffic along Dalton Street to a temporary bridge at Vine Street, re-joining Thule Street at Whymoul Street.
3. Install a temporary bridge next to the existing bridge, rejoining Thule Street near the existing merge point.

The noise from traffic has been assessed to NSW Road Traffic Noise Policy. Construction Noise has been assessed to the NSW Interim Construction Noise Guidelines. Victorian Noise Criteria have not been used.

Using measurements of the current noise levels from traffic and a computer noise model, noise levels have been predicted to all houses in both towns to find out which of the three options has the least impact, compared to the existing situation. Based on the predictions, **Option 3** has the least impact with regards to noise from traffic.

In NSW the limits for construction noise are based on the existing background noise level. Measurements have been taken of the existing background noise levels and the noise limits have been calculated from these.

Construction noise has also been predicted using a computer noise model. The results show that there is a potential for high impact from the piling works. Measures to reduce the impact to residents have been recommended for this stage. For other stages, the impact is predicted to be minimal.

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1 INTRODUCTION

Roads and Maritime Services of NSW (Roads and Maritime) proposes to construct a new temporary bridge over the Murray River at Barham whilst the existing bridge undergoes repair and refurbishment. The repairs are expected to take approximately 12 months.

SLR Consulting Australia Pty Ltd. (SLR Consulting) has been commissioned to conduct a route option study of the potential road traffic and construction noise and vibration impact for the proposed temporary realignment.

The potential noise and vibration impact of the proposal can be broken down as follows:

- Impact on surrounding areas during the construction phase of the proposal:
    - Construction noise
    - Construction vibration.
- Operational impact after proposal commissioning, consisting primarily of:
    - Noise emissions due to changed road traffic conditions.

1.1 Relevant guidelines

Noise from the operation of the proposal is required to be assessed in accordance with guidelines provided in the NSW *Road Noise Policy* (RNP) ((NSW) Environment Protection Agency (EPA), 2011) as interpreted by Roads and Maritime in the *Noise Criteria Guideline* (NCG) (Road and Maritime, 2014). The NCG provides a consistent approach to identifying road noise criteria for Roads and Maritime Services projects and meets the intention of the RNP. Guidance for additional noise mitigation is taken from the *Noise Mitigation Guideline* (NMG) (Roads and Maritime, 2014). Guidance for assessing the potential for sleep disturbance from maximum noise events is taken from *Practice Note III* in the *Environmental Noise Management Manual* (ENMM) (Roads and Maritime, 2001).

Construction noise has been assessed in accordance with the *Interim Construction Noise Guideline* (ICNG) ((NSW) Department of Environment and Climate Change (DECC), 2009). Construction road traffic noise has been assessed taking guidance from the noise assessment procedure contained in the RNP. Vibration from construction has been assessed in accordance with *Assessing Vibration: A Technical Guideline* ((NSW) Department of Environment and Conservation (DEC), 2006).

1.2 Operational noise metrics

The noise metrics applied in the modelling and assessment of airborne noise from road traffic are:

$L_{Aeq(15hour)}$ the ‘energy average noise level’ evaluated over the daytime period (7.00 am to 10.00 pm). The L_{Aeq} can be likened to a noise dose representing the cumulative effects of all the noise events occurring in the relevant time period.

$L_{Aeq(9hour)}$ the ‘energy average noise level’ evaluated over the night-time period (10.00 am to 7.00 am).

$L_{Aeq(1hour)}$ the ‘energy average noise level’ evaluated for a specific one-hour period.

L_{Amax} The maximum noise level from road traffic noise occurring at a particular location.

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

This report uses terms which may have specific technical meanings. Reference should always be made to **Appendix A** (Acoustic Terminology), which defines these terms.

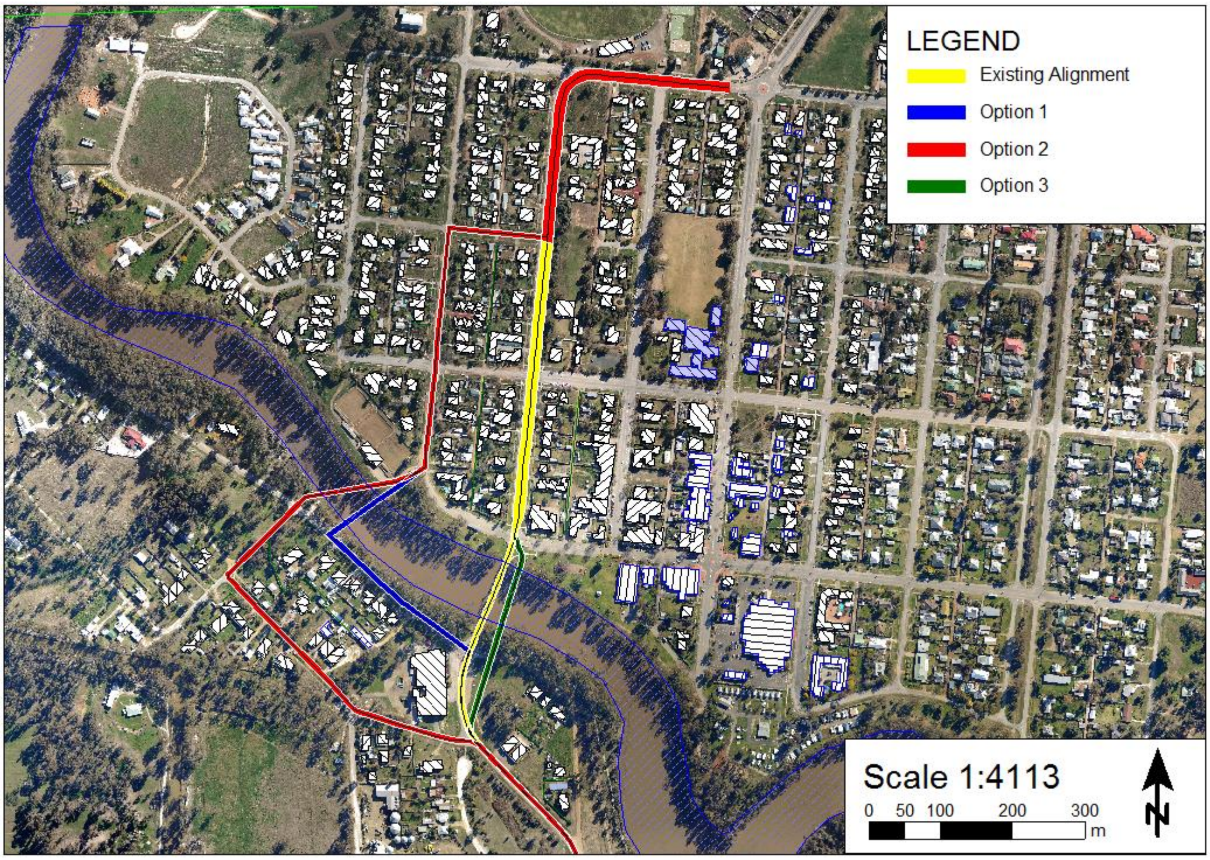
2 SITE AND ROUTE DESCRIPTION

The proposal is located on the Murray River across two townships; Barham in NSW and Koondrook in Victoria. The town on the south side of the river is Koondrook. Barham is the larger town, and is on the north side of the river (NSW side).

The terrain is generally flat throughout the town with trees either side of the river.

Three alternative proposed alignments are to be modelled for existing (2015) road traffic volumes and are shown below in **Figure 1**.

Figure 1 Alternative Route Options



From discussions with Roads and Maritime, the preferred route option is currently Option 3, alongside the existing bridge.

3 NOISE MONITORING

3.1 Noise monitoring locations

Environmental noise monitoring was carried out at a total of seven residential locations throughout the two townships. The measured noise levels have been used to establish existing road traffic noise levels to allow for validation of the operational noise model, and as a basis for assessing potential noise impact during construction. The noise monitoring locations detailed in **Table 1** were selected to be representative of receivers and communities potentially affected by the construction and operation of the proposal.

Unattended noise loggers were installed next to residential dwellings to measure the prevailing levels of road traffic noise over a period of one week. The measurements were conducted at a height of 1.5 metres above ground and generally at a distance of one metre from the facade of the subject building, in accordance with the standard procedure for monitoring road traffic noise.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of AS 1259.2-1990 *"Acoustics - Sound Level Meters. Part 2: Integrating - Averaging"* and carried appropriate and current calibration certificates.

The equipment utilised for the continuous unattended noise surveys comprised of Acoustic Research Laboratories NGARAs and Type EL316 environmental noise loggers, fitted at all times with microphone wind shields.

The calibration of the loggers was checked prior to, and following, each measurement survey and the variation in calibration at any location was found to not exceed 0.5 dBA at all times.

All noise loggers were set to record statistical noise descriptors in continuous 15-minute sampling periods for the duration of their deployment.

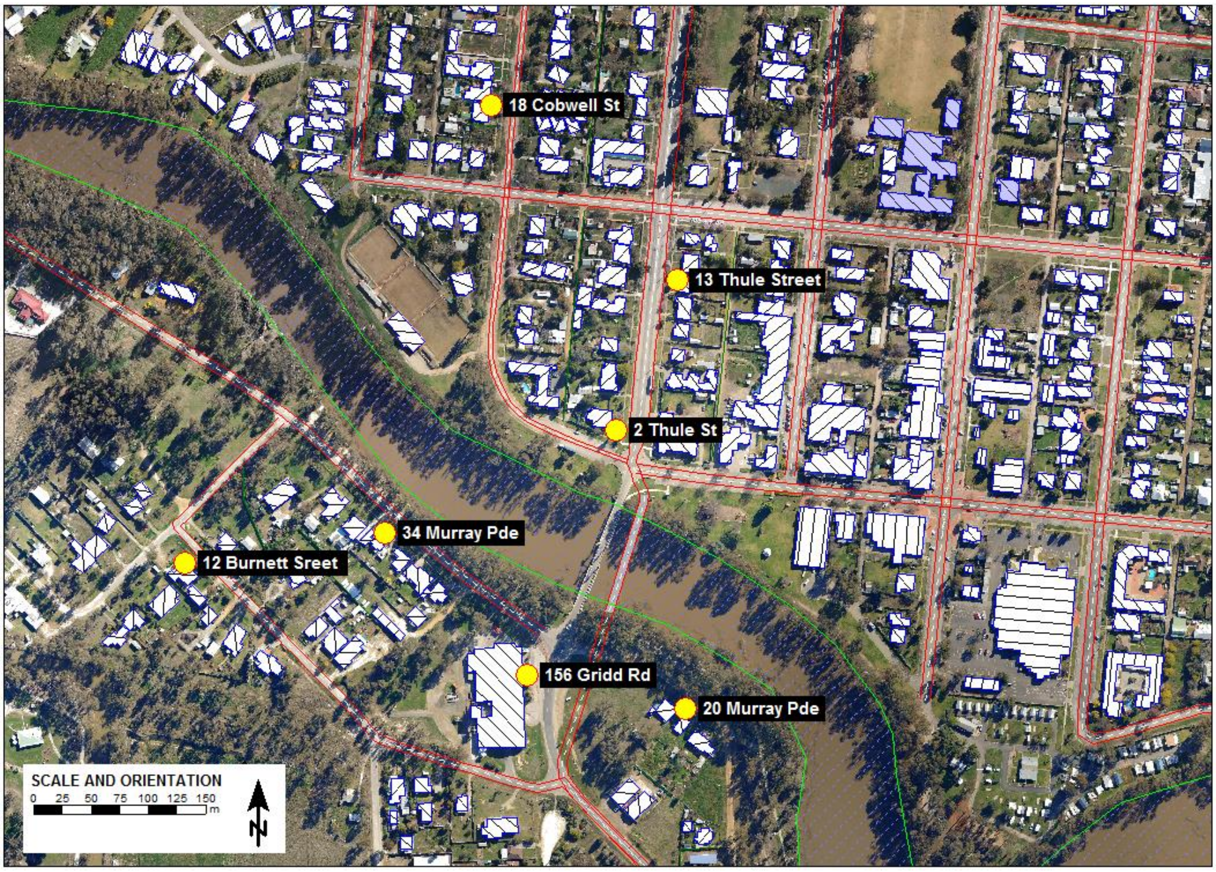
Information from the Bureau of Meteorology for the period of the noise survey was used to assist in identifying conditions that could have had an adverse effect on the measured noise levels, such as high wind and rain periods, etc. Potentially affected data during adverse weather conditions was excluded from the analysis, as was any other data that appeared to be due to extraneous noise sources.

The noise monitoring locations are described in **Table 1** and shown in **Figure 2**.

Table 1 Background noise monitoring locations

Location	Township	Within 2 m of a Façade?	Monitored for:
2 Thule Street	Barham		Traffic / Background
12 Burnett Street	Koondrook	Yes	Background
13 Thule Street	Barham	Yes	Traffic / Background
18 Cobwell Street	Barham		Traffic / Background
20 Murray Parade	Koondrook		Background
34 Murray Parade	Koondrook	Yes	Traffic / Background
156 Grigg Road	Koondrook		Traffic

Figure 2 Background noise monitoring locations



3.2 Background noise monitoring results

The results of the background noise monitoring are presented in **Table 2** and **Table 3** and are also illustrated in **Appendix B** (in the form of plots which show the average 24 hour noise levels at each monitoring location for the duration of each logging period).

Road traffic noise emissions typically vary throughout the day. As such the $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise indices are used as they represent the energy-averaged noise level that prevails during the daytime (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am) periods. These indices, which are used for the operational assessment, are provided in **Table 3**.

The *Road Noise* Policy (RNP) requires that, when conducting ambient noise monitoring, it is only the noise level contributions from road traffic noise that are relevant, therefore in order for the measured data to reflect the prevailing levels of road traffic noise, the data was processed taking into account the following:

- Prevailing weather conditions
- Uncharacteristic changes in the noise indices
- Uncharacteristic variations of the L_{Aeq} compared to the L_{A10} index.

As required by the RNP, periods which are deemed to be effected by extraneous noise sources that are not related to traffic were excluded from the monitoring data.

Table 2 Summary of RBL unattended noise survey results

Address	Township	Construction noise indices (RBL) (dBA)		
		Daytime period [1]	Evening period [2]	Night-time period [3]
12 Burnett St	Koondrook	33	34	37
2 Thule St	Barham	42	40	32
13 Thule St	Barham	36	35	30
18 Cobwell St	Barham	32	35	32
20 Murray St	Koondrook	38	38	37
34 Murray St	Koondrook	38	38	37
156 Grigg Rd	Koondrook	42	37	32

Note 1: Standard construction hours are: 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.

Note 2: Evening hours: 6.00 pm to 10.00 pm.

Note 3: Night-time hours: 10.00 pm to 7.00 am Monday to Friday, 10.00 pm Saturday to 8.00 am Sunday.

Table 3 presents ambient L_{Aeq} noise data relevant to the assessment of operational road traffic noise.

Table 3 Summary of L_{Aeq} unattended noise survey results, dBA L_{eq15}Hour / $L_{eq9Hour}$

	Location ($L_{eq15Hour}$ / $L_{eq9Hour}$, dBA)					
Date	**12 Burnett St**	**2 Thule St**	**13 Thule St**	**18 Cobwell St**	**34 Murray St**	**156 Grigg Rd**
Thu, Feb 05, 2015		60/51	58/49			60/53
Fri, Feb 06, 2015		60/51	58/49			59/50
Sat, Feb 07, 2015		56/47	54/45			58/49
Sun, Feb 08, 2015		56/48	54/47			57/55
Mon, Feb 09, 2015		58/52	58/51			60/53
Tue, Feb 10, 2015		60/51	59/50			60/52
Wed, Feb 11, 2015		59/50	58/48			61/53
Thu, Feb 12, 2015		59/55	58/59			60/56
Fri, Feb 13, 2015		59/48	59/48			60/50
Sat, Feb 14, 2015		55/47	55/47			59/50
Sun, Feb 15, 2015		55/48	55/50			57/53
Mon, Feb 16, 2015		59/0	59/-			59/-
Tue, Feb 17, 2015	46/47				62/50	
Wed, Feb 18, 2015	48/45			50/39	56/46	
Thu, Feb 19, 2015	45/45			48/42	56/52	
Fri, Feb 20, 2015	46/48			49/44	56/49	
Sat, Feb 21, 2015	46/43			48/40	53/49	
Sun, Feb 22, 2015				47/42	52/49	
Mon, Feb 23, 2015				49/42	56/45	
Tue, Feb 24, 2015				49/41	56/48	
Wed, Feb 25, 2015				50/44	60/51	

	Location (Leq15Hour / Leq9Hour, dBA)					
Date	**12 Burnett St**	**2 Thule St**	**13 Thule St**	**18 Cobwell St**	**34 Murray St**	**156 Grigg Rd**
Thu, Feb 26, 2015					56/-	
Average	**46/46**	**58/50**	**57/49**	**49/42**	**56/49**	**59/52**
Average Weekday	**46/46**	**59/51**	**58/50**	**49/42**	**57/49**	**60/52**

4 CRITERIA – OPERATIONAL ROAD TRAFFIC NOISE

4.1 Roads and Maritime Noise Criteria Guideline

This assessment is undertaken with guidance from the *Noise Criteria Guideline* (NCG).

The NCG documents Roads and Maritime Services' interpretation of the NSW *Road Noise Policy* (RNP). The NCG provides a consistent approach to identifying road noise criteria for Roads and Maritime Services projects.

Criteria for road projects comprising of new and redeveloped road segments are assigned with reference to the RNP.

Although it is not mandatory to achieve the noise assessment criteria in the NCG, 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 impact from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impact from existing roads and corridors is typically more limited.

As the alignment options are only to remain in place until after the completion of the rehabilitation work, the usual approach of considering ten years after completion is not applicable. The approach adopted in this report is to assess impact of each of the route options and compare outcomes. Noise modelling is to be undertaken to estimate the increase in traffic noise expected along detour routes for Options 1, 2 and 3 (refer to **Section 2**). This would be presented to the community as a comparative measure of impact for these alternatives.

Guidelines recommended in the policy are based on the functional categories of the subject roads,

- Arterial roads (including freeways) support major regional and inter regional traffic movement. Freeways and motorways usually feature strict access controls via grade separated interchanges
- Sub-arterial roads provide connection between arterial roads and local roads. May support arterial roads during peak periods. May have been designed as local streets but can serve major traffic generating developments or support non local traffic
- Local roads, provide vehicular access to abutting property and surrounding streets. Provide a network for the movement of pedestrians and cyclists, and enable social interaction in a neighbourhood. Should connect, where practicable, only to sub arterial roads

The catchment zone has been limited to 450 m east and west of the central traffic corridor that is currently used. This zone is sufficient to capture all affected residences from the proposed route options of the road.

It is noted that the noise criteria presented within the RNP noise policy document are guidelines and as such, are non-mandatory.

Table 4 summarises the assessment criteria for residences to be applied to particular types of project, road categories and land uses. These criteria are presented for assessment against facade noise levels measured in front of a building facade.

Table 4 RNP Criteria – Residential land uses

Road category	Type of project/land use	Assessment criteria – external dBA	
		Daytime (7 am – 10 pm)	Night-time (10 pm – 7 am)
Freeway / arterial / sub-arterial roads	Existing Residences affected by noise from **new** freeway / arterial / sub-arterial road corridors	$L_{Aeq(15hour)}$ 55	$L_{Aeq(9hour)}$ 50

Table 5 RNP Criteria – Non-residential land uses

Existing sensitive land use	Assessment Criteria dBA		Additional Considerations
	Day (7am – 10pm)	Night (10pm – 7am)	
School Classrooms	$L_{Aeq(1hour)}$ 40	-	
Open Space (active use)	$L_{Aeq(15hour)}$ 60		Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.
Open Space (passive use)	$L_{Aeq(15hour)}$ 55		Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading.

The proposal is classified as a **new freeway arterial/sub-arterial road**. The RNP noise criteria applicable to the proposal are therefore external noise levels of **55 dBA daytime $L_{Aeq(15hour)}$** and **50 dBA night-time $L_{Aeq(9hour)}$.**

The noise models predict noise levels for $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ intervals (day and night). Where receivers have one-hour criteria, the model outputs have been converted accordingly (refer to **Section 6.5**).

In addition to the noise criteria in **Table 4**, 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. As the proposal diverts traffic along existing roads the existing noise levels would not be 12 dB below the NCG criteria. Therefore the RIC does not apply for this Project.

4.2 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.*

The protocol for assessing the potential for sleep disturbance, detailed within *Practice Note III* of the ENMM, is determined by performing an L_{AFmax} – $L_{Aeq(1hr)}$ calculation on individual vehicle passby noise measurements. A maximum noise level event is then defined as a passby for which the night-time L_{AFmax} – $L_{Aeq(1hr)}$ difference is greater than 15 dB.

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 are unlikely to awaken people from sleep*
> - *one or two noise events per night, with maximum internal noise levels of 65–70 dB, 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 this conservative minimum attenuation of 10 dB, the first conclusion above suggests that short term external noise levels of 60 dB to 65 dB L_{AFmax} 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 dB to 80 dB L_{AFmax} are not likely to affect health and wellbeing significantly.

5 CRITERIA - NSW INTERIM CONSTRUCTION NOISE GUIDELINE

5.1 Residential Receivers

In NSW, construction noise is currently assessed with reference to the NSW Government document *Interim Construction Noise Guideline* (ICNG) (DECC 2009). Recommended maximum levels for construction noise at noise sensitive locations are based on the Rating Background Level or RBL, as defined in Section 3.1 of the NSW *Industrial Noise Policy* (INP) (EPA 2000).

The ICNG was developed with an emphasis on minimising construction noise impact by implementing various work practices rather than focussing only on achieving numerical noise levels. The guideline recognises that construction activities are often inherently noisy but are generally of a temporary nature.

ICNG provides recommended Noise Management Levels (NMLs) for construction activities with an anticipated duration of more than three weeks (construction of the proposal is anticipated to last for one year).

Where construction noise levels are predicted to exceed the NMLs, all feasible and reasonable work practices are to be investigated to minimise noise emissions. If construction noise levels are still predicted to exceed the NMLs then the potential noise impact is to be managed using site specific construction noise management plans.

The basis for deriving NMLs is presented in Table 6.

Table 6 Recommended noise management levels for construction noise at residential locations (INCG)

Time of Day	NML, $L_{Aeq(15min)}$[1]	How to Apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays	Noise affected RBL+ 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that would be provided.
Outside recommended standard hours	Noise affected RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1: 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.

Guidance on applicable construction noise goals for commercial receivers is also provided in the ICNG. Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into two broad categories:

- Industrial premises: external $L_{Aeq(15minute)}$ 75 dBA
- Offices, retail outlets: external $L_{Aeq(15minute)}$ 70 dBA

5.2 Sleep disturbance

The current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background noise levels plus 15 dBA (as described in the Application Notes to the INP), and to undertake further analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during the night-time period.

Where the screening criterion cannot be met, the additional analysis should consider the level of exceedance as well as factors such as:

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

Other guidelines that contain additional advice relating to potential sleep disturbance impact should also be considered, including the RNP.

The RNP Criteria is discussed in **Section 4.1.3**:

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

5.3 Scope for exceedance

Where predicted or measured levels exceed the NMLs the ICNG recommends that the proponent apply all “feasible and reasonable” work practices in order to minimise noise.

Where $L_{Aeq(15minute)}$ construction noise levels are predicted to be “highly noise affected” (ie above 75 dBA) the relevant authority may require respite periods to be observed. This may include restricting the hours that the very noisy activities can occur, taking into account:

- Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences)

- If the community is prepared to accept a longer period of construction in exchange for restrictions in construction times.

The implementation of an effective community consultation and liaison programme is emphasised as being a critical tool in successfully handling adverse noise impacts from construction work.

5.4 Construction vibration assessment criteria

Vibration targets vary primarily according to whether the particular activities of interest are continuous in nature or intermittent and whether they occur during the day or night-time. 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, (ie human disturbance)
- Those in which the integrity of the building or the structure itself may be prejudiced
- Those where the building contents may be affected.

Criteria which are relevant to the response of building occupants to vibration are more stringent than those relevant to building damage. This is because people are able to “feel” vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building.

This ability of people to sense vibration at relatively low magnitudes has created a widespread and strong public misconception which can cause considerable overestimation of the risk of damage associated with vibration in buildings. This is particularly the case when the source of that vibration is outside the building, visible and audible, but generally not within the occupant’s control.

Many people, for example, believe that even barely perceptible levels of building vibration from say, traffic, excavation or construction works, can damage dwellings, or may affect delicate objects or other items of personal value within their homes. This largely subjective response is particularly the case when these low levels of vibration are accompanied by high noise levels, or if there are other adverse connotations or effects associated with the source of the vibration. These might include startlement, loss of privacy or perceived loss of property value, fear, inconvenience, odour, etc.

On the other hand, sources of much higher levels of vibration (eg domestic appliances, people walking on floors, slamming of doors, etc) are readily accepted due to their day-to-day familiarity or because they are “within the control” of the occupant.

It is primarily these day-to-day effects which cause the gradual, long-term fatigue-induced deterioration of most structures - considered to be normal ageing. Provided that the levels of vibration-induced structural stress from an additional source are well below those of these “normal” stress-inducing events, then the additional source of vibration is unlikely to accelerate the normal ageing process.

1.1.1 General

"Assessing Vibration: a technical guideline" (DEC 2006) notes that "vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time)."

Construction activities typically generate building vibrations that are intermittent or impulsive in nature, however vibration levels may sometimes be constant from sources such as generators or ventilation fans.

Examples of typical vibration sources are provided in **Figure 3**.

Figure 3 Examples of vibration (DEC Vibration Guideline)

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Where vibration is intermittent or impulsive in character, the DEC vibration guideline (and other similar guidelines) recognises that higher vibration levels are tolerable to building occupants than for continuous vibration. As such, higher vibration goals are usually applicable for short term, intermittent and impulsive vibration activities than for continuous vibration sources.

1.1.2 Human comfort goals for continuous and impulsive vibration

"*Assessing Vibration: a technical guideline*" (DEC 2006) is based on the guidelines contained in British Standard BS 6472-1992 "*Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*". The DEC guideline refers only to human comfort considerations and nominates preferred and maximum vibration goals for critical areas, residences and other sensitive receivers. The applicable human comfort vibration goals for continuous, intermittent and impulsive vibration sources are provided in **Table 7** and **Table 8** respectively. In all cases, the vibration goals are expressed in terms of the RMS vibration velocity level in mm/s, measured in the most sensitive direction (z-axis).

The DEC vibration guideline notes the following in relation to the preferred and maximum vibration levels:

> *"There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Activities should be designed to meet the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the maximum value may be used if they can be justified. For values beyond the maximum value, the operator should negotiate directly with the affected community. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short term duration. An example is a construction or excavation project.*

In circumstances where work is short term, feasible and reasonable mitigation measures have been applied, and the project has a demonstrated high level of social worth and broad community benefits, then higher vibration values (above the maximum) may apply. In such cases, best management practices should be used to reduce values as far as practicable, and a comprehensive community consultation programme should be instituted."

Table 7 Preferred and maximum vibration levels for continuous vibration

Building Type	Preferred Vibration Level RMS Velocity (mm/s)	Maximum Vibration Level RMS Velocity (mm/s)
Critical Working Areas (eg hospital operating theatres, precision laboratories)	0.10	0.20
Residential Daytime	0.20	0.40
Residential Night-time	0.14	0.28
Offices, schools, educational institutions and places of worship	0.40	0.80
Workshops	0.80	1.60

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Table 8 Preferred and maximum vibration levels for impulsive vibration

Building Type	Preferred Vibration Level RMS Velocity (mm/s)	Maximum Vibration Level RMS Velocity (mm/s)
Critical Working Areas (eg hospital operating theatres, precision laboratories)	0.1	0.2
Residential Daytime	6.0	12.0
Residential Night-time	2.0	4.0
Offices, schools, educational institutions and places of worship	13.0	26.0
Workshops	13.0	26.0

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

1.1.3 Intermittent vibration (vibration dose values)

For most construction activities that generate perceptible vibration in nearby buildings, the character of the vibration emissions is intermittent. This includes equipment such as rockbreakers, excavators, piling rigs, rock drills, vibratory rollers and heavy vehicle movements.

Intermittent vibration is defined in the DECCW vibration guideline as follows:

*"**Intermittent vibration** can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose values".*

Where vibration comprises a number of events, a Vibration Dose (Dv) may be estimated for each event by the following formula using vibration measured in velocity:

Dv = 0.07 V (rms) x $t^{0.25}$ $m/s^{1.75}$

Where, V (rms) = rms particle velocity (mm/s)

t = Total cumulative time (seconds) of the vibration event or period of vibration

The total vibration dose is then calculated using the following formula:

$$Dv = \left(\sum_{n=1}^{n=N} Dv_n^4 \right)^{0.25}$$

Where, Dv = Total vibration dose value for the day or night

Dvn = Vibration dose value for each vibration dose event

N = Total number of vibration dose events

The permissible vibration level corresponding to the vibration dose value varies according to the duration of exposure. For example, higher vibration levels are permitted if the total duration of the vibration event(s) is small, additionally lower vibration levels are permitted if the total duration of the vibration event(s) is large.

This concept is illustrated graphically in Error! Reference source not found. where the intermittent vibration curves for the daytime and night-time periods correspond to the preferred vibration dose values in **Table 9.**

As the total duration of the intermittent vibration sources during the daytime and night-time periods get larger, the intermittent vibration goals approach the preferred continuous vibration goals in **Table 7**.

Figure 4 Vibration levels corresponding to 'low probability of adverse comment' for residential receiver's continuous and intermittent vibration

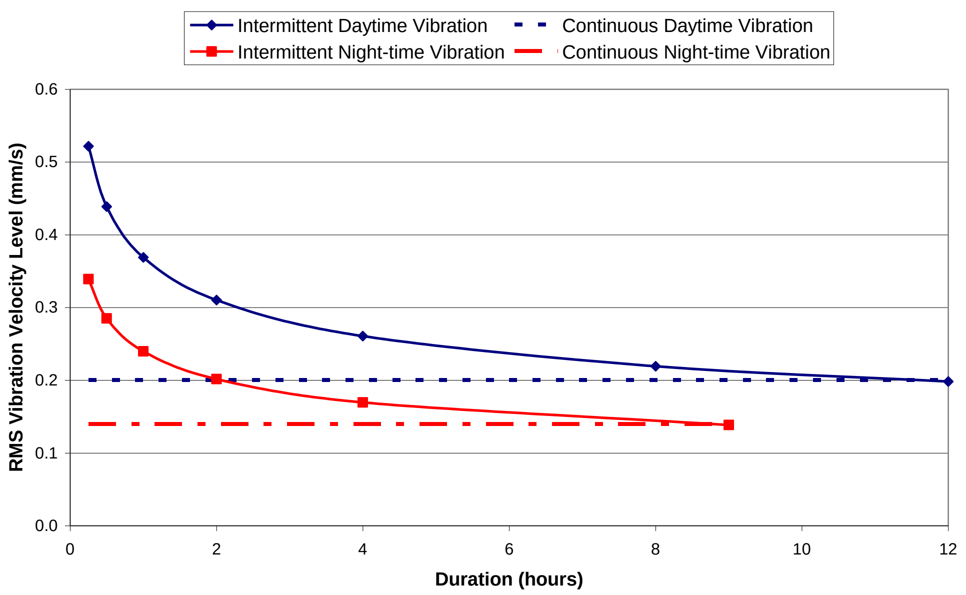


Table 9 Preferred and maximum vibration levels for intermittent vibration (vibration dose values)

Building Type	Preferred Vibration Dose Value ($m/s^{1.75}$)	Maximum Vibration Dose Value ($m/s^{1.75}$)
Critical Working Areas (eg hospital operating theatres, precision laboratories)	0.10	0.20
Residential Daytime	0.20	0.40
Residential Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80
Workshops	0.80	1.60

Note: For the definition of the Vibration Dose Value refer to the discussion in the following section. Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

1.1.4 Vibration criteria - surface structures

Most commonly specified “safe” structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

British standard 7385: Part 2 - 1993 guidelines

In terms of the most recent relevant vibration damage goals, Australian Standard AS 2187: Part 2-2006 *“Explosives - Storage and Use - Part 2: Use of Explosives”* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *“Evaluation and measurement for vibration in buildings Part 2”* as they “are applicable to Australian conditions”.

The Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration- induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 10** and graphically in **Figure 6**.

Table 10 Transient vibration guide values - minimal risk of cosmetic damage

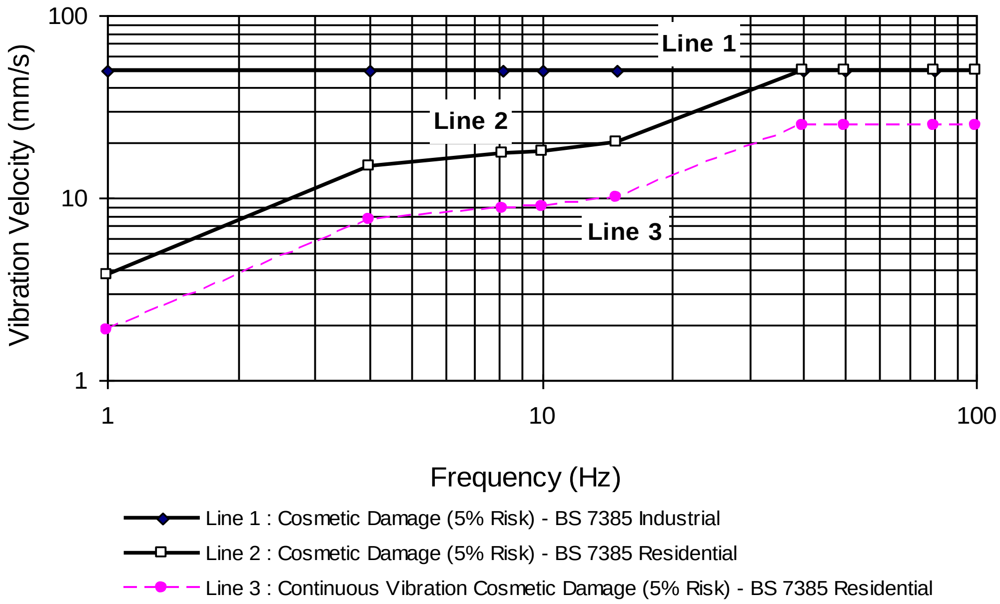
Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial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

The Standard states that the guide values in **Table 10** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 10** may need to be reduced by up to 50%.

Note: rockbreaking/hammering activities are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may therefore be appropriate to reduce the transient values by 50 per cent.

Figure 5 Graph of transient vibration guide values for cosmetic damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to “Line 2” are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The Standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 10**, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the Standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 10** should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS 2187 specifies that vibration measured should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the guidance curves presented in **Figure 5**.

6 OPERATIONAL ROAD TRAFFIC NOISE MODELLING OF THE STUDY AREA

6.1 Assessment Scenarios

As the alignment options are only to remain in place until after the completion of the rehabilitation works, the usual approach of considering ten years after completion is not applicable.

The approach adopted in this report is to assess the impact of each of the route options and compare outcomes. Noise modelling is to be undertaken to estimate the increase in traffic noise expected along detour routes for Options 1, 2 and 3 (refer to **Section 2**). This would be presented to the community as a comparative measure of impact for these alternatives.

Four Scenarios have been modelled for the project, they are as follows:

- Existing scenario, based on the modelled traffic flow and corrected to the measured noise levels at specific locations
- Route Option 1 – Alternative Detour Route via Murray Parade
- Route Option 2 – Alternative Detour Route via Dalton St/Vine St
- Route Option 3 – Preferred Detour Route, alongside existing bridge

6.2 Road noise prediction algorithms

Noise modelling of the project area was carried out using the *Calculation of Road Traffic Noise* (CORTN) (UK Department of Transport, 1988)[1] algorithms incorporated in SoundPLAN V7.3. 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 algorithm output of CORTN (fundamentally an L_{A10} predictor) has been modified to calculate the relevant daytime $L_{Aeq(15hour)}$ and night-time $L_{Aeq(9hour)}$ road traffic noise emission levels at noise sensitive receivers, as required by the RNP.

The SoundPLAN noise models were set up to calculate noise levels at receiver points for all facades and all floors of each noise sensitive receiver identified within the project area. Noise modelling of the present study was carried out using the *"Calculation of Road Traffic Noise"* (CORTN) (UK Department of Transport 1988) algorithms incorporated in the SoundPLAN 7.3 noise software. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, ground absorption and shielding from ground topography and physical noise barriers.

6.3 Study area: terrain, roadways

Ground topography, current and propsed route option road alignment and other cadastral data (eg property boundaries) were derived from aerial photographs and information supplied electronically. The noise modelling was based on the alternative route options for the temporary re-alignment.

The catchment zone has been limited to 450 m east and west of the central traffic corridor that is currently used. This zone is sufficient to capture all affected residences from the proposed route options of the road

6.4 Traffic count data

For the existing scenario (2015), the traffic volumes and speeds were derived from traffic counts conducted in conjunction with the baseline ambient monitoring described in **Section 3.** These figures, along with representative vehicle speeds measured at the same time as the traffic counts, are presented in **Table 11** and **Table 12**.

Table 11 Daytime Traffic Flows

	Highway South of Bridge	Murray Pde (East of Vine St)	On Bridge	Thule St (b/n Murray St and Whymoul St)	Thule St (b/n Whymoul St and Gonn Stt)	Cobwell St (b/n Murray St and Whymoul St)	Whymoul St (b/n Cobwell St and Thule St)	Dalton St / Burnett St /Vine St	All other local Roads
Existing	4029 (6%)	1500 (14.3%)	4029 (6%)	1844 (10.7%)	1844 (10.7%)	386 (8.7%)	386 (8.7%)	102 (14.3%)	386 (8.7%)
Option 1	4029 (6%)	4029 (6%)	4029 (6%)	386 (8.7%)	1844 (10.7%)	1844 (10.7%)	1844 (10.7%)	102 (14.3%)	386 (8.7%)
Option 2	4029 (6%)	1500 (14.3%)	4029 (6%)	386 (8.7%)	1844 (10.7%)	1844 (10.7%)	1844 (10.7%)	4029 (6%)	386 (8.7%)
Option 3	4029 (6%)	-	4029 (6%)	1844 (10.7%)	1844 (10.7%)	386 (8.7%)	386 (8.7%)	1602 (14.3%)	386 (8.7%)

Table 12 Night-time Traffic Flows

	Highway South of Bridge	Murray Pde (East of Vine St)	On Bridge	Thule St (b/n Murray St and Whymoul St)	Thule St (b/n Whymoul St and Gonn Stt)	Cobwell St (b/n Murray St and Whymoul St)	Whymoul St (b/n Cobwell St and Thule St)	Dalton St / Burnett St / Vine St	All other local Roads
Existing	266 (9.7%)	100 (5.8%)	266 (9.7%)	115 (16.3%)	115 (16.3%)	25 (5.8%)	25 (5.8%)	50 (18.0%)	25 (5.8%)
Option 1	266 (9.7%)	266 (9.7%)	266 (9.7%)	25 (5.8%)	115 (16.3%)	115 (16.3%)	115 (16.3%)	50 (18.0%)	25 (5.8%)
Option 2	266 (9.7%)	100 (5.8%)	266 (9.7%)	25 (5.8%)	115 (16.3%)	115 (16.3%)	115 (16.3%)	266 (9.7%)	25 (5.8%)
Option 3	266 (9.7%)	-	266 (9.7%)	115 (16.3%)	115 (16.3%)	25 (5.8%)	25 (5.8%)	150 (18.0%)	25 (5.8%)

* Note that night-time values were input as 10 times higher, with a -10 dB correction applied to the results; this is an accepted method used to disable the low flow correction in SoundPlan. The low flow correction is a known source of errors.

6.5 Summary of noise modelling parameters

Table 13 summarises the various parameters used in the noise modelling.

Table 13 Modelling parameters

Input Parameter	**Source of Data**
Ground topography	Surveyed road corridor data
Proportion of absorbing ground	0.7 (CORTN)
Receiver Locations	Aerial photography
Vehicle Speeds	Validation - As measured duringtraffic monitoring Route option study – As posted
Source Heights	Cars & trucks 0.5 m
Road Surface Correction	**0 dB** correction on all roads
Number and Location of sensitive receiver points	All sensitive receiver buildings, all facades and all floors, excluding facades shorter than 2.0 meters Facade point located at the centre of the facade
Receiver Location (@ 1m from Facade)	Ground floor[3] 1.5m First floor[3] 4.3m
Facade Correction	+2.5 dB
ARRB	-1.7 dB for facade conditions
L_{A10} to L_{Aeq}	-3 dB
$L_{Aeq(15hour)}$ to $L_{Aeq(1hour)}$	+1.2 dB (based on 13 Thule St Logger)

7 OPERATIONAL ROAD TRAFFIC NOISE ASSESSMENT

7.1 Verification of noise model

The road traffic noise model was verified against the results of the ambient noise monitoring. This was achieved by carrying out predictions to the unshielded noise logger monitoring locations (refer to **Figure 2**).

Small variations between measured and predicted values are to be expected within any noise model. This is due to the dependence of measured noise levels on road surface characteristics near the specific measurement sites, the use of brakes approaching the bridge, the effects of local screening (eg fences, sheds), etc.

The results of the single point receiver runs for the current scenario are presented in **Table 14** and **Table 15.**

Table 14 Model Calibration Derivation – Daytime, dBA

Name	Predicted $L_{Aeq(15hour)}$	Measured $L_{Aeq(15hour)}$	Difference
2 Thule St	58.1	57.1	1.0
13 Thule St	58.4	57.3	1.1
18 Cobwell St	50.9	48.9	2.0
34 Murray Pde	57.9	57.2	0.7
156 Grigg Rd	59.6	59.3	0.3
AVERAGE			**1.0**

Differences between measured and modelled daytime noise levels were within 2 dB of the measured levels. The model is therefore sufficient for the comparative purposes of the route options study.

Table 15 Model Calibration Derivation –Night-time, dBA

Name	Predicted $L_{Aeq(15hour)}$	Measured $L_{Aeq(15hour)}$	Difference
2 Thule St	50.3	50.5	-0.2
13 Thule St	50.3	51.2	-0.9
18 Cobwell St	41.9	42.0	-0.1
34 Murray Pde	47.5	49.3	-1.8
156 Grigg Rd	51.6	52.8	-1.2
AVERAGE			**-0.9**

Differences between measured and modelled night-time noise levels were within 2 dB of the measured levels. The model is therefore sufficient for the comparative purposes of the route options study.

A summary of the final, $L_{Aeq(15hour)}$ daytime and $L_{Aeq(9hour)}$ night-time noise predictions for all scenarios are presented in tabulated form in **Appendix E.**

Appendix C provides full noise contour plots for the existing scenario and for the three route options considered, for both $L_{Aeq\ (15\ hour)}$ and $L_{Aeq\ (9\ hour)}$ noise levels.

7.2 Assessment of noise levels

Results of the modelled scenarios are presented in graphical format in **Appendix C** and in tabular format in **Appendix E**. Results have been summarised in **Table 16** and **Table 17**.

Table 16 Modelling Results Summary - Residential

Route	Number of dwellings >55 dBA, daytime	Number of dwellings >50 dBA, night-time
Existing	51	16
Option 1	48	20
Option 2	54	18
Option 3	54	23

Table 17 Modelling Results – Non-residential

Route	Schools > 40 dBA internal*	Open Space passive use >55 dBA
Existing	1	0
Option 1	0	1
Option 2	0	1
Option 3	1	0

* A 10 dB difference between internal and external noise levels has been conservatively assumed.

For Options 1 and 2, as traffic is diverted from the main thoroughfare, predicted noise levels at the school decrease, and predicted noise levels at the open spaces (lawn bowls club and football ground) increase. The exceedances of the criteria are fairly minor, less than 3 dB in all cases. All 3 options are therefore considered roughly equivalent on these criteria.

In addition to the NCG controlling criteria any increase in total traffic noise levels at a location due to the proposal must be considered.

Figure 6 shows the predicted change in noise levels for the three route options (Route option – Existing).

Figure 6 Change in Daytime Noise Level Summary

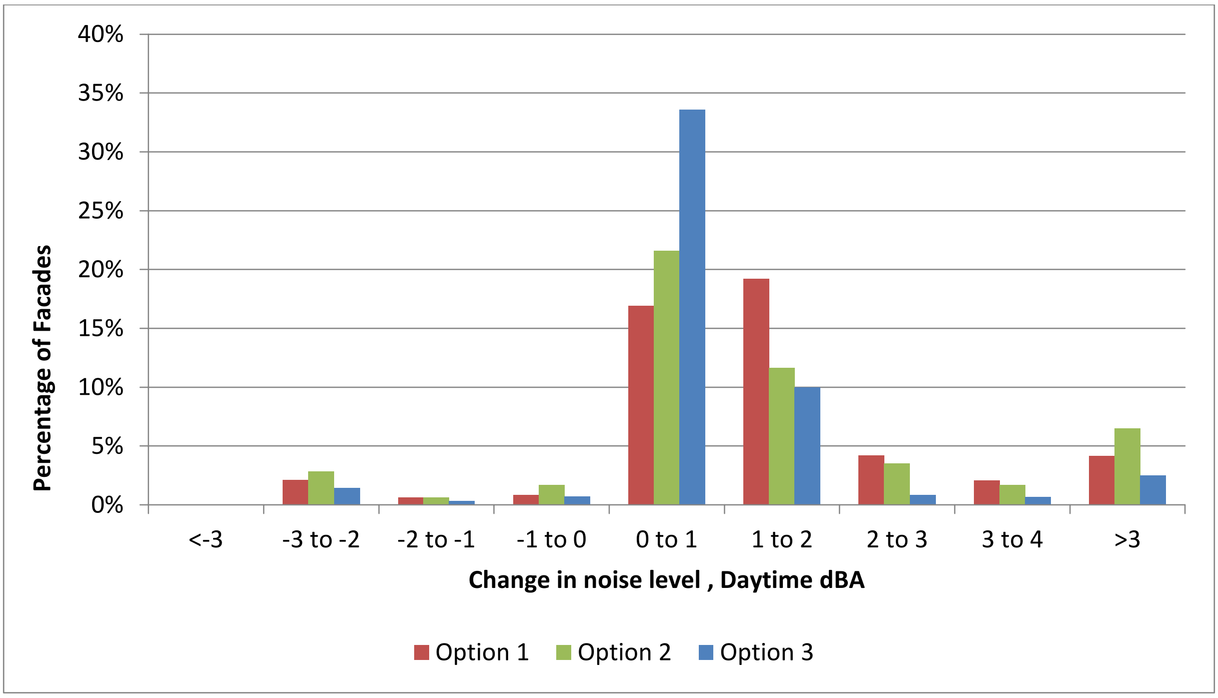
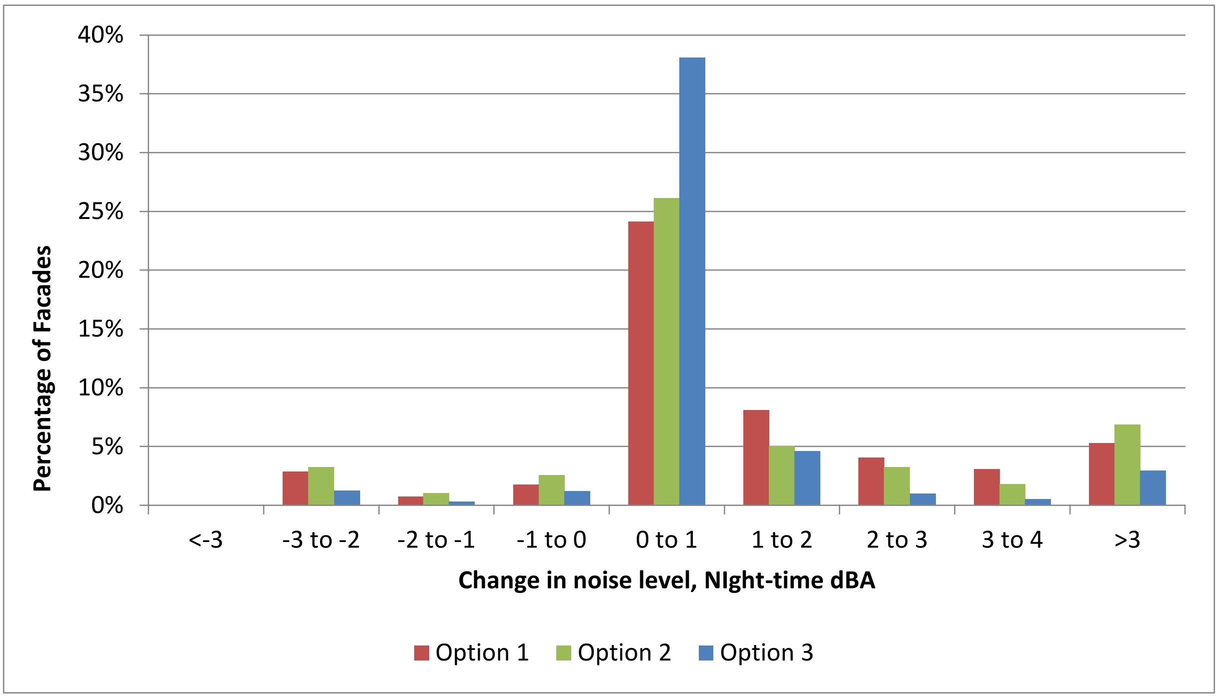


Figure 7 shows the predicted change in night-time noise levels for the three route options.

Figure 7 Change in Night-time Noise Level Summary



7.3 Assessment of Noise Levels

The review of the modelling results provides the following key findings:

1.1.5 Existing Conditions

- All existing receivers fronting onto Thule St are currently exposed to moderate noise levels, with 'Existing 2015' noise levels approximately 54 to 60 dBA during the day and 45 to 50 dBA at night.

1.1.6 Realignment option 1

- Receivers fronting Cobwell St would be exposed to similar noise levels to that currently experienced in the existing alignment Thule St.
- Properties to the along the detour route are predicted to experience slightly elevated noise levels particularly along Cobwell St where the levels increase by approximately 4 to 6 dBA due increased traffic movements as well as Murray Pde where the levels increase approximately 3 dBA.

1.1.7 Realignment option 2

- Receivers fronting Cobwell St would be exposed to similar noise levels to that currently experienced in the existing alignment Thule St.
- Properties to the along the detour route are predicted to experience slightly elevated noise levels particularly along Cobwell St where the levels increase by approximately 4 to 6 dBA due increased traffic movements as well as Burnett St where the levels increase approximately 3 dBA.

1.1.8 Realignment option 3

- Receivers fronting Thule St would be exposed to similar noise levels to that currently experienced.
- Properties to the along Vine St and Burnett St are predicted to experience highly elevated noise levels due to the closure of Murray Pde. The increase is approximately 10 dBA due increased traffic movements.

7.4 Review of maximum noise levels

When assessing short term maximum noise levels from the proposal, the current sleep disturbance guidelines used in NSW have been considered. A review of research on sleep disturbance in the RNP indicates that in some circumstances, higher noise levels may occur without significant sleep disturbance. Based on studies into sleep disturbance, the RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions
- One or two noise events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

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

The ENMM therefore defines a maximum noise event as any passby for which:

- The L_{Amax} noise level exceeds the $L_{Aeq(1\ hr)}$ noise level by at least 15 dBA *and* is in excess of 65 dBA.

The analysis was performed on two representative days of logger data on 13 Thule St, where L_{Amax} from trucks. Results of this assessment are provided in **Table 18** and include predicted maximum internal noise levels. The internal L_{Amax} noise levels are based on the 95th percentile event L_{Amax}, and include a conservative 10 dBA outside to inside noise reduction assuming open windows (for ventilation). Results that are 65 dBA or higher are highlighted in red.

Table 18 Night-time vehicle pass by (L_{Amax} – L_{Aeq}) noise assessment - 13 Thule St

Hour	0	1	2	3	4	5	6	22	23	TOTAL (to next night)
5/02/2015								60 / 4	64 / 2	**27**
6/02/2015	63 / 1	63 / 4	61 / 1	59 / 1	62 / 2	61 / 7	70 / 5	62 / 5	62 / 5	**25**
7/02/2015	58 / 2	59 / 1	58 / 2	60 / 2	62 / 1	56 / 5	64 / 2	0 / 0	61 / 3	**17**
8/02/2015	58 / 2	57 / 3	0 / 0	0 / 0	59 / 1	58 / 5	65 / 3	58 / 6	59 / 2	**26**
9/02/2015	60 / 1	56 / 1	57 / 3	59 / 1	63 / 3	62 / 7	67 / 2	59 / 1	65 / 6	**21**
10/02/2015	60 / 1	59 / 1	61 / 1	63 / 2	62 / 1	61 / 6	70 / 2	60 / 5	61 / 3	**32**
11/02/2015	61 / 3	60 / 2	61 / 3	60 / 1	58 / 1	60 / 7	68 / 7	63 / 5	55 / 2	**31**
12/02/2015	63 / 3	58 / 1	61 / 2	59 / 2	66 / 2	63 / 5	67 / 9	66 / 6	64 / 3	**28**
13/02/2015	92* / 1	62 / 3	61 / 3	0 / 0	0 / 0	64 / 6	78 / 6	64 / 3	63 / 3	**26**
14/02/2015	56 / 2	0 / 0	58 / 2	61 / 1	65 / 3	60 / 8	66 / 4	57 / 2	70 / 3	**16**
15/02/2015	57 / 2	56 / 1	0 / 0	58 / 1	0 / 0	71 / 3	71 / 4	66 / 6	58 / 1	**23**
16/02/2015	61 / 1	0 / 0	0 / 0	57 / 1	59 / 2	64 / 6	68 / 6			**-**

* This result is assumed to be extraneous.

From **Table 18**, up to 32 maximum noise level events may be expected per night, with typical internal L_{Amax} levels of 58 dBA to 63 dBA, and a small number of events greater than 65 dBA.

For Option 1 and Option 2, similar L_{Amax} levels would be experienced by residents along the diverted route to those measured and presented above.

Option 3 would represent the least change to the current situation, as houses are already exposed to L_{Amax} events from trucks.

For Options 1 and 2, the number of L_{Amax} events experienced by residents would be similar to those presented in the table above.

8 CONSTRUCTION NOISE IMPACT ASSESSMENT

8.1 Construction noise modelling

To allow for the complex effects due to shielding and reflection provided by the various buildings, a three dimensional (3D) computer noise model was prepared using the SoundPLAN (ver7.3) computer noise modelling package. The model used the CONCAWE algorithm to predict the level of noise at the surrounding noise sensitive receiver areas.

The noise model included the following input parameters:

- A digitised terrain map (ground contour elevations) as per the operational road traffic noise model.
- The location of sensitive receivers for assessment purposes. The same receptors as used in the operational road traffic noise model have been used for the construction noise assessment.
- The location and acoustic Sound Power Level (SWL) of critical construction noise plant (refer to **Section 9.3**).
- Ground and air absorption effects. The model includes absorptive ground as the vast majority of the surrounding land is comprised of grassy parkland, and reserve areas (i.e. there are minimal sealed roads or concreted areas surrounding the works site).
- Shielding provided by any intervening buildings, earth bunds or changes in elevation.

8.2 Construction hours

The proposed work is anticipated to take 12 months, with construction scheduled to being in Q3 2015.

In order to minimise the potential noise and vibration impact upon nearby sensitive receivers, the majority of the construction work is proposed to be undertaken during standard daytime periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays) with no work on Sundays or Public Holidays.

8.3 Construction scenarios, equipment and sound power levels

The proposed construction work would be undertaken using standard plant and equipment frequently used on similar sites. In order to assess the potential noise and vibration impact during construction, a number of scenarios comprising typical plant and equipment have been developed. These scenarios are summarised in **Table 17**.

In accordance with the ICNG, activities identified as being particularly annoying attract a 5 dB “annoyance penalty”. Activities and associated plant operations which contain potential tonal, impulsive, and intermittent and/or low frequency noise characteristics would typically be identified as annoying. The reported sound power levels include appropriate adjustments to account for this.

Table 19 Construction scenarios and typical equipment involved

Scenario	Activity	Equipment used	No. of plant	Sound power level (dBA) L_{Aeq}
1	Installation of new piles for temporary bridge and sheet piling at coffer dam	Crane & barge	2	106
		Craneage for Piling (lifting piles, casings etc.)	1	98
		Impact Piling Rig (pre-cast concrete piles)	2	128[A]
		Sheet Piling Rig	1	131[A]
		Truck (delivery / removal)	1	93
2	Install span to temporary bridge	100T Crane	1	105
		Franna Crane	1	106
		Crane & barge	2	106
		Generator	1	101
		Compressor	1	106
		Pump	1	97
		Boat	1	90
3	Remove old timber decking / clean metalwork, rust etc.	Circular Saw	2	106[A]
		Chainsaw	2	117[A]
		Small grinder and drill	1	108[A]
		Needle gun	1	106[A]
		General hand tools	1	94
		Boat	1	90
		Compressor	1	106
		Generator	2	101
		Pump	1	97
		Truck (delivery / removal)	1	93
		Scissor Lift	1	98
4	Install new timber decking	Hand tools	2	94
		Circular saw	1	106[A]
		Chainsaw	1	117[A]
		Nail gun	3	106[A]
		Hand drill	2	100
		Compressor	1	106
		Generator	2	101
		Truck (delivery / removal)	1	93
		Scissor Lift	1	98
5	Install trusses to Bridge	100T Crane	1	105
		600T Crane	1	110
		Franna Crane	1	106
		Crane & barge	1	106
6	Temporary Bridge Removal	Mobile Crane	2	105
		Crane & Barge	2	106
		Excavator w/ rock breaker (breaking piles)	1	126[A]

Note A: Denotes "annoying" item of equipment, as defined in the ICNG, and as such includes a +5 dB penalty to predictions.

9 CONSTRUCTION NOISE ASSESSMENT

Using the sound power levels in **Table 19**, construction noise levels have been predicted at the surrounding receiver locations for each construction scenario.

The resultant noise levels would inevitably depend on the number and type of plant and equipment operating at any one time and their precise location relative to the receiver of interest. For this assessment all plant and equipment considered in each scenario has been conservatively assumed to be operating simultaneously. In practice, the noise levels would vary due to the fact that plant and equipment would move about the worksites and would not all be operating concurrently. In some cases, reductions in noise levels would also occur when plant is located behind hoardings, buildings or even other items of equipment.

Due to the large number of receptors located throughout the township and considered in the assessment it would be impractical to show the predicted noise level for each receptor. Consequently, the results presented in **Table 20** show the total number of receptors for each scenario within the nominated noise range including the highly noise affected threshold (i.e. greater than 75 dBA) and lower noise affected range (i.e. greater than the daytime NML).

Noise contour plots are also shown for each stage of works / scenario in **Appendix D**.

Table 20 Construction noise predictions

Predicted Noise Range $L_{Aeq(15min)}$ dBA	Number of Receptors within Predicted Noise Range for Scenario					
	1. Driven / sheet piling works	2. Install span to temporary bridge	3. Remove old decking & clean metalwork	4. Install new timber decking	5. Install trusses to bridge	6. Temporary bridge removal
> 75	28	0	0	0	0	2
70 to 75	68	0	3	2	0	7
65 to 70	84	2	6	4	2	23
55 to 65	180	17	57	53	17	109
50 to 55	16	34	58	47	33	97
45 to 50	0	45	100	94	47	65
40 to 45	0	95	91	93	91	44
No. receptors > NML	376	68	163	140	63	276

9.1 Discussion of Exceedances

From **Table 19** it is evident that the predicted noise levels exceed the nominated daytime NML criterion at a large number of receptors for most of the construction stages.

A brief discussion of the various scenarios is provided below.

Scenario 1 – Driven / Sheet Piling Works

The largest impact during the entire construction program is expected to occur during the driven/sheet piling work required for the construction of the temporary Mabey bridge and coffer dam. During this work the noise at up to 28 receptors (located within approximately 150 m of the works area) are predicted to exceed the 75 dBA highly noise affected range nominated in the ICNG.

For the closest most affected residential premises on Murray Pde (southwest of the temporary bridge area) the predicted noise from the piling work was up to 83 dBA. This equates to an exceedance of the daytime NML of 45 dBA.

As noise levels at both the residential and commercial/industrial receivers are predicted to exceed the highly noise affected threshold nominated in the ICNG, a high level of impact is probable during this work and all feasible and reasonable means of reducing this exceedance should be made. To do this it is recommended that respite periods be considered, with particular consideration be given to receptors closest the proposed work areas (ie residential properties fronting Murray Pde to the south and Murray Street to the north as well as the Barham District Services Memorial Bowling Club, Barham Bridge Motor Inn and Royal Hotel – refer to **Appendix D**).

In addition, further consideration should also be given to restricting the hours that piling would occur, taking into account:

- Times identified by the community when they are less sensitive to noise (such as mid-morning or mid-afternoon for works near residences).
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Scenario 2 – Install Span to Temporary Bridge

During this work the highest noise level was 67 dBA predicted at the Royal Hotel located to the north east of the existing bridge. The noise levels are due to the nearby operation of the cranes required to install the span to the temporary bridge.

The predicted noise levels at the closest residential areas to the work is typically between 55 dBA and 60 dBA. For dwellings approximately more than 150 m from the temporary bridge approach, the predicted noise levels are typically below 55 dBA. While this still equates to a number of exceedances of the NML criteria, the exceedances are fairly minor and are likely to be tolerated for the reasons notified above.

Scenario 3 & 4 – Remove / Install Timber Decking to Bridge

For these scenarios there are no predicted exceedances of the highly noise affected criteria. The highest noise levels for both stages (up to 73 dBA) were predicted at the Orange Factory at 156 Grigg Road.

It is noted that the results predicted during these stages exceed the nominated NML criteria at a large number of receptors; however, the high levels are predominantly due to the operation of particularly loud items of hand operated equipment (predominantly the chainsaws). Once again, whilst this equipment is will likely be required for more than a continuous 15 minute period where extensive works are required, the equipment is unlikely to be used throughout the entire day. Where the chainsaws are not used a significant reduction (up to 10 dBA) in noise levels is predicted.

Scenario 5 – Install Trusses to Bridge

The results for this stage are similar to those for Scenario 2 where the temporary bridge was installed by crane albeit the location of the work is slightly different. The highest predicted noise level was 67 dBA at the Royal Hotel located opposite the intersection to the north of the bridge.

The predicted noise levels would generally be tolerated given that work would be conducted during the day period only.

Scenario 6 – Temporary Bridge Removal

The predicted noise levels were found to exceed the highly noise affected criterion at up to two properties; the Royal Hotel and one location on Murray Pde.

The predicted noise levels during this stage were dominated by the excavator mounted rock breaker required to remove the concrete piles for the temporary bridge. If possible it is recommended that alternative methodology be considered such as saw cutting.

9.2 Noise Mitigation and Management Measures

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

In order to minimise the potential noise and vibration impact upon nearby sensitive receivers, most construction work is proposed to be undertaken during the EPA's standard daytime construction periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays).

Examples of mitigation measures which may be considered appropriate for this work are:

- Where practicable, install localised acoustic hoarding around significantly noise generating items of plant. This would be expected to provide between 5 dB and 10 dB of additional noise attenuation, if adequately constructed to ensure line-of-sight between all receivers and the construction equipment is broken.
- Planning of the higher Noise Management Level exceedance activities/locations to be undertaken predominantly during less noise-sensitive periods (i.e. away from early morning / late afternoon periods when residents are home from work), where available and possible.
- Briefing of the work team in order to create awareness of the locality of sensitive receivers and the importance of minimising noise emissions.
- Use of less noise-intensive equipment, where reasonable and feasible.
- Use of respite periods during highly noise intrusive works.

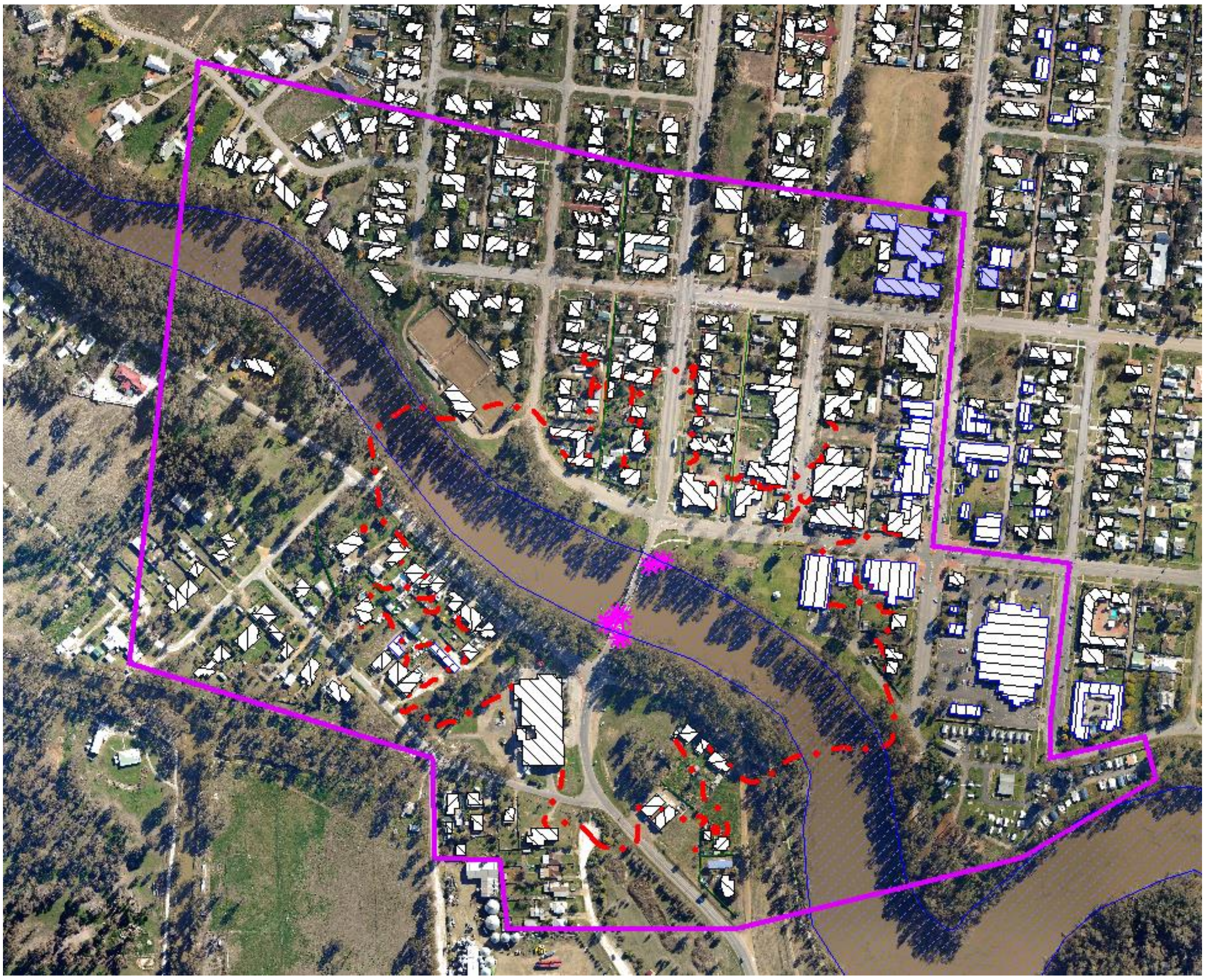
1.1.9 Noise Mitigation Requirements

With reference to **Section 9** and considering that all work is proposed to occur during standard construction hours, noise impact during the piling work is likely to be quantified as moderately to highly intrusive.

Consequently, it is recommended that a letterbox drop and attended monitoring be undertaken during this stage.

It is noted that due to the generally low background noise levels in the area the affected area extends for a considerable distance (approximately 350 m to 400 m) from the work. The relevant area is shown in **Figure 8** as a thick pink line.

Figure 8 Recommended Area for Mitigation Measures during Piling Works



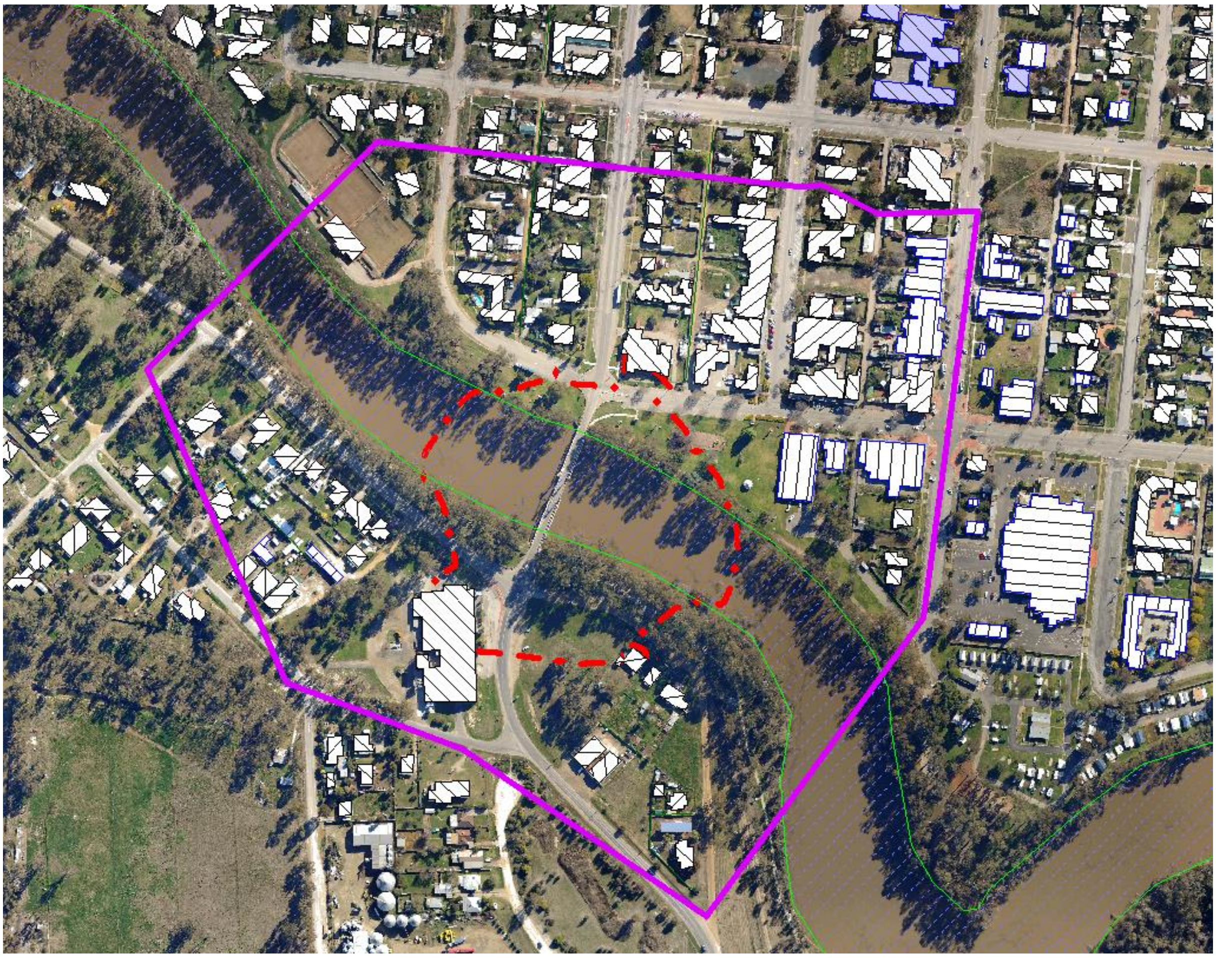
It is recommended that as a minimum a letterbox drop be conducted informing all building occupants of the proposed works ahead of time. This letter should outline the proposed timing and duration of work as well as provide the community with a contact number or liaison officer available to adequately respond to all project related enquiries.

In accordance with the CNS, additional recommended mitigation strategies to be implemented at these receptors also include noise monitoring for which it is recommended particular attention be provided to the highly noise affected zone outlined in **Appendix D**, **Map 1** and shown in **Figure 7** as the red dashed line .

With the exception of the final stage (i.e. the removal of the temporary bridge), construction noise emissions for the remaining scenarios are generally not sufficient to warrant additional mitigation measures such as monitoring.

For the final Scenario 6 the recommended zone is provided in **Figure 9** below**.** As with the earlier Piling Work, it is recommended that any attended monitoring focus on the Highly Noise Affected Zone as outlined in **Appendix D**, **Map 6** (shown in **Figure 9** as the red dotted line). As previously mentioned, the resultant zone of influence can be substantially reduced where the piles are cut instead of broken.

Figure 9 Recommended Area for Implementation Measured during Removal of Temporary Bridge



9.3 Construction vibration

As discussed in **Section 5.4**, equipment such as rockbreakers, excavators, piling rigs and heavy vehicle movements are considered intermittent.

1.1.10 Assessment

Indicative safe working distances for typical items of vibration intensive plant are listed in **Table 21**. The indicative working distances are quoted for both structural building damage and human comfort.

Table 21 Indicative working distances for vibration intensive plant

Plant Item	Rating/description	Indicative safe working distance (metres)	
		Structural damage	Human response[1]
Small hydraulic hammer	(300 kg - 5 to 12t excavator)	5 m	10 m
Medium hydraulic hammer	(900 kg - 12 to 18t excavator)	15 m	25 m
Large hydraulic hammer	(1600 kg - 18 to 34t excavator)	40 m	75 m
Vibratory pile driver	Sheet piles	8 m	20 m
Pile boring	≤ 800 mm	4 m	8 m
Jackhammer	Hand held	2 m	Avoid contact with structure

Note 1: The working distances for Human Response assume that the source of the vibration is continuous throughout the daytime period. Higher levels of vibration are acceptable when the vibration levels are intermittent or impulsive. The safe working distances are therefore considered to be conservative and it is likely that the safe working distances corresponding to a "low probability of adverse comment" would be lower than indicated.

The working distances presented in **Table 21** are indicative only and would vary depending on the particular item of plant and local geotechnical conditions.

Vibration intensive activities (earthwork and piling) for this project are not expected to take place at distances closer than the structural damage working distances presented in **Table 21**. Some human response may be experienced by residents. As work is to take place in the day period only this represents a low-risk of impact. Management techniques should be implemented should complaints be received by the project. **Section 10** discusses these in more detail.

10 CONSTRUCTION NOISE CONTROL MEASURES

A Noise and Vibration Management plan will need to be developed as part of the overall Construction Environment Management Plan (CEMP).

Given the potential for the predicted noise exceedances, noise mitigation strategies should be implemented wherever feasible during the construction work. Where feasible and reasonable, the quietest plant and equipment should be utilised in combination with management measures to minimise the noise impact on the local community.

Refer to *AS2436 – 1981 Guide to noise control on construction, maintenance and demolition sites*, which provides guidance on control of noise and vibration from construction activities.

Construction strategies

- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers would also result in reduced noise emissions
- Where practicable, the offset distance between noisy plant items and nearby noise sensitive receivers should be as great as possible
- As far as possible, maintenance work on all construction plant should be carried out away from noise sensitive receivers and confined to standard daytime construction hours
- Regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than normal
- Restricting truck speed on the site to reduce noise from the transport operation
- Limiting the hours during which site activities are likely to create high levels of noise and vibration
- Ensuring that site access roads are kept even so as to mitigate the potential for vibration from trucks.

Ongoing noise monitoring during construction at sensitive receivers during critical periods (ie times when noise emissions are expected to be at their highest) would assist in identifying and controlling high risk noise events.

Source noise control strategies

- Engines and exhausts are typically the dominant noise sources on mobile plant such as bulldozers, cranes, graders, excavators, trucks, etc. In order to reduce noise emissions, more efficient silencers or exhausts could be fitted potentially providing additional attenuation
- Low noise “silenced” generators should be used on the project where feasible
- Regular maintenance of all plant and machinery used for the project would assist in minimising noise emissions.

Noise Barrier Control Strategies

Temporary noise barriers are recommended where feasible, between the noise sources and all nearby potentially affected noise sensitive receivers, wherever possible. Typically, 7 dBA to 10 dBA of attenuation can be achieved with a well-constructed barrier. Specific strategies include:

- Orientation of the noisy equipment whereby the least noisy side of the equipment is facing the closest receiver.

The positioning of any site huts/maintenance sheds adjacent to the noisy equipment, in the direction of the closest receiver

Limiting of hours

The assessment of the potential impact from construction noise indicated that the higher exceedances of the Noise Management Levels were generally associated with use of:

- Rockbreakers;
- Jackhammers; and
- Piling Rigs.

There is therefore scope to reduce the potential noise impact during the more sensitive periods by restricting such activities, where sensitive receivers are likely to be adversely affected, to daytime and evening periods, where feasible and reasonable.

Noise management versus noise control

The mitigation of noise impact can often involve noise management as distinct from noise control. For example, the scheduling of noise-intensive activities could be an effective noise management strategy.

Specifically, time restrictions should be placed on the most noise-intensive activities, especially, rockbreaking and the use of jackhammers in the vicinity of sensitive receivers, as discussed above. For example, where there is a definite requirement for such activities to be completed out of the normal construction hours, they could be restricted to 9:00 pm to 11:00 pm where reasonable and feasible.

Similarly, with respect to the activities located at any one section in the vicinity of sensitive receivers, advanced notice of high noise activities should be provided and respite periods employed, eg no two consecutive evenings in the same area where rockbreaking are being used, where feasibly and reasonably practicable.

An important component therefore of the noise management of the proposed work is comprehensive community consultation which should continue through all major stages of the construction programme.

The community would be kept informed as to the nature, timing and duration of impending work, the nearest sensitive receivers likely to be affected and the monitoring programme associated with the impending work.

Community liaison

A primary aim of the project should be to ensure that the local community is kept informed of the progress of the construction work in a proactive and progressive manner. A combination of internet-based information, community meetings, local newsletters, leaflets, newspaper advertisements and community notice boards should be used as appropriate.

As part of the Community Liaison process a contact person should be nominated within the Construction Noise and Vibration Management Plan to directly address any noise and/or vibration complaints that the community may have during the construction phase of the project.

The community liaison process would be progressively "fine-tuned" to meet the specific requirements of the particular works under consideration. In this manner, equipment selections and work activities can be continuously coordinated and modified where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints and other issues of concern, should they arise.

Management response strategy

In the event of a potential exceedance of the relevant noise emission criteria, an investigation would be undertaken. Consideration would be given to the margin of exceedance and the source of emission, if it has been identified. The noise, weather and plant operating data shall be documented so that the matter can be investigated and appropriate actions undertaken accordingly.

Response measures, which would be adopted following noise complaints, would include:

- Identify the noise source that has caused the complaint. This would be done by consultation with the complainant and by conducting a noise survey to quantify the level of disturbance
- Reassess mitigation techniques employed at the site to reduce the impact of the noise source in question. Particular attention should be given to the scheduling of noisy activities and the location of equipment used on site
- Following the adoption of noise mitigation, a further noise survey should be conducted at the complainant's residence to ensure the success of the mitigation strategy.

Vibration mitigation measures

The following "baseline" vibration mitigation measures are recommended where practicable:

- All construction work should be carried out Monday to Friday, 7:00 am to 6:00 pm, where possible.
- When working close to sensitive receivers, use lower vibration generating items of plant and equipment where possible eg smaller vibratory rollers and hydraulic hammers.
- Minimise consecutive vibration intensive work in the same locality (if applicable).

11 CONCLUSION

11.1 Traffic noise

The township of Barham, on the border of Victoria and New South Wales is proposed to have construction works for a period of 12 months. During this period traffic is to be diverted to a temporary bridge, with the most likely location being adjacent to the existing bridge (Option 3). Three route options have been considered and predicted noise levels presented for each.

Mitigation options usually available would not be considered for a project whose construction period is only temporary. The route selection is therefore the most viable way of minimising noise impact to the township.

From the assessment process, the number of houses affected varies very little between the three route options. For Options 1 and 2, those houses on Thule St currently experiencing high noise levels would have a reduction in noise levels. Houses on Cobwell Street would have an increase in daytime and night-time noise levels of 4 to 6 dBA and experience up to 32 significant L_{Amax} noise events during the night.

Option 3 represents the smallest change from the existing scenario and sees the greatest change in noise level from the closure of Murray Parade and the re-direction of traffic onto Vine St and Burnett St. This represents a smaller number of houses than those impacted by either Option 1 or Option 2.

It is therefore our recommendation that Option 3, the alignment alongside the existing bridge, is selected as this presents the least noise impact to the township.

11.2 Construction Noise and Vibration

Three dimensional noise modelling was conducted of the construction scenarios for the proposal in order to evaluate the potential noise impact to the community. The assessment was conducted for the following six scenarios for all of the identified receivers / catchments areas.

1. Installation of new piles for temporary bridge and sheet piling at coffer dam
2. Install span to temporary bridge
3. Remove old timber decking / clean metalwork, rust etc.
4. Install new timber decking
5. Install trusses to Bridge
6. Temporary Bridge Removal

At any particular location, the potential noise and vibration impact can vary greatly depending on factors such as the relative proximity of noise-sensitive receivers, the overall duration of the construction work, the intensity of the noise and vibration emissions, the time at which the construction work are undertaken and the character of the noise or vibration emissions.

A combination of selection of quietest available equipment and construction techniques and engineering controls in combination with environmental management and community consultation is recommended to minimise the construction noise and vibration impact at the receivers detailed above. It is recommended that a Construction Noise and Vibration Management Plan be prepared to assess the potential construction noise impact in consideration of the proposed construction methodology and plant selection and to document procedures to control and minimise the impact.

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 LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2E-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
120 110	Heavy rock concert Grinding on steel	Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerbside of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to quiet
40 30	Inside private office Inside bedroom	Quiet to very quiet
20	Unoccupied recording studio	Almost silent

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

3 Sound power level

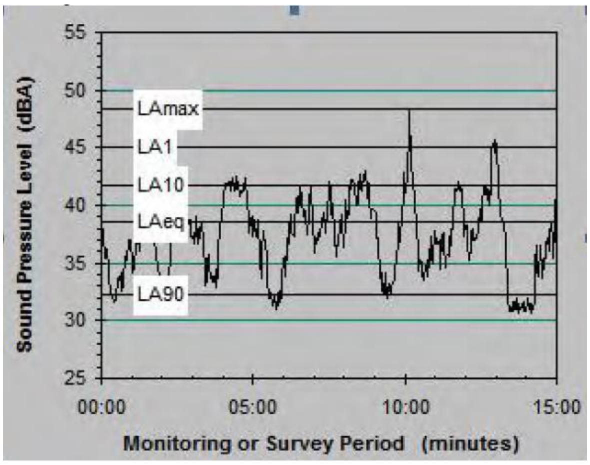
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 1E-12 W.

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 LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

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

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

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

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

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" LA90 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 (LAeq, LA10, 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

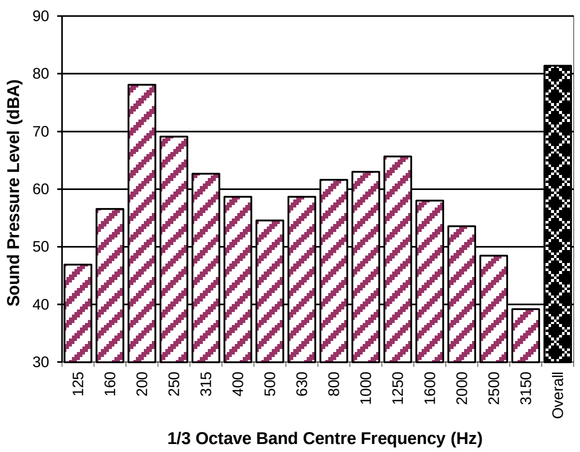
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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/Vo), where Vo is the reference level (1E-6 mm/s). Care is required in this regard, as other reference levels are 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

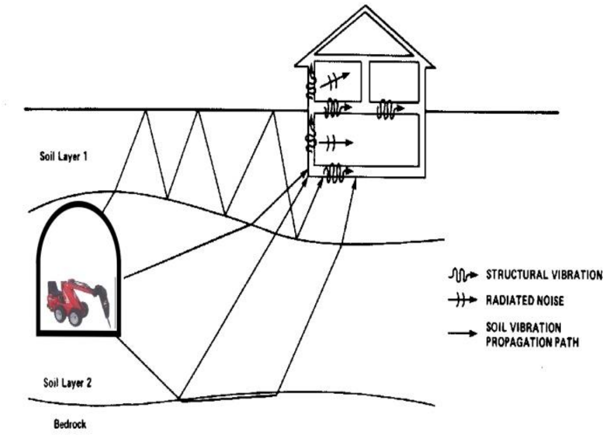
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Regenerated noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed "regenerated noise", "structure-borne noise", or sometimes "ground-borne noise". Regenerated 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 regenerated noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

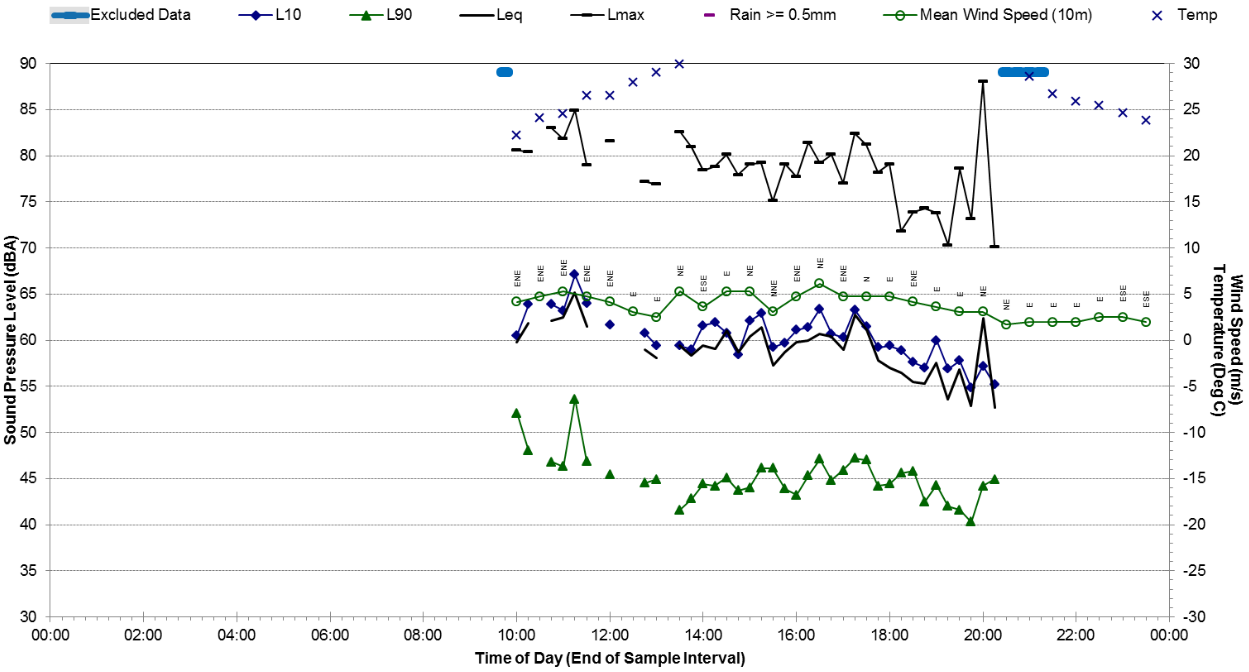
The following figure presents the various paths by which vibration and regenerated noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term "regenerated noise" is also used to describe other types of noise that are emitted from the primary source as a different form of energy. One example would be a fan with a silencer, where the fan is the energy source and primary noise source. The silencer may effectively reduce the fan noise, but some additional noise may be created by the aerodynamic effect of the silencer in the airstream. This "secondary" noise may be referred to as regenerated noise.

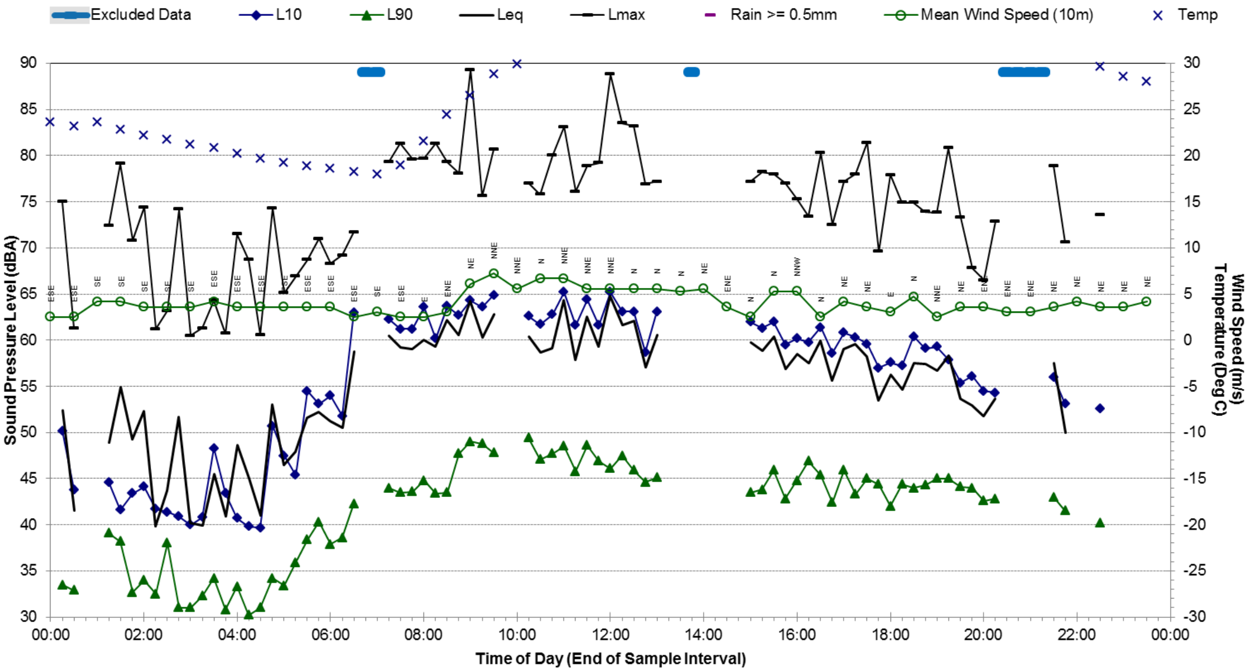
Statistical Ambient Noise Levels

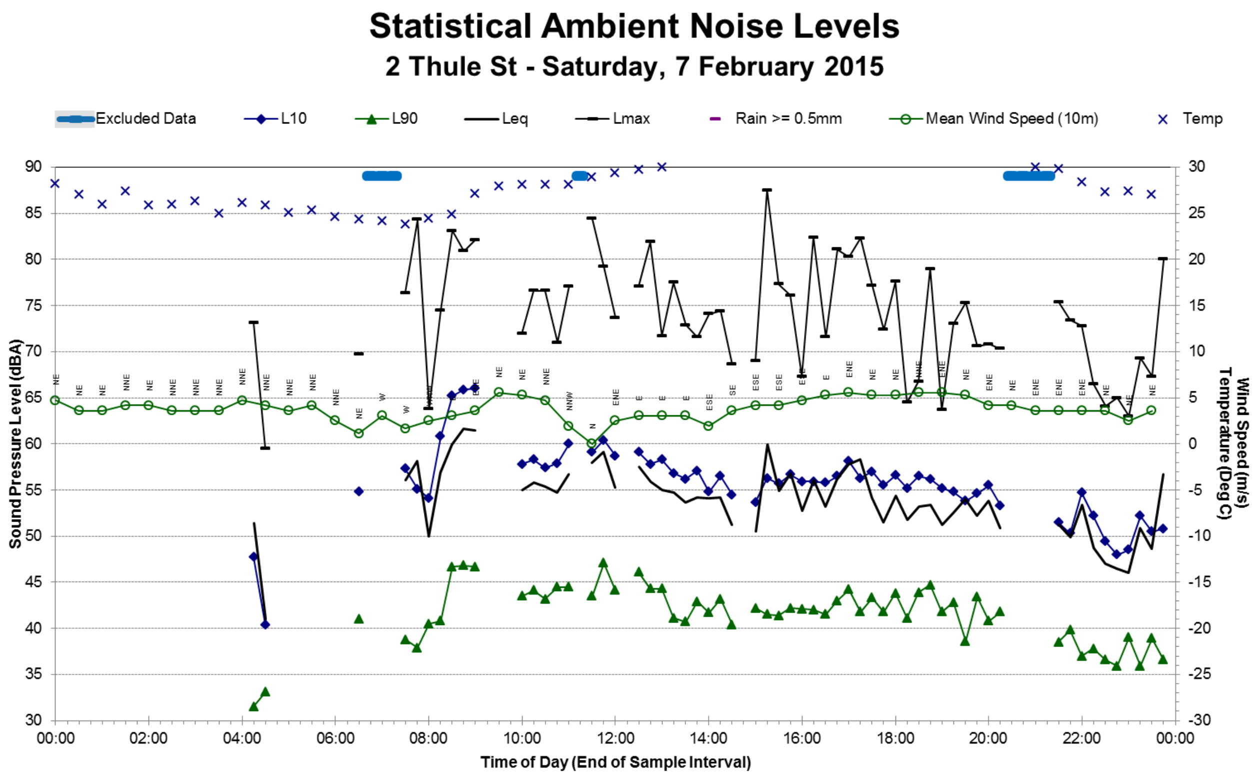
2 Thule St - Thursday, 5 February 2015

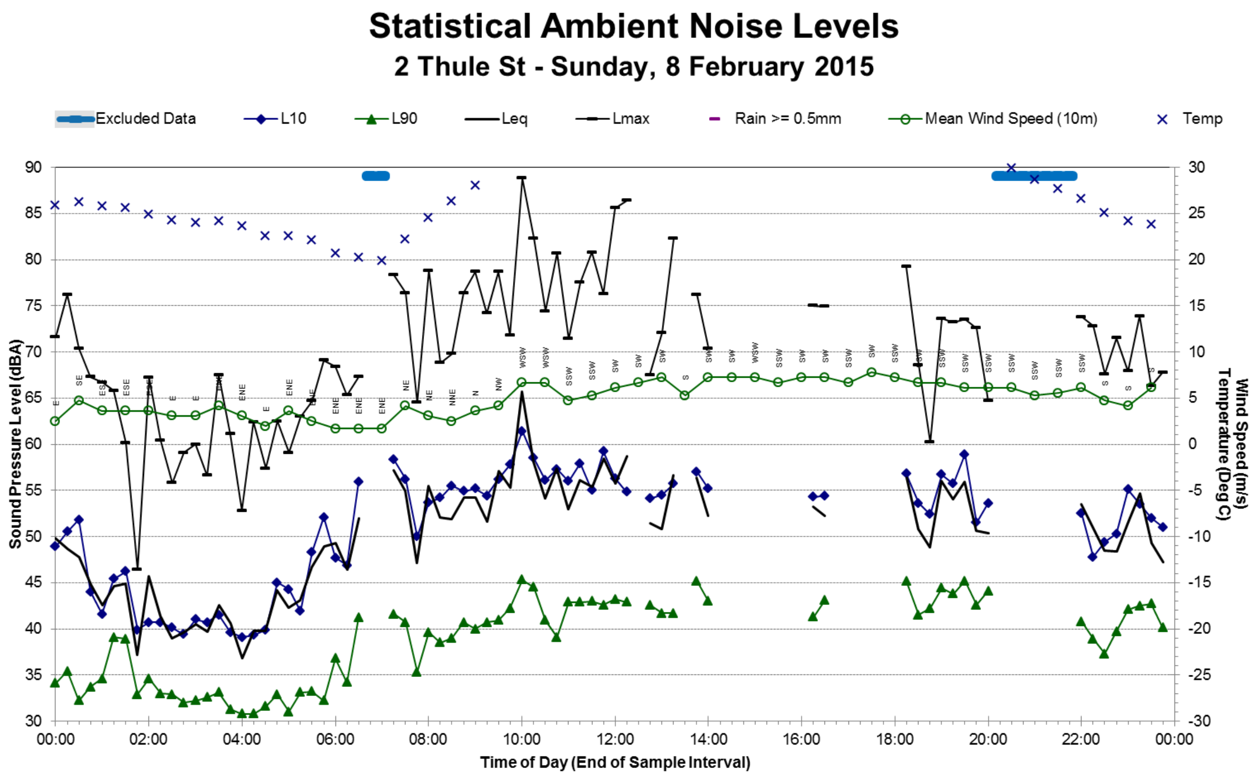


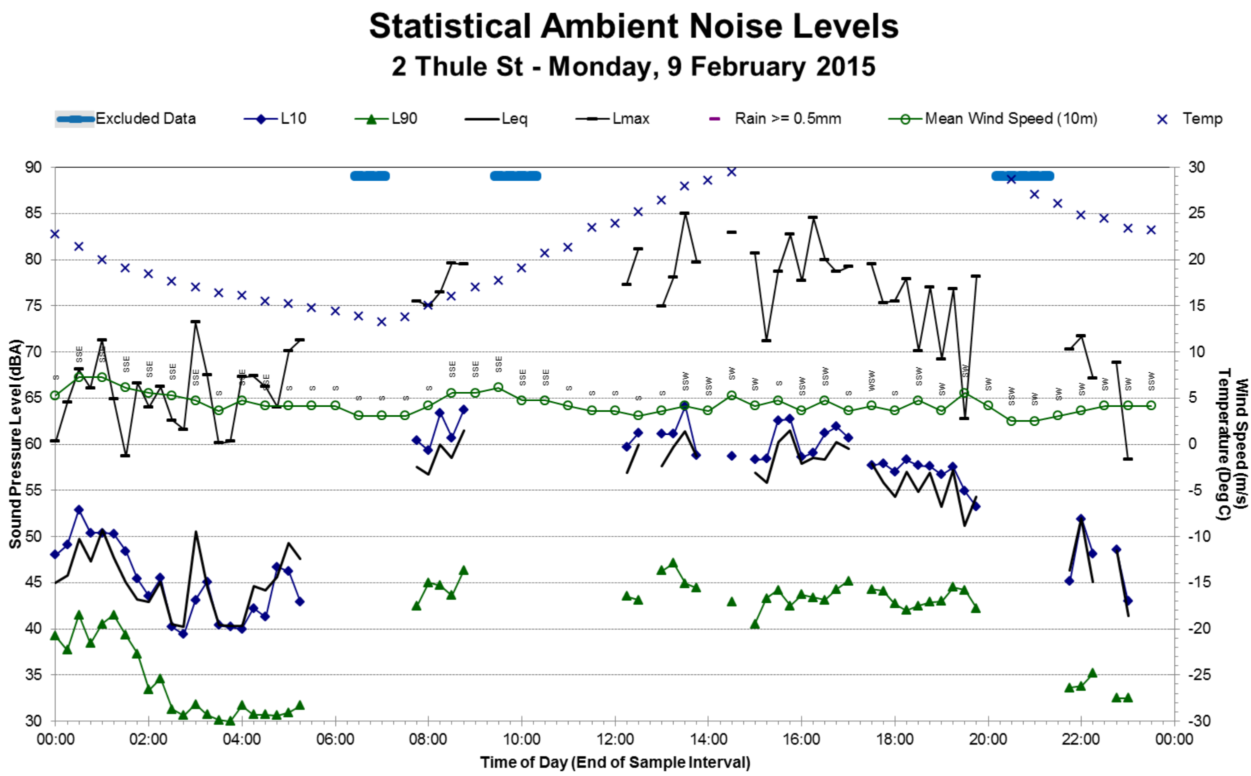
Statistical Ambient Noise Levels

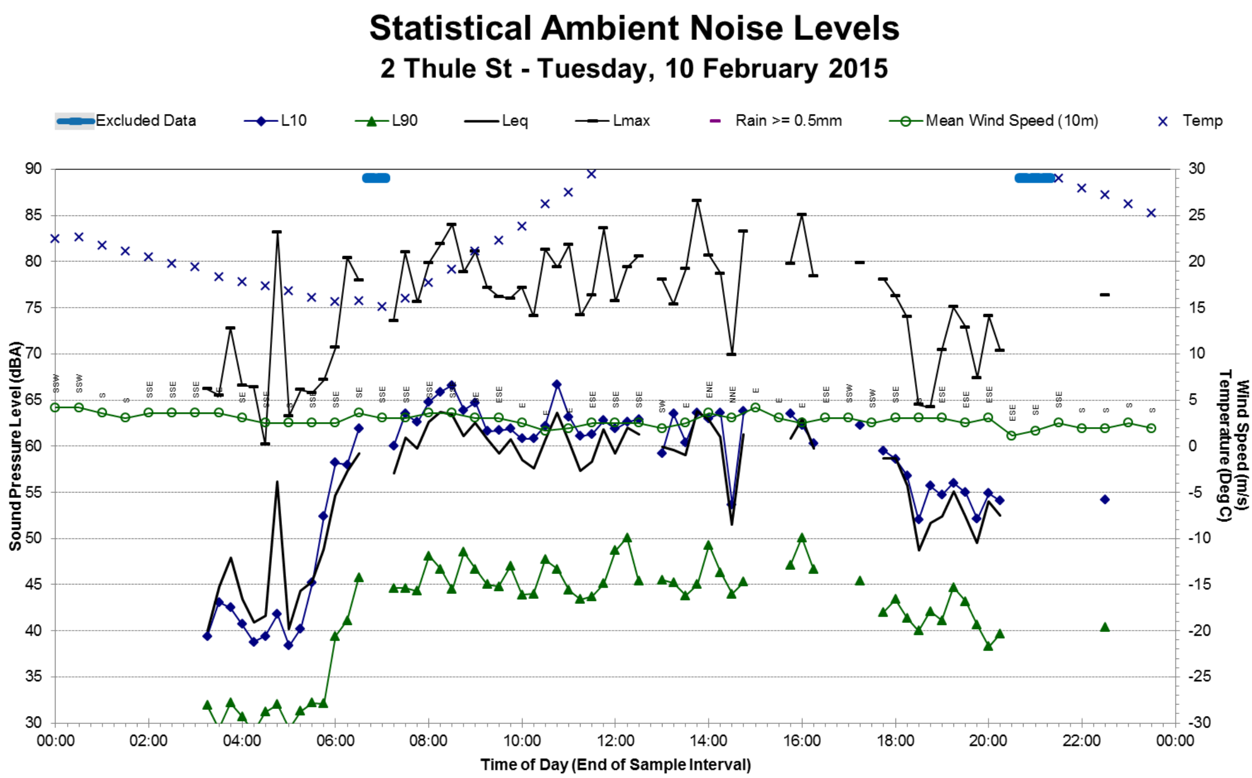
2 Thule St - Friday, 6 February 2015

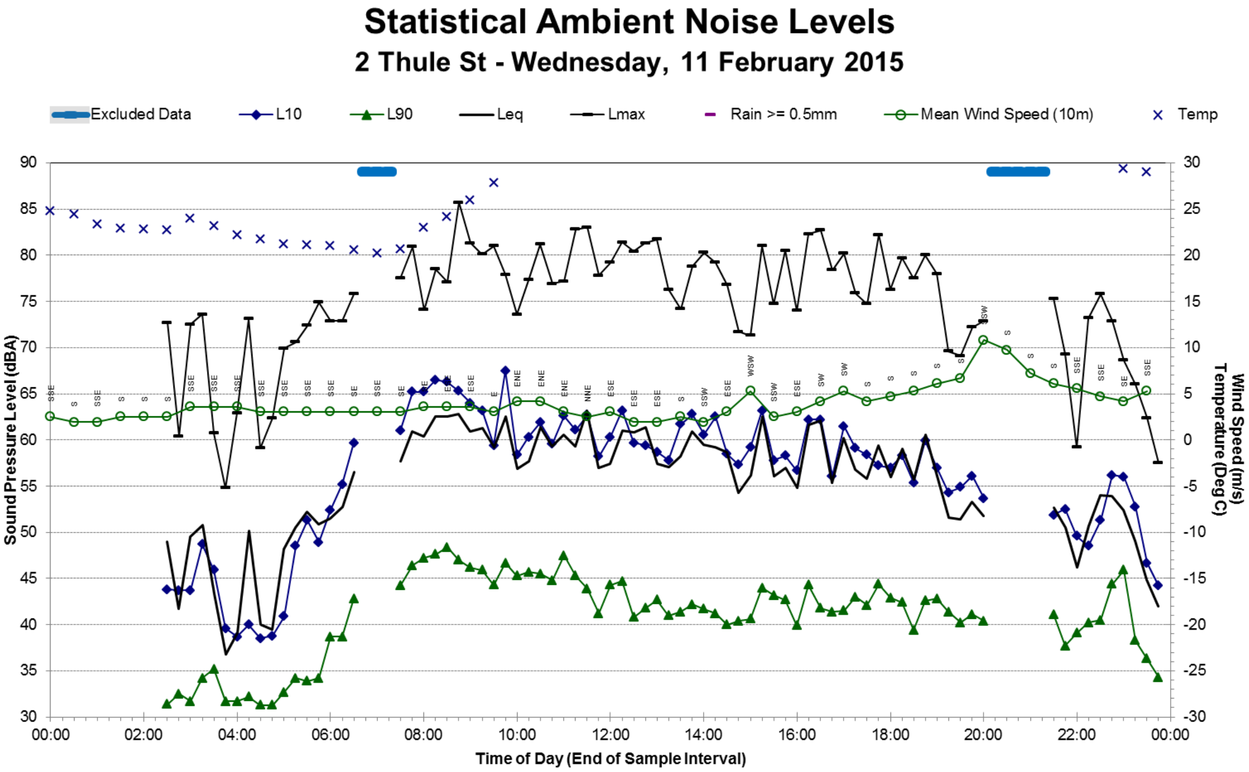


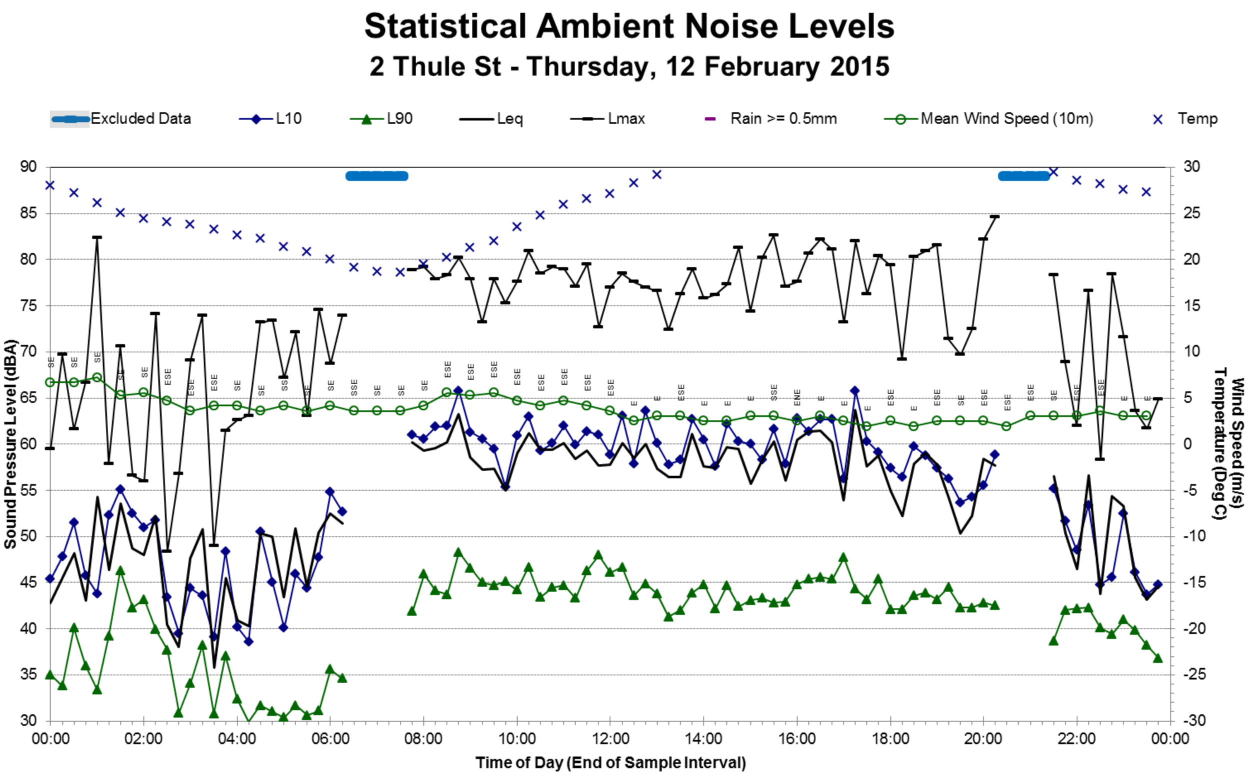

Statistical Ambient Noise Levels
2 Thule St - Saturday, 7 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
2 Thule St - Sunday, 8 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

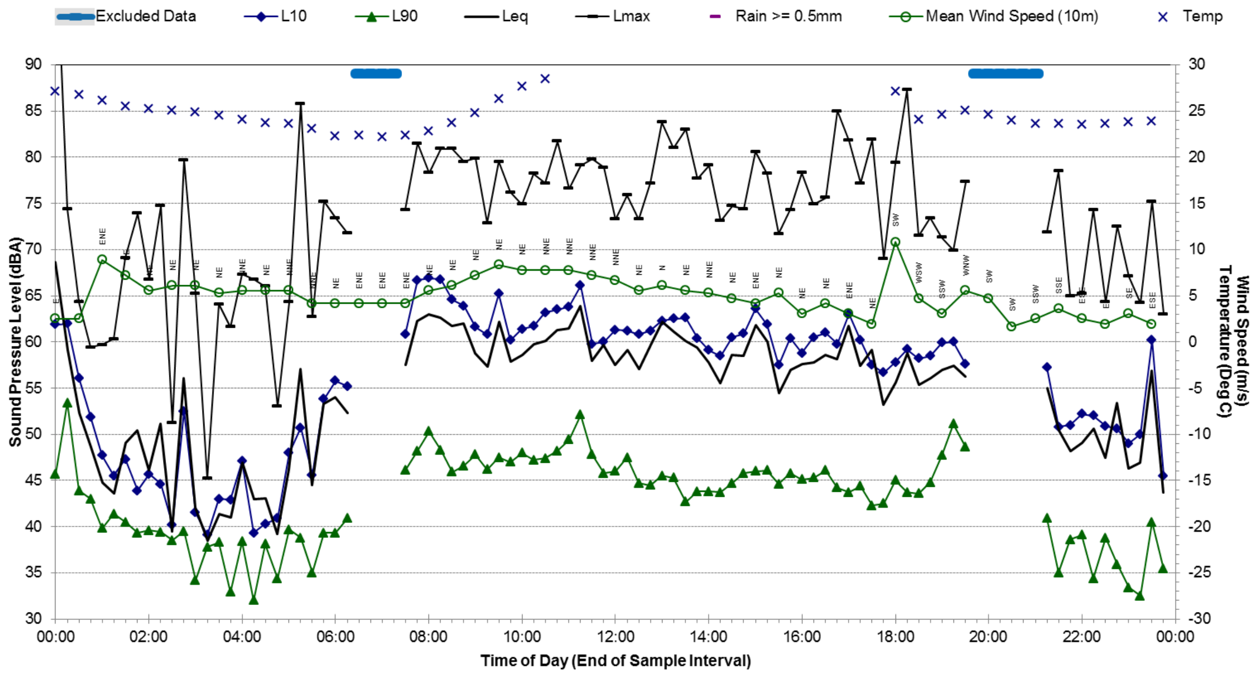

Statistical Ambient Noise Levels
2 Thule St - Monday, 9 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
2 Thule St - Tuesday, 10 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

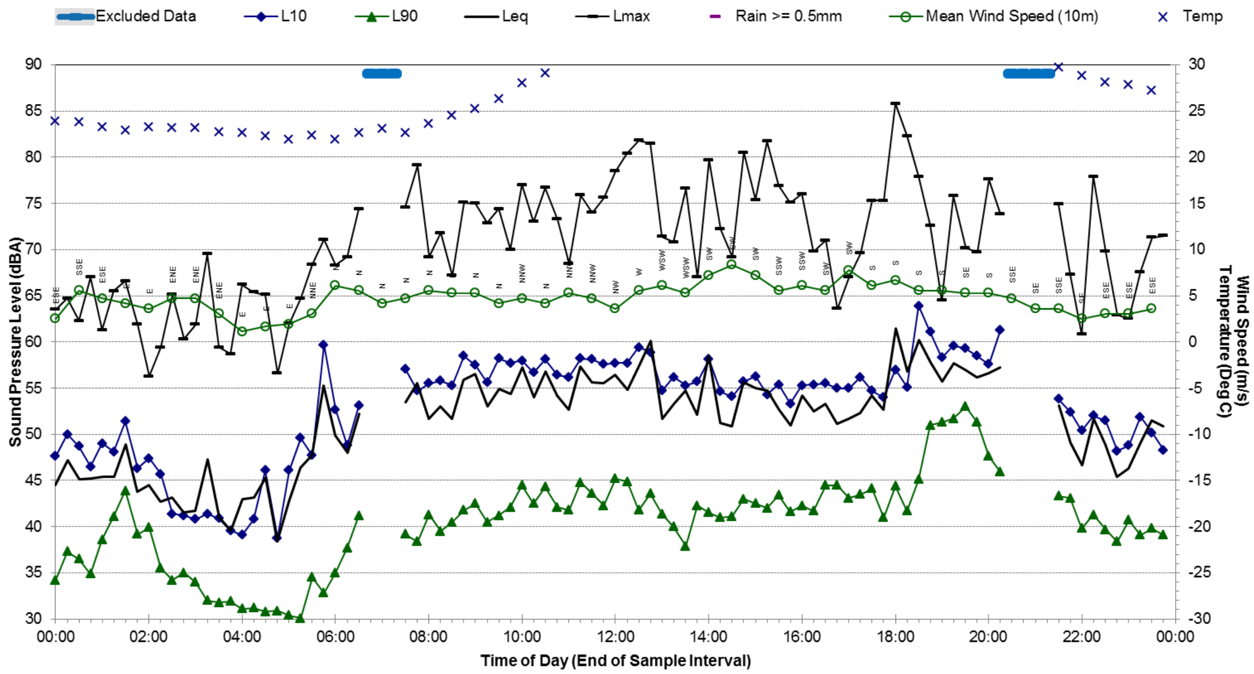

Statistical Ambient Noise Levels
2 Thule St - Wednesday, 11 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

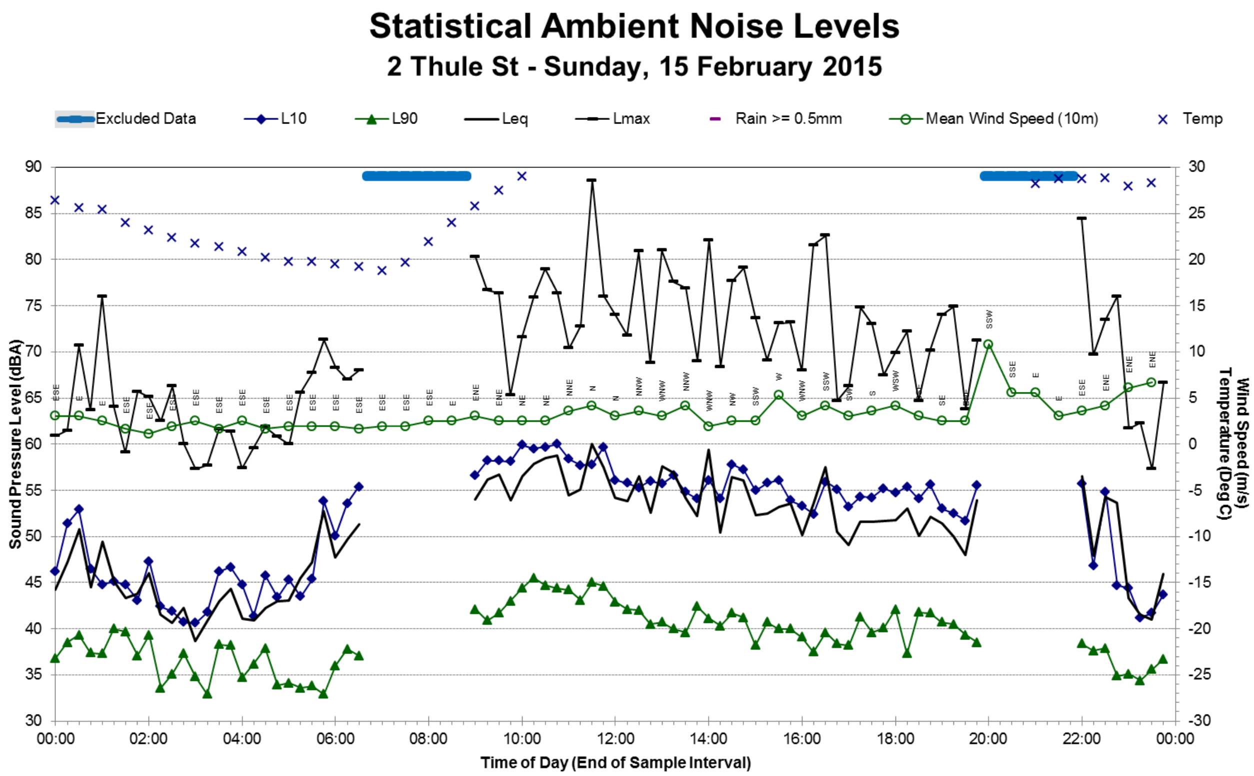

Statistical Ambient Noise Levels
2 Thule St - Thursday, 12 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

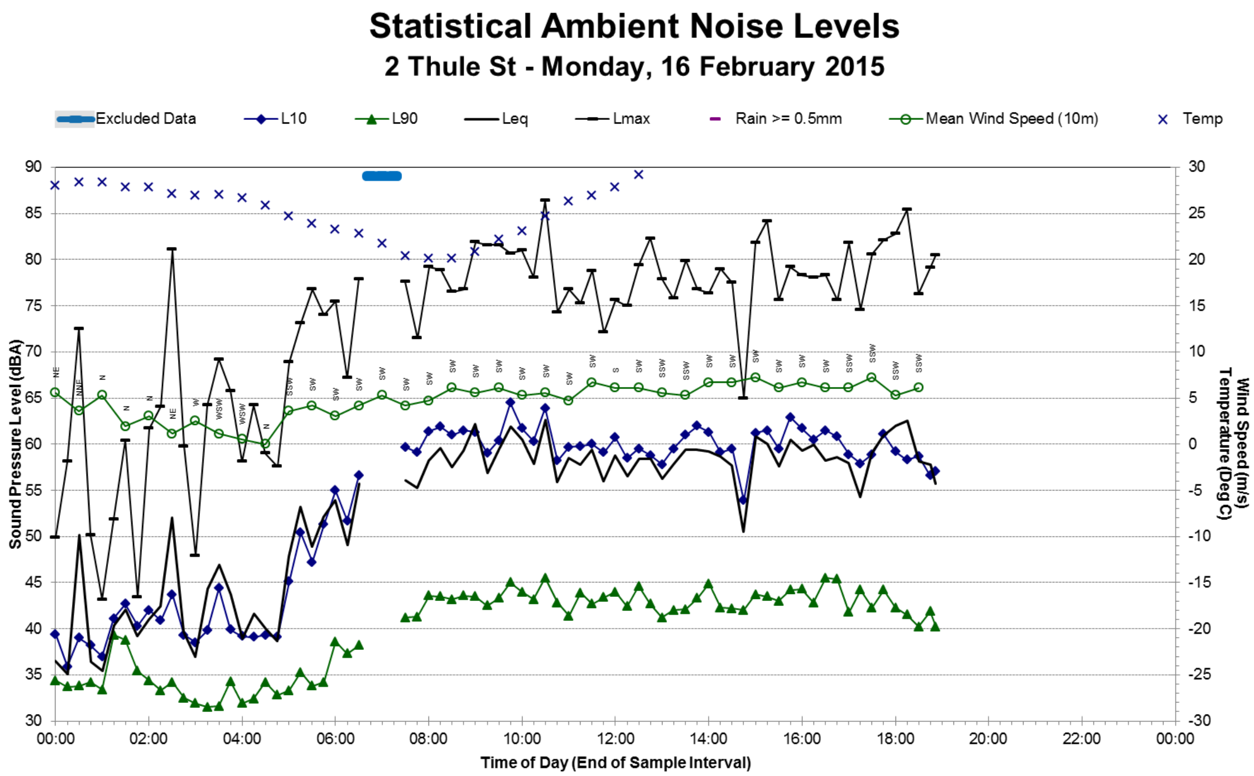
Statistical Ambient Noise Levels
2 Thule St - Friday, 13 February 2015

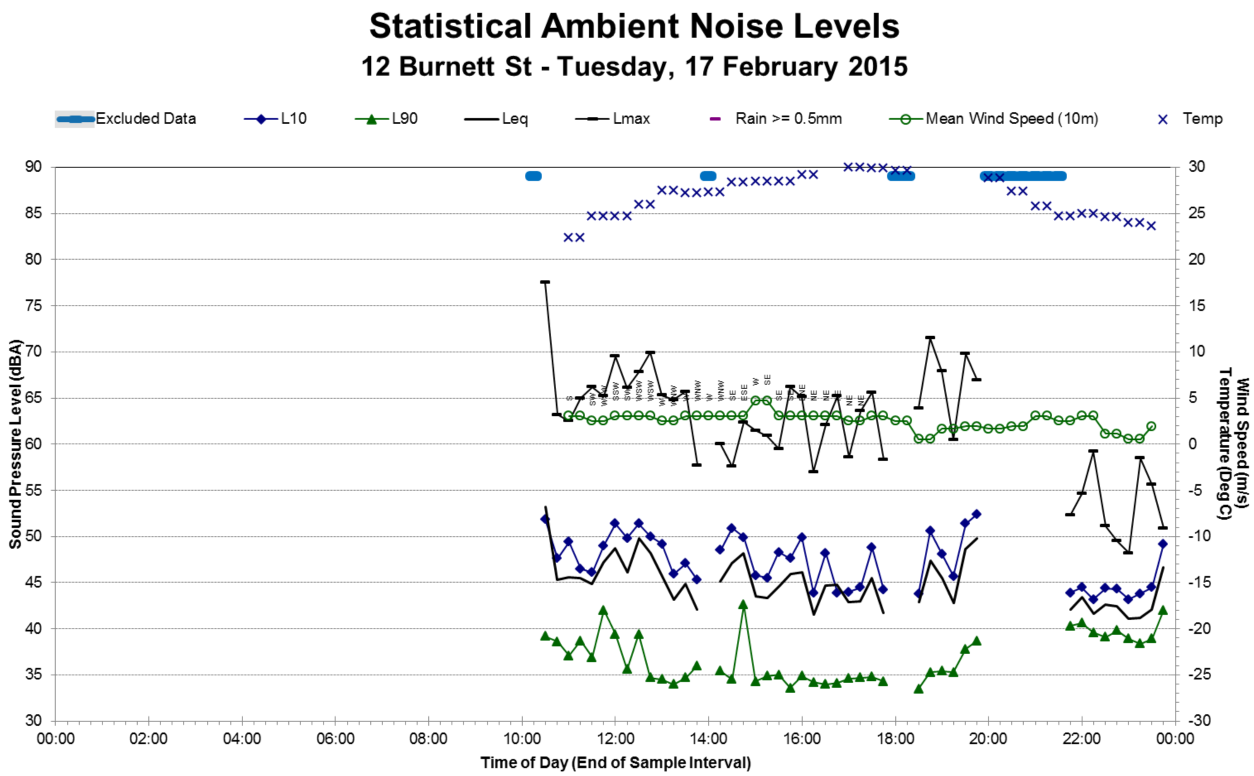


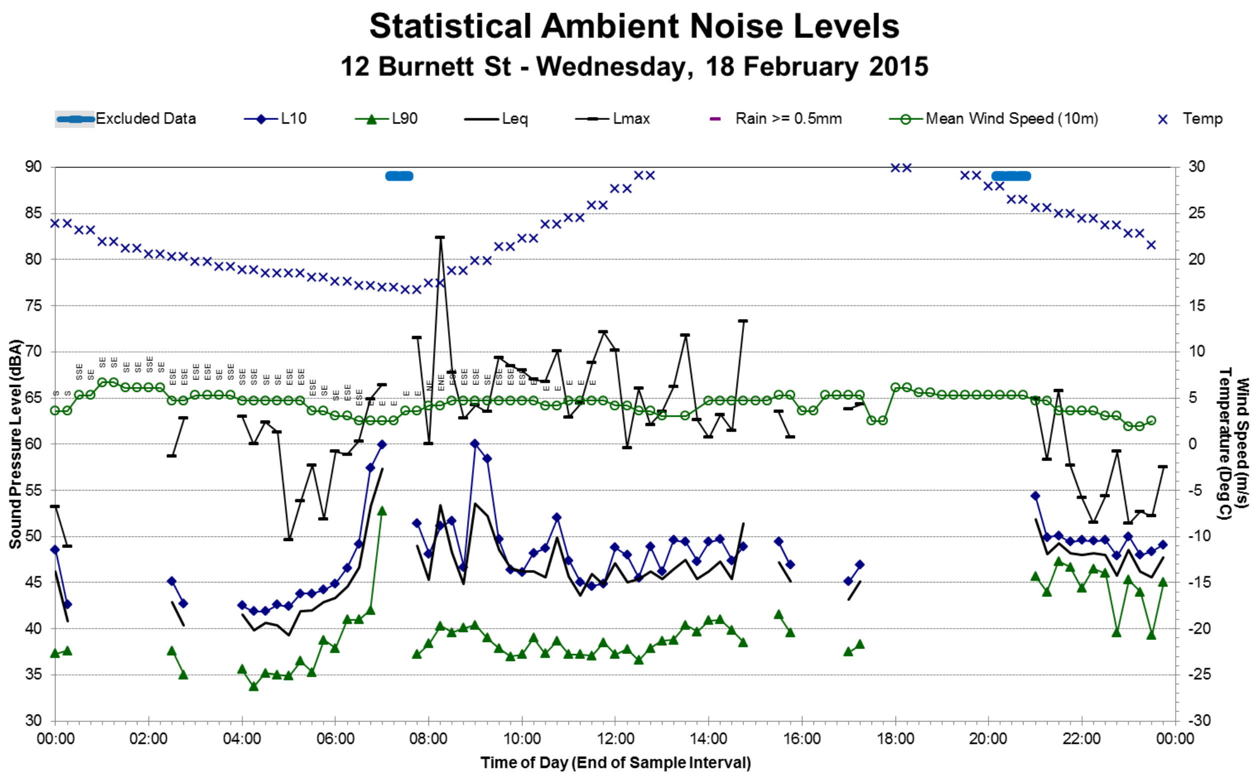
Statistical Ambient Noise Levels
2 Thule St - Saturday, 14 February 2015




Statistical Ambient Noise Levels
2 Thule St - Sunday, 15 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

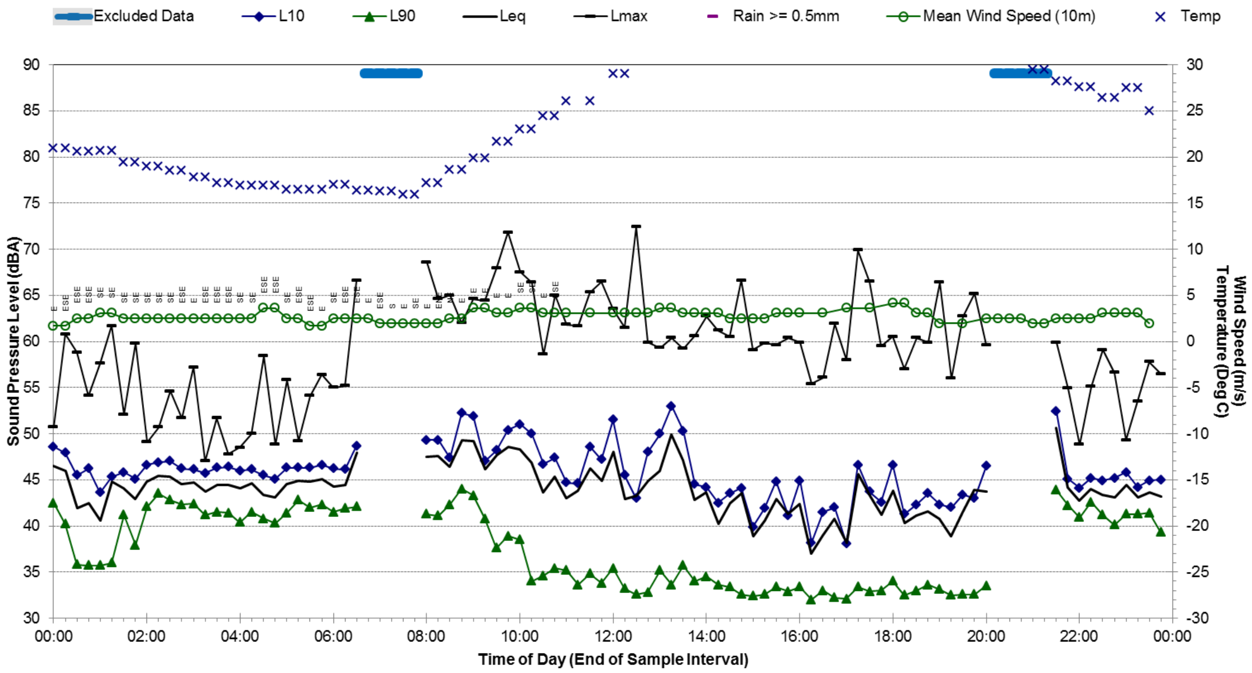

Statistical Ambient Noise Levels
2 Thule St - Monday, 16 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
12 Burnett St - Tuesday, 17 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
12 Burnett St - Wednesday, 18 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

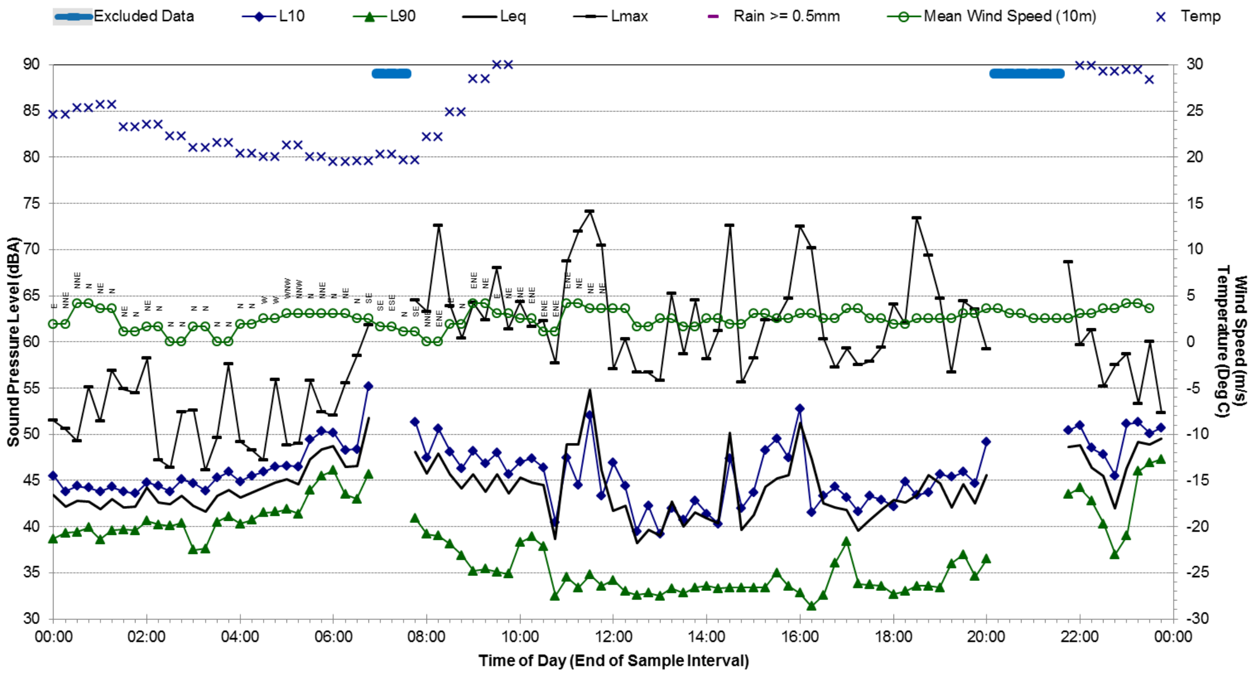
Statistical Ambient Noise Levels

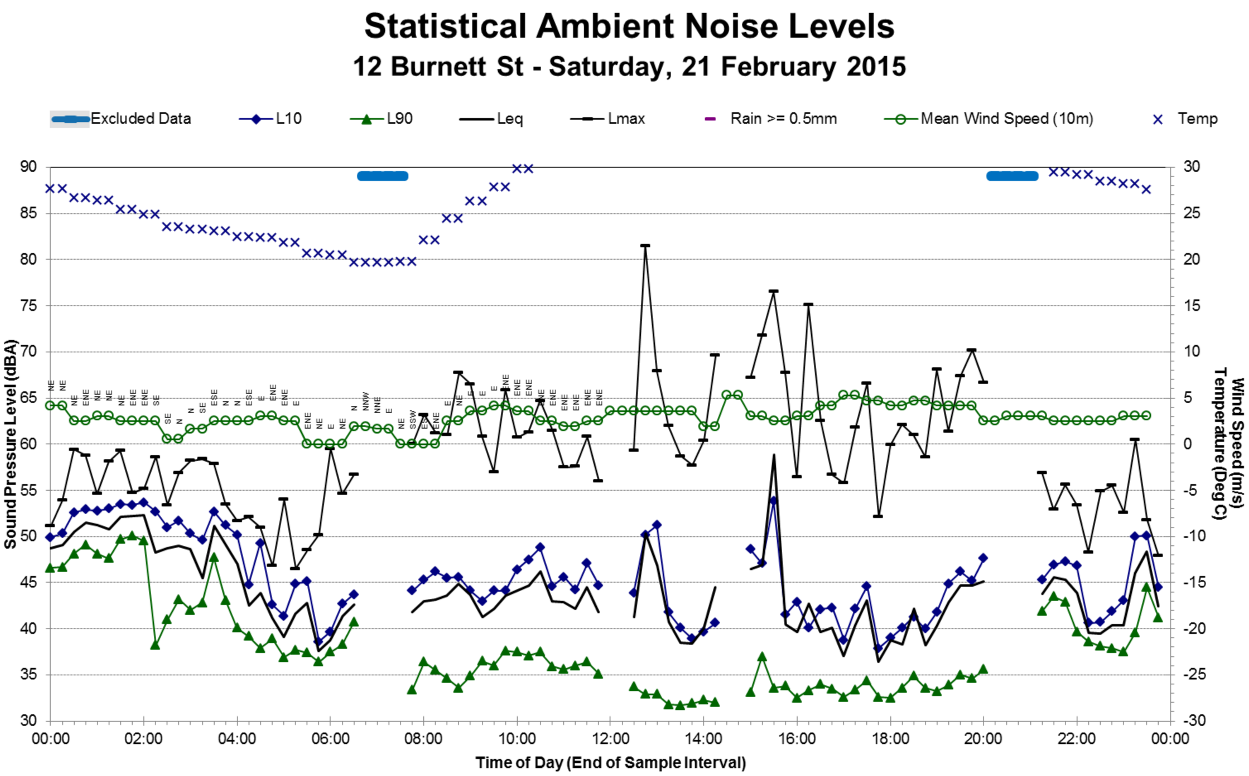
12 Burnett St - Thursday, 19 February 2015

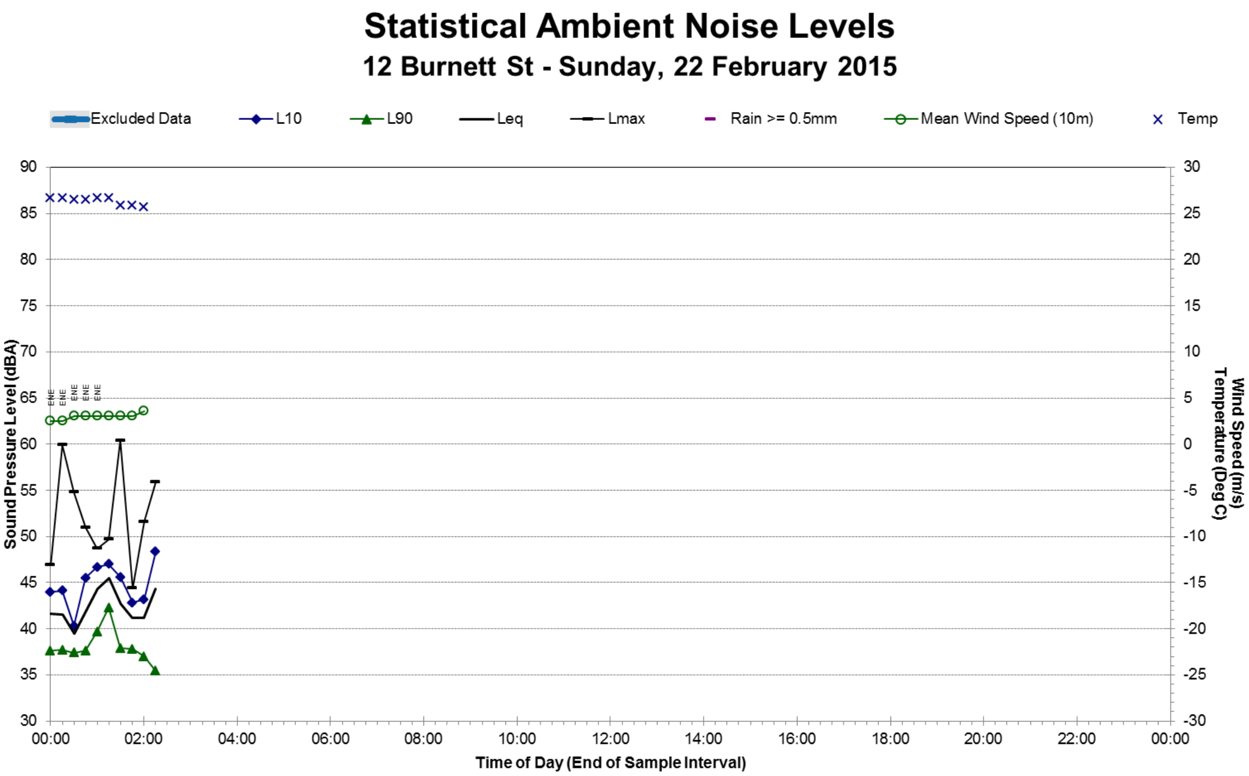


Statistical Ambient Noise Levels

12 Burnett St - Friday, 20 February 2015

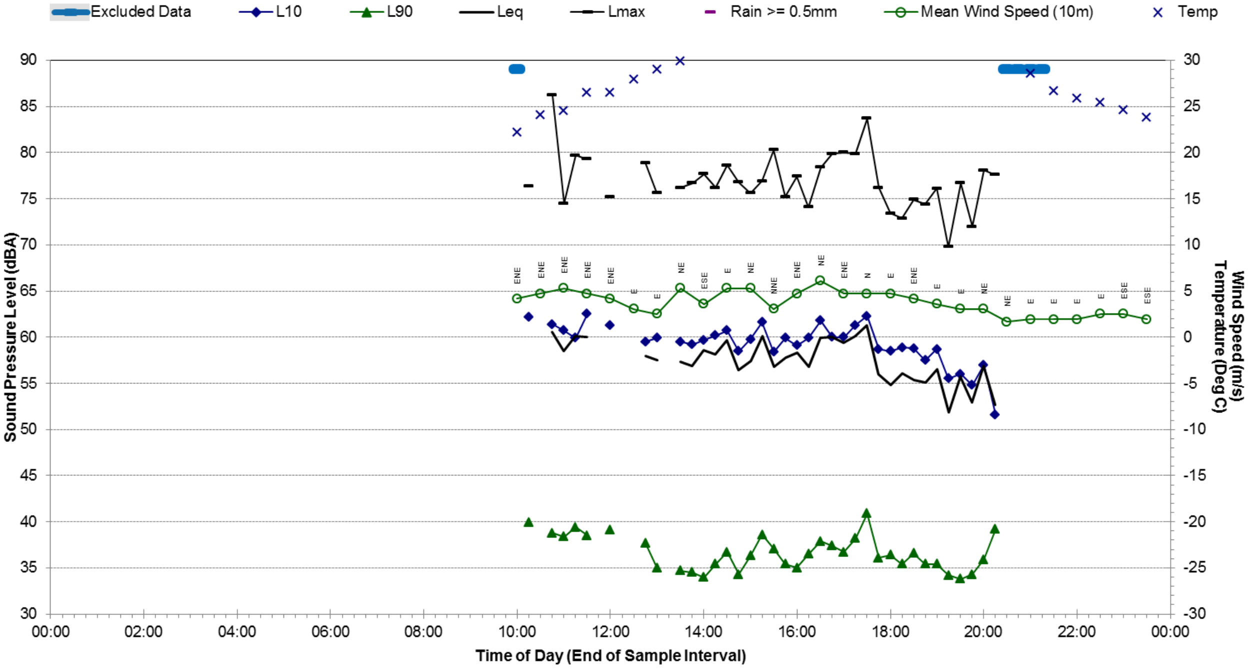



Statistical Ambient Noise Levels
12 Burnett St - Saturday, 21 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
12 Burnett St - Sunday, 22 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

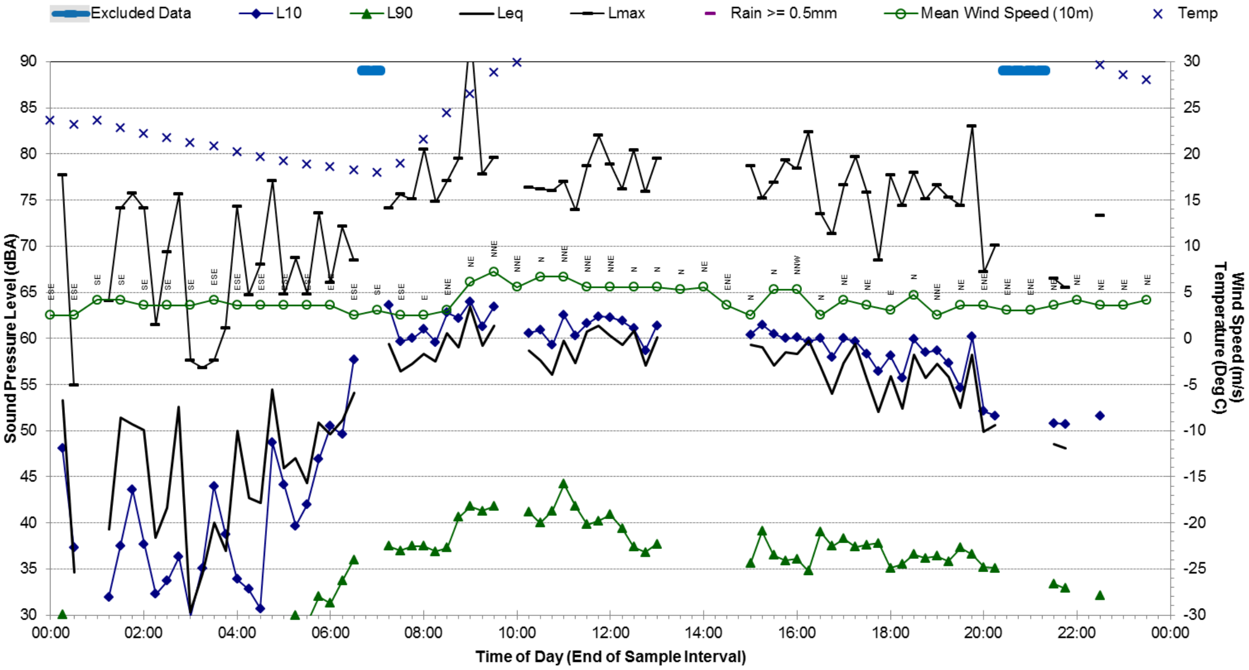
Statistical Ambient Noise Levels

13 Thule St - Thursday, 5 February 2015

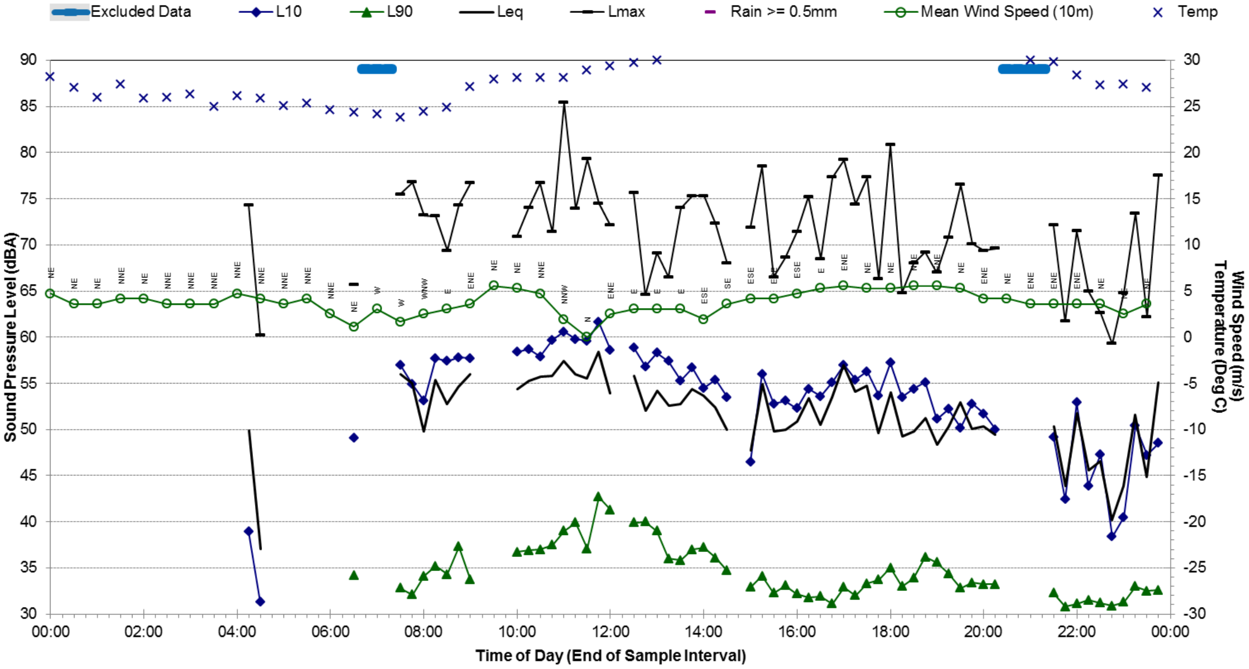


Statistical Ambient Noise Levels

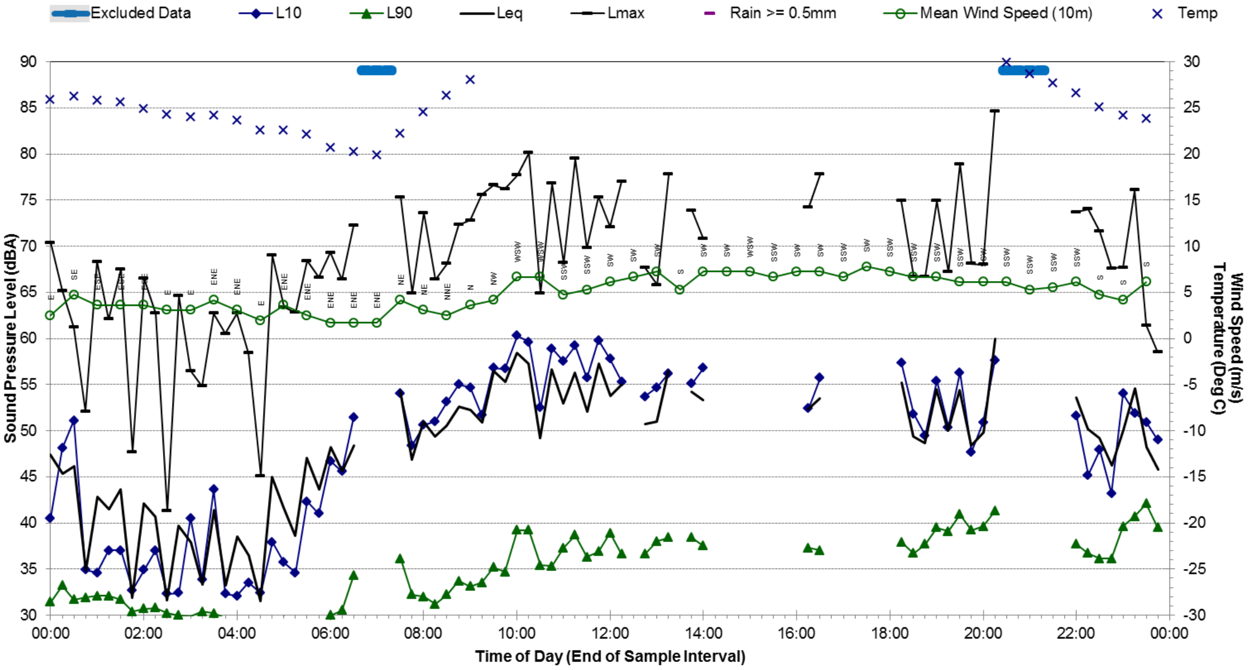
13 Thule St - Friday, 6 February 2015



Statistical Ambient Noise Levels
13 Thule St - Saturday, 7 February 2015

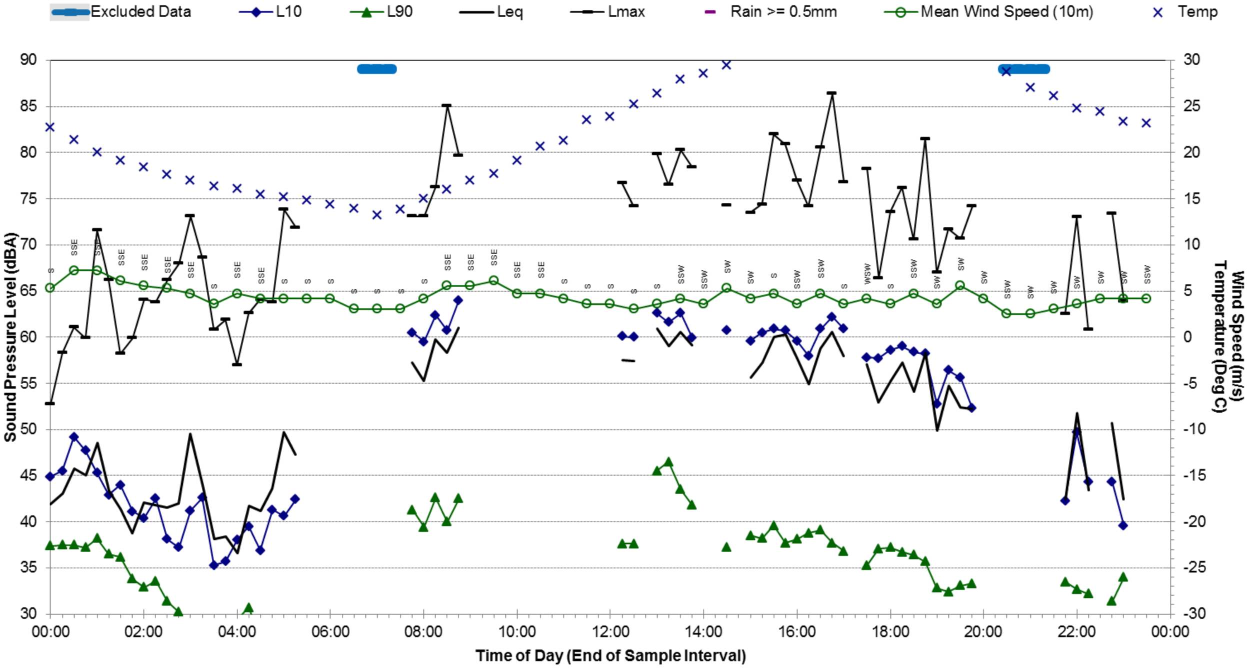


Statistical Ambient Noise Levels
13 Thule St - Sunday, 8 February 2015



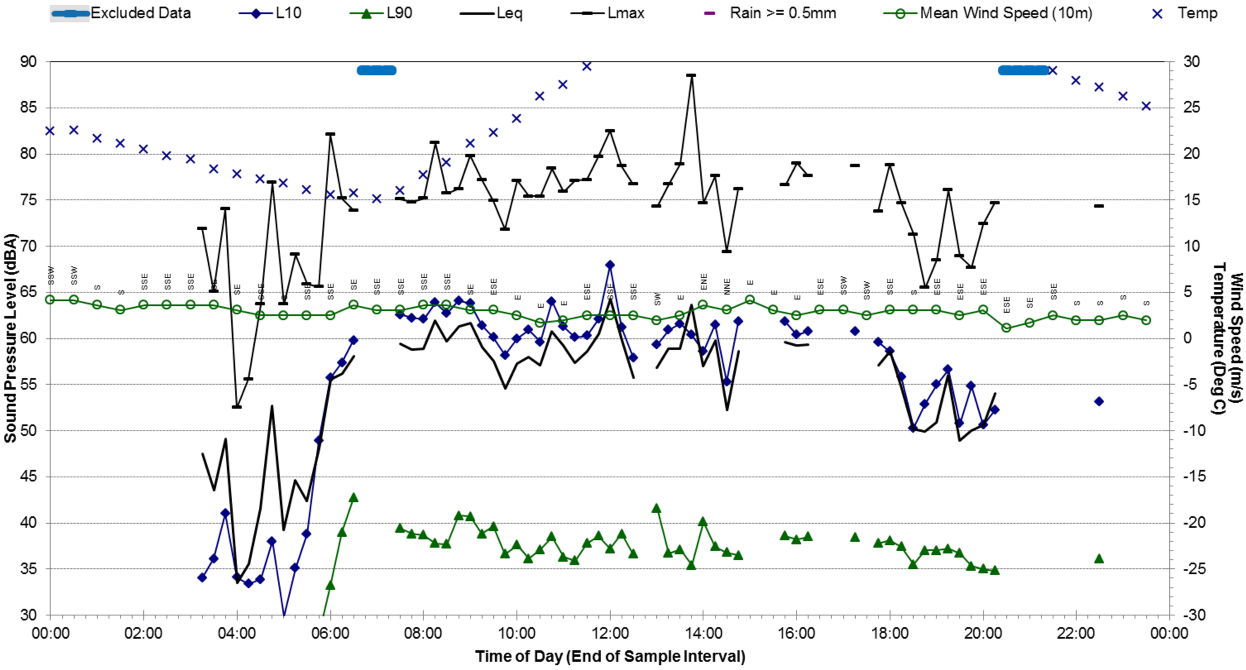
Statistical Ambient Noise Levels

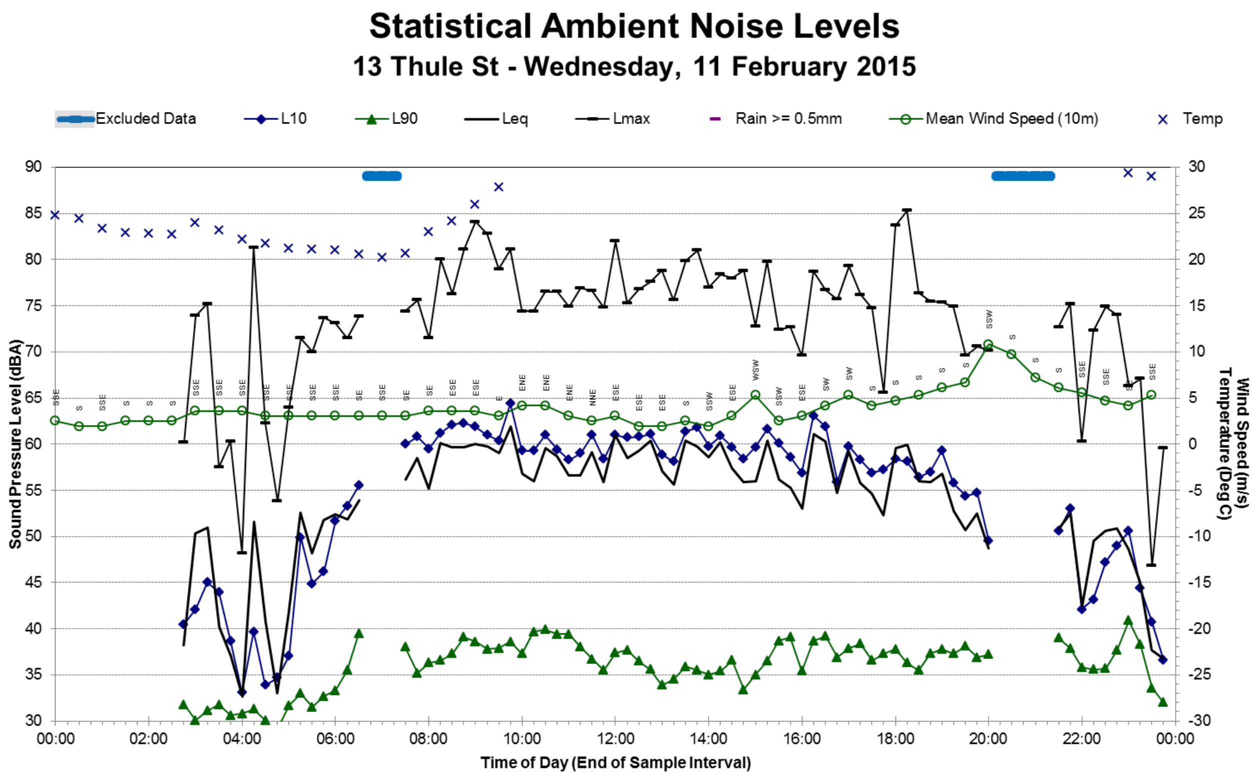
13 Thule St - Monday, 9 February 2015

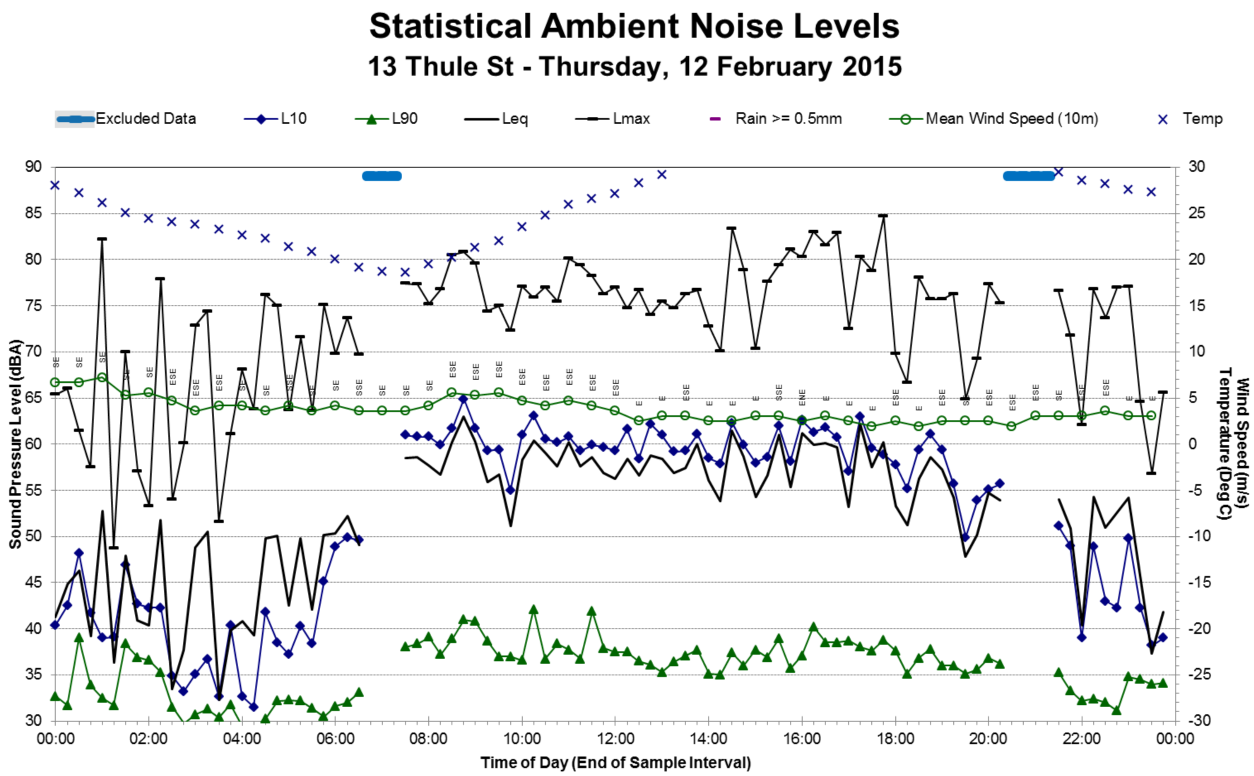


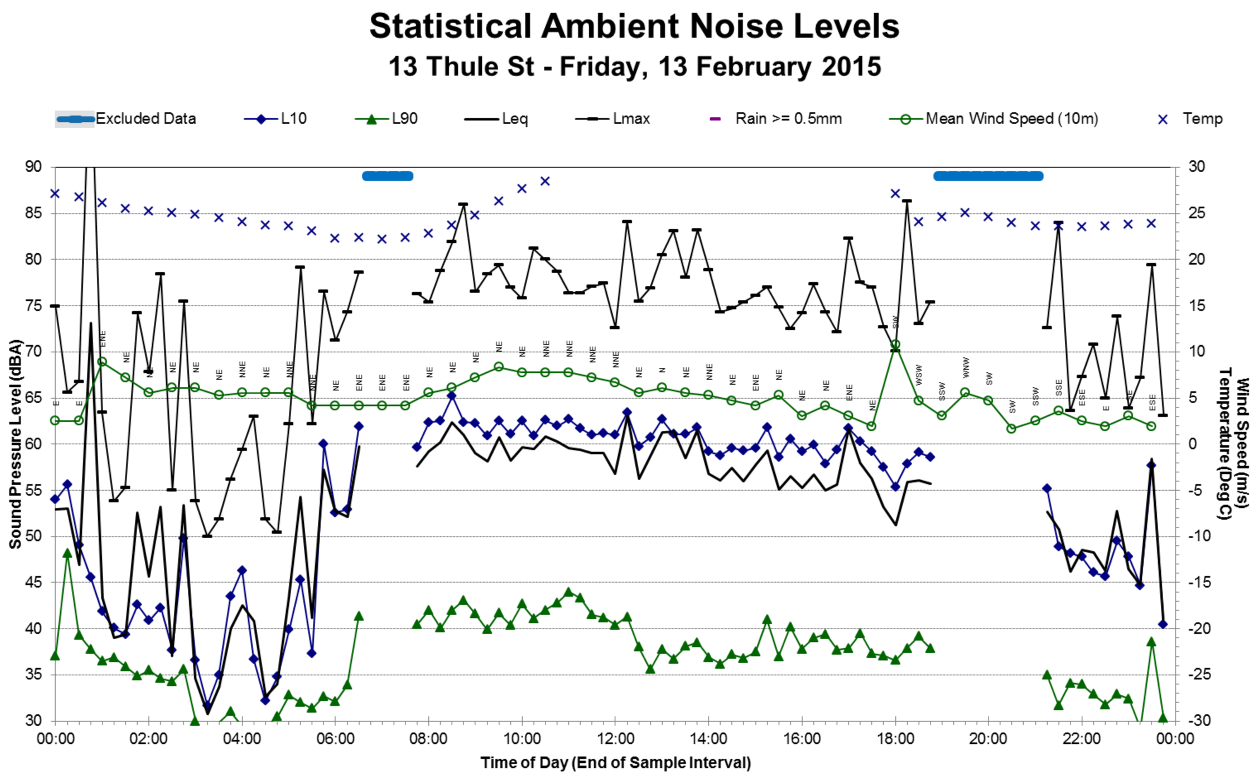
Statistical Ambient Noise Levels

13 Thule St - Tuesday, 10 February 2015

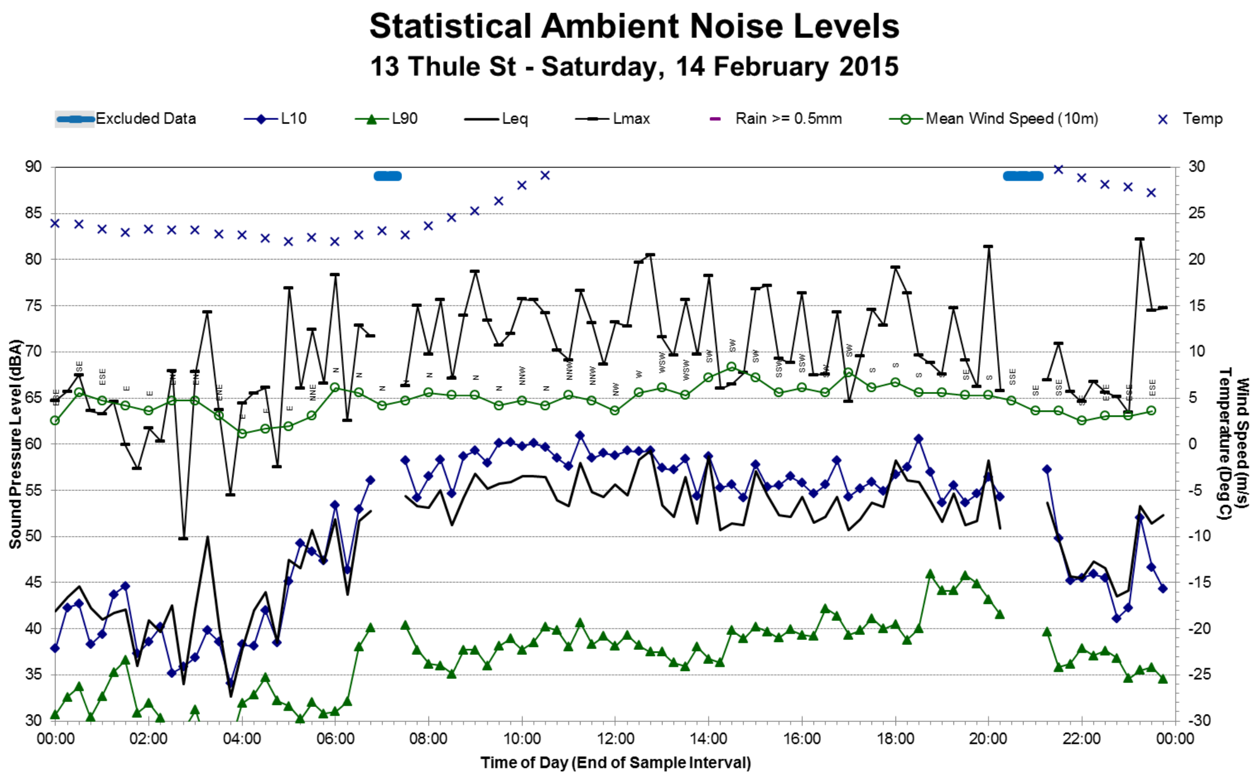



Statistical Ambient Noise Levels
13 Thule St - Wednesday, 11 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
13 Thule St - Thursday, 12 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

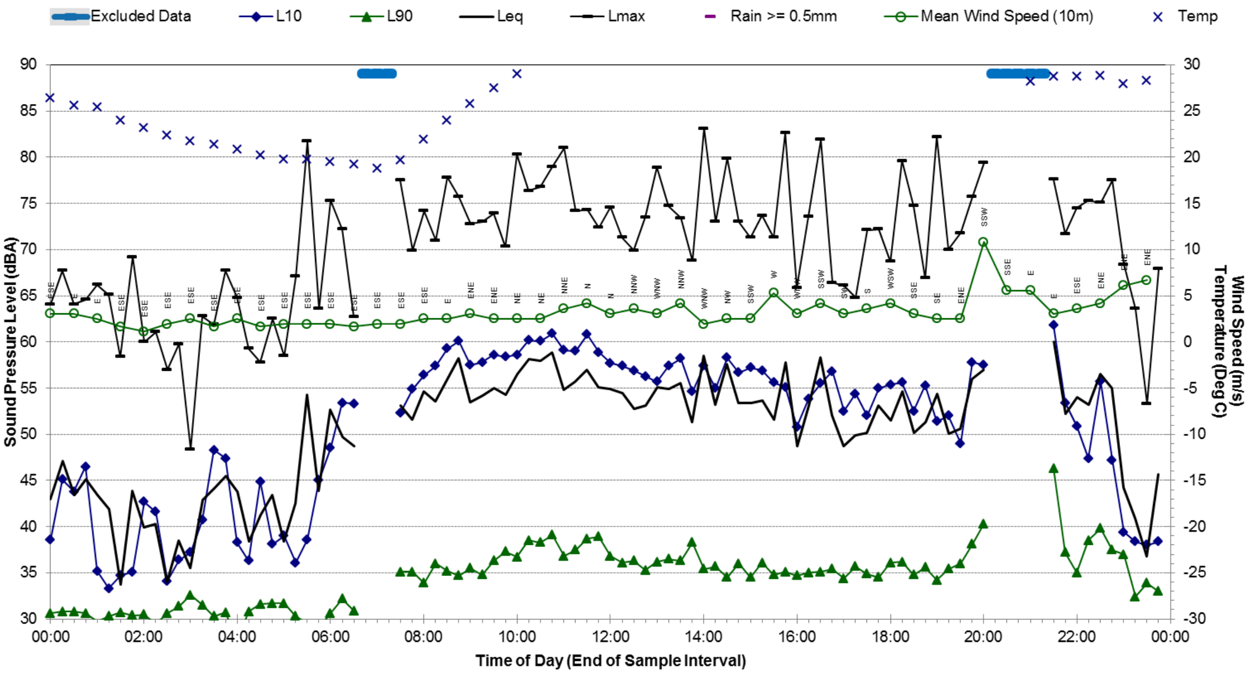


Statistical Ambient Noise Levels
13 Thule St - Friday, 13 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

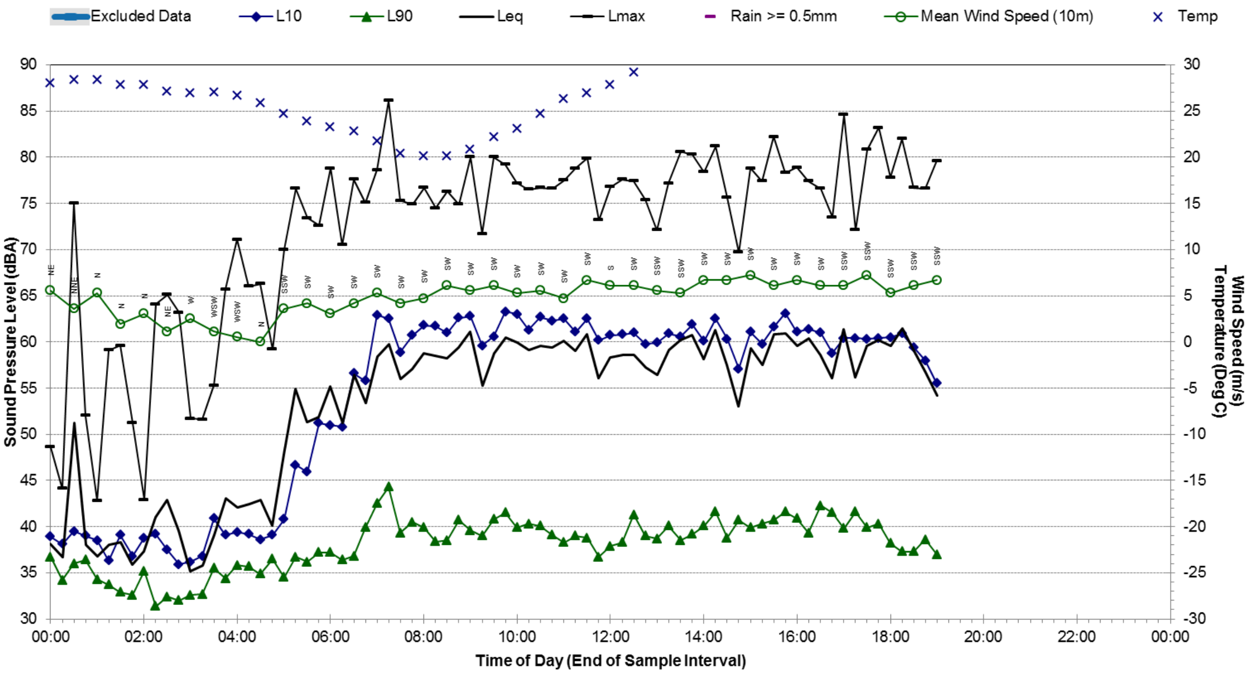


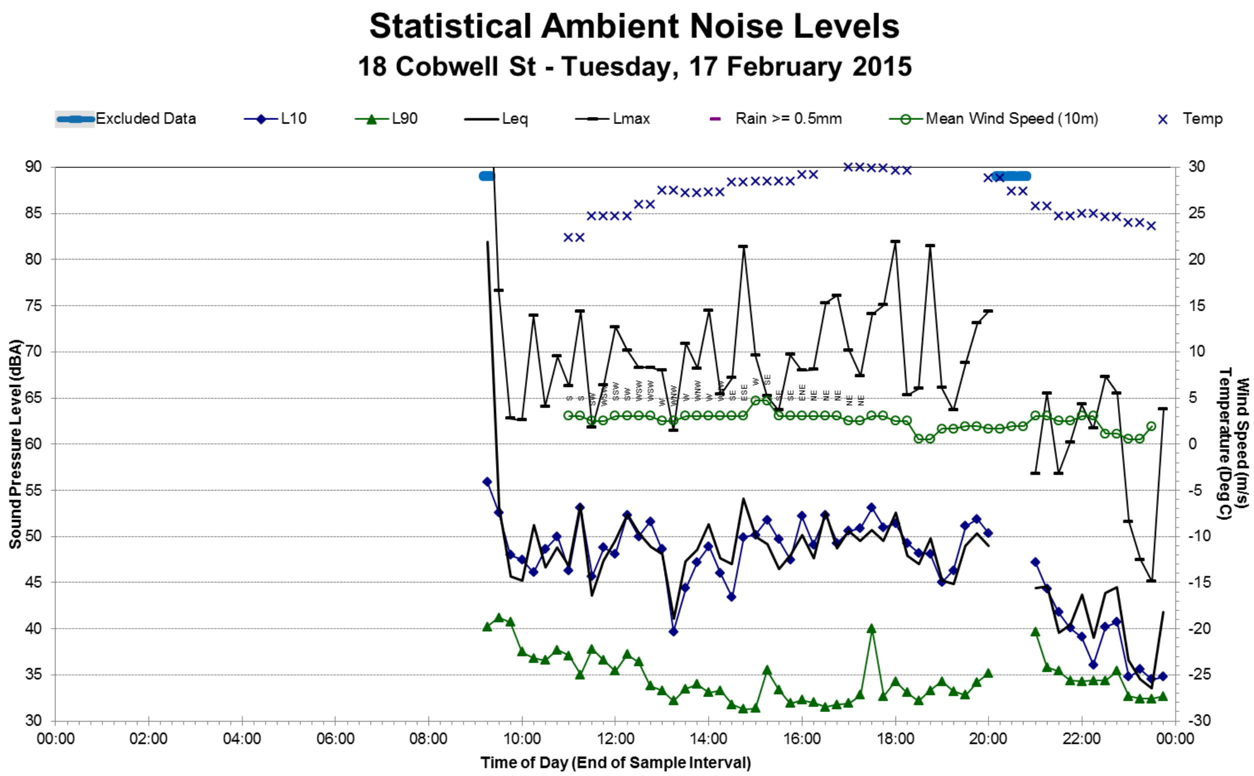
Statistical Ambient Noise Levels
13 Thule St - Saturday, 14 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

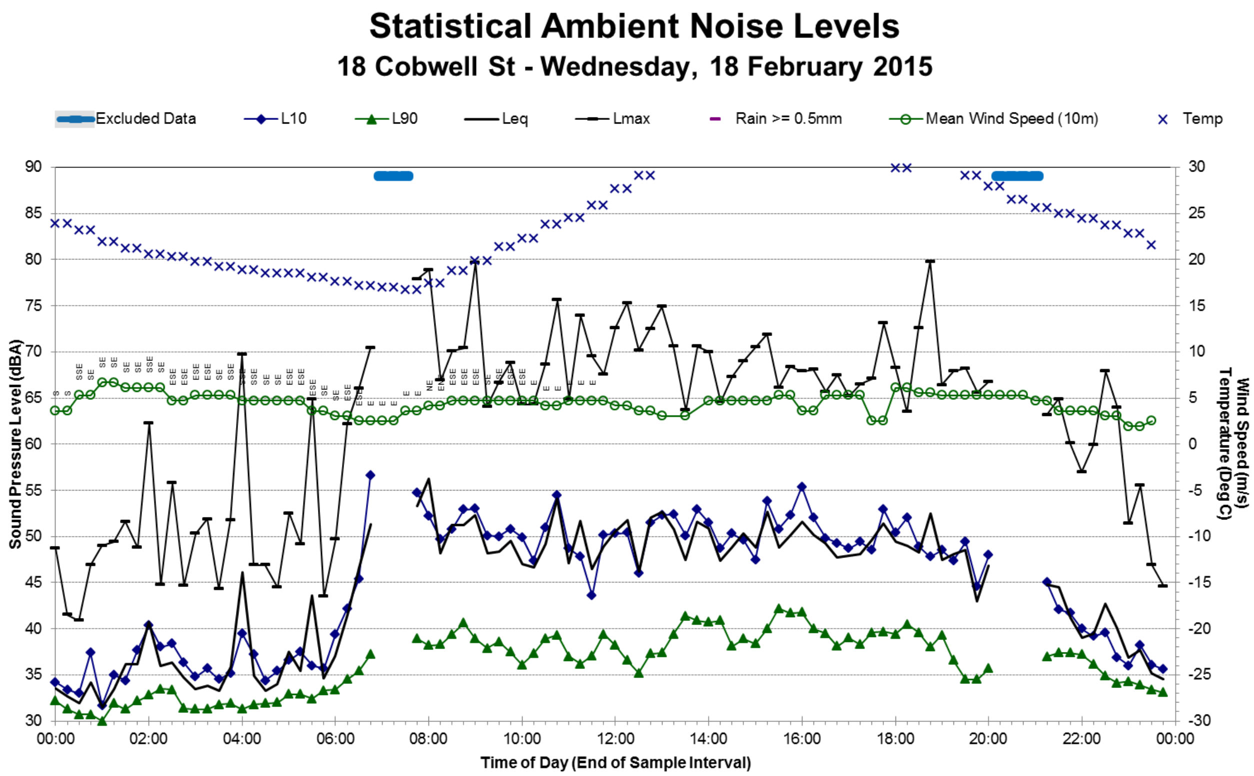
Statistical Ambient Noise Levels
13 Thule St - Sunday, 15 February 2015

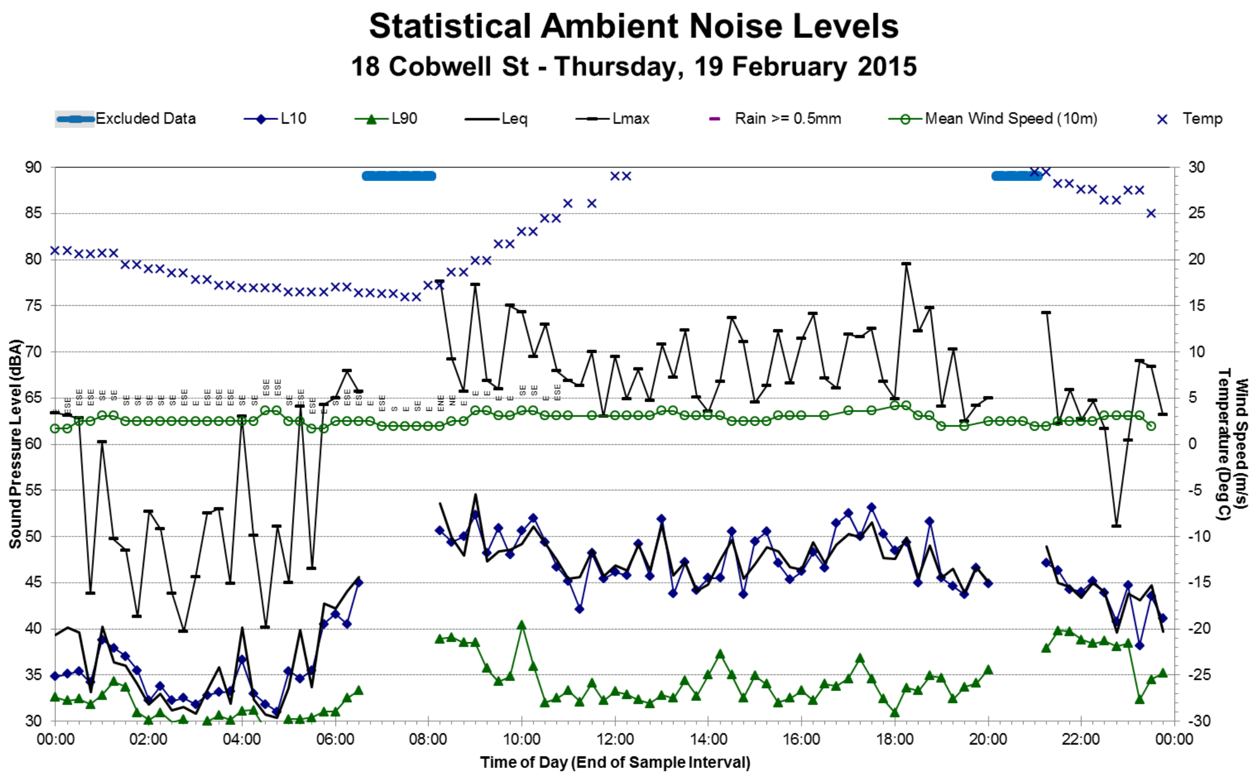


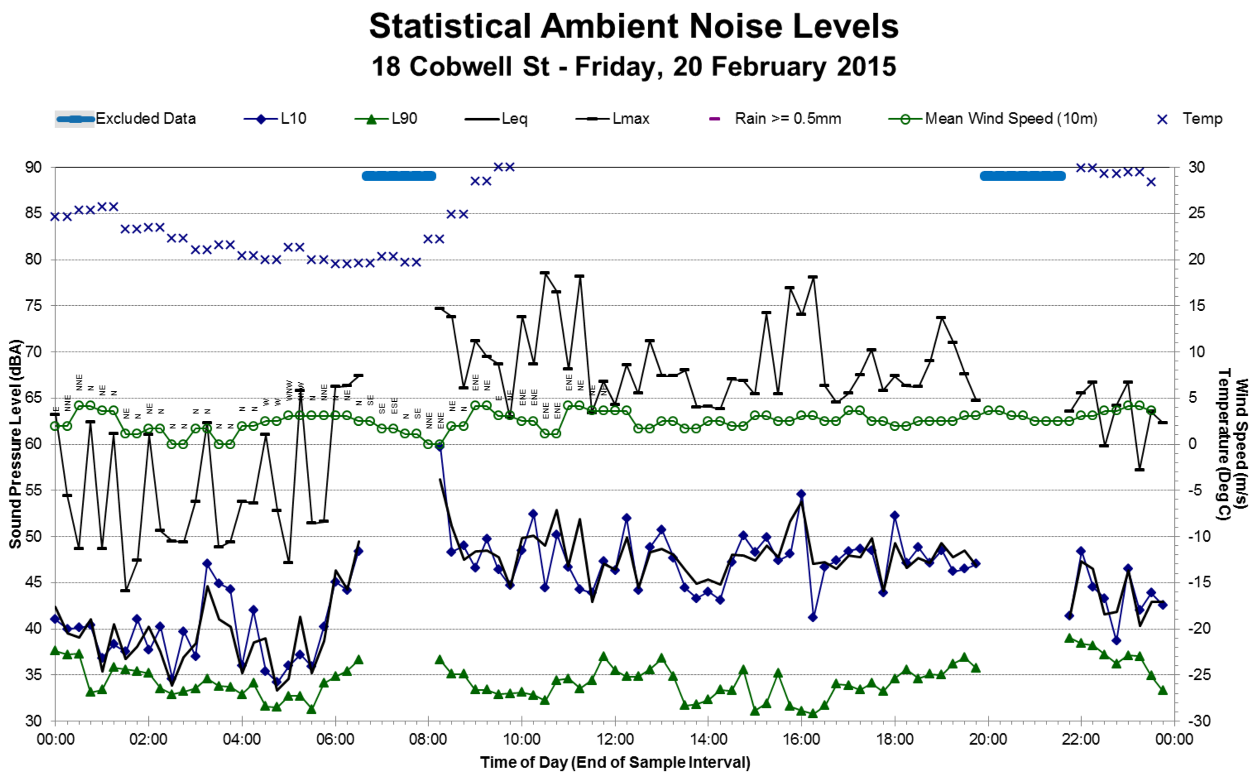
Statistical Ambient Noise Levels
13 Thule St - Monday, 16 February 2015




Statistical Ambient Noise Levels
18 Cobwell St - Tuesday, 17 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

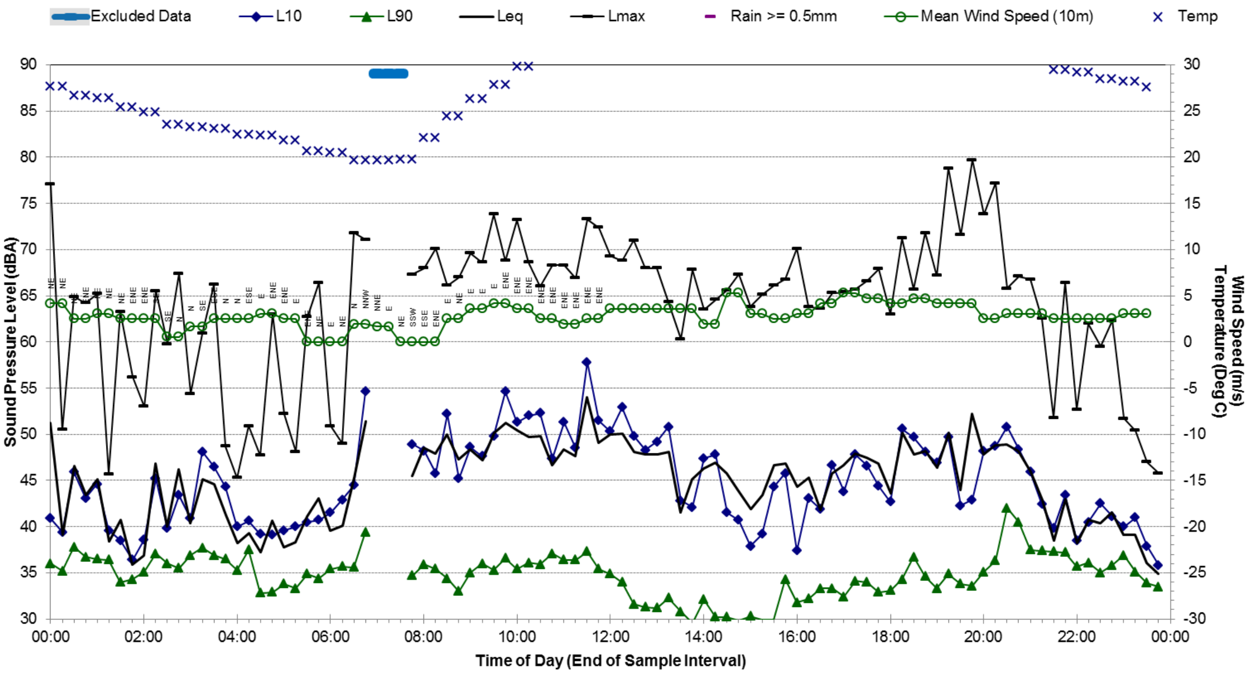

Statistical Ambient Noise Levels
18 Cobwell St - Wednesday, 18 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
18 Cobwell St - Thursday, 19 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
18 Cobwell St - Friday, 20 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

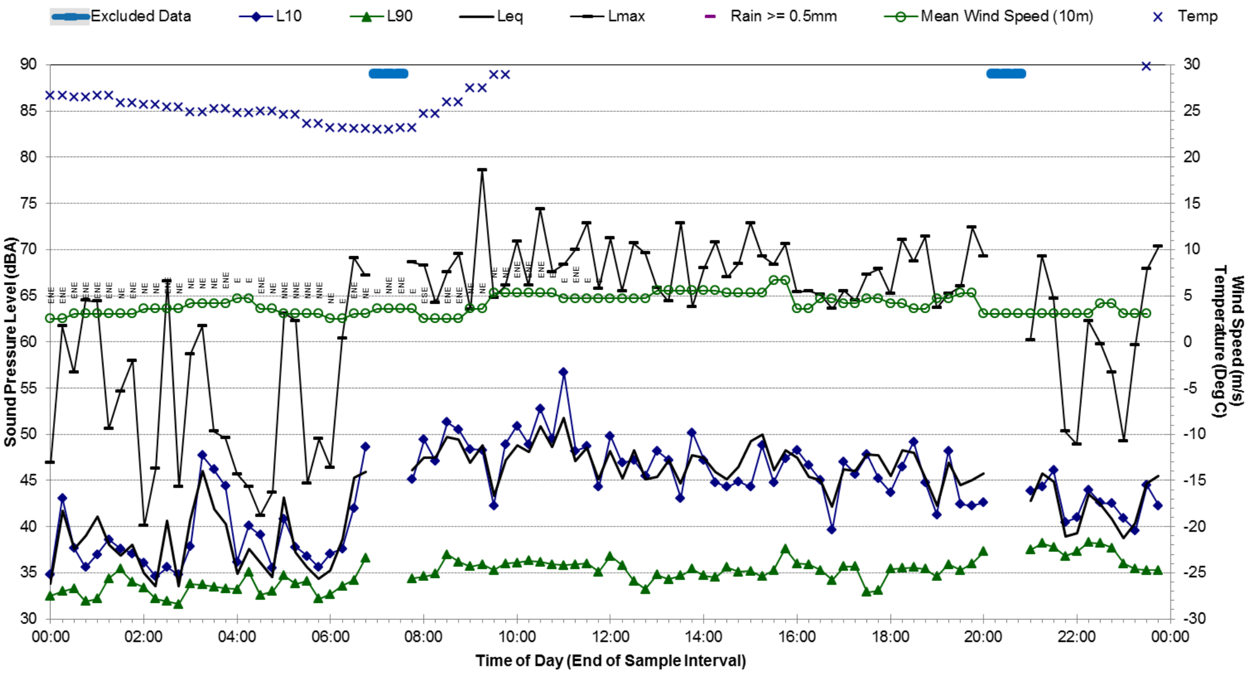
Statistical Ambient Noise Levels

18 Cobwell St - Saturday, 21 February 2015

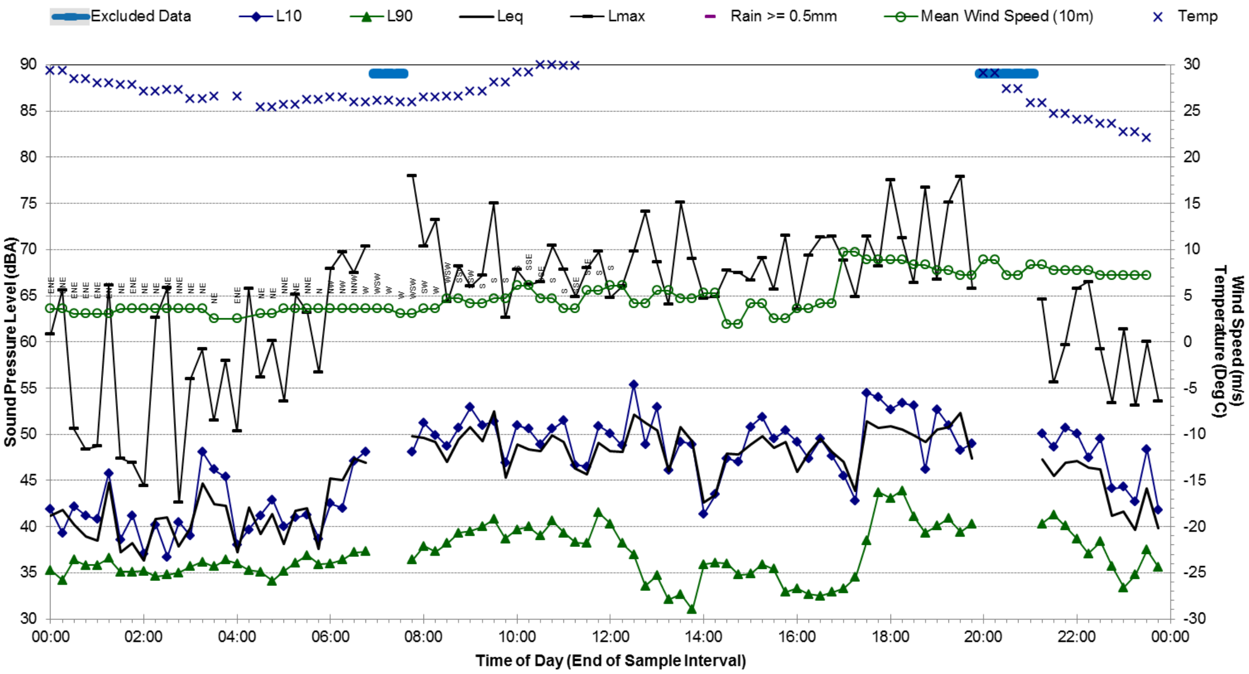


Statistical Ambient Noise Levels

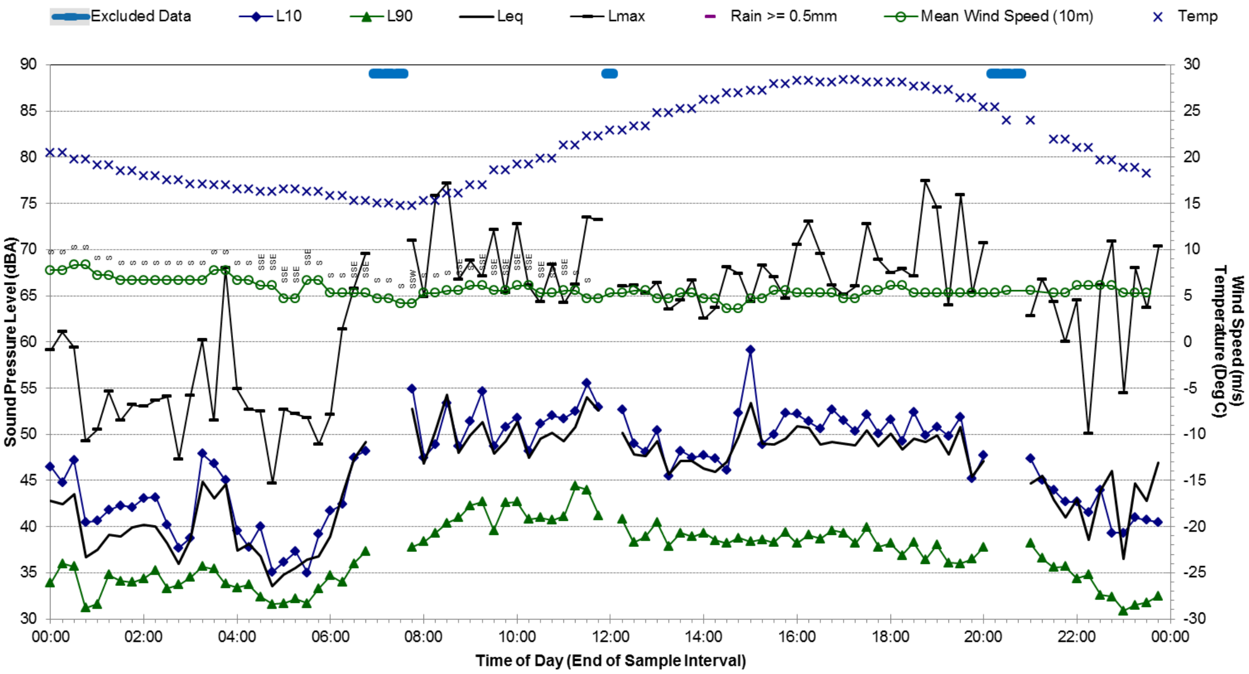
18 Cobwell St - Sunday, 22 February 2015



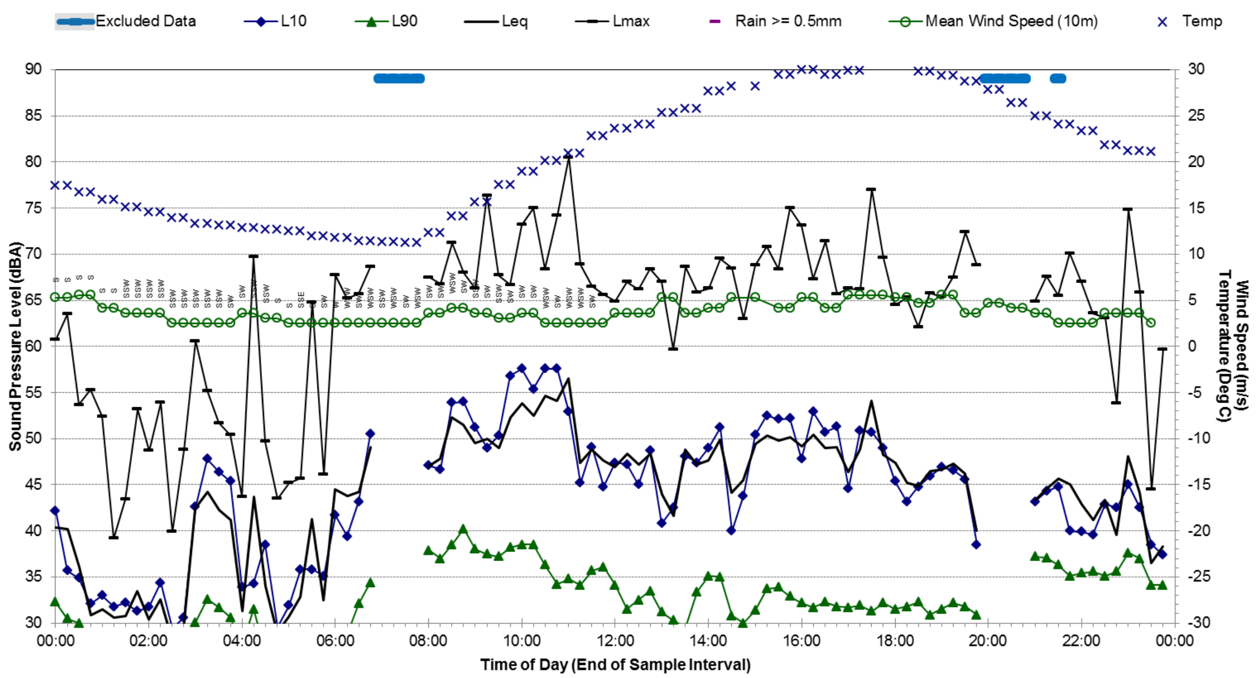
Statistical Ambient Noise Levels
18 Cobwell St - Monday, 23 February 2015



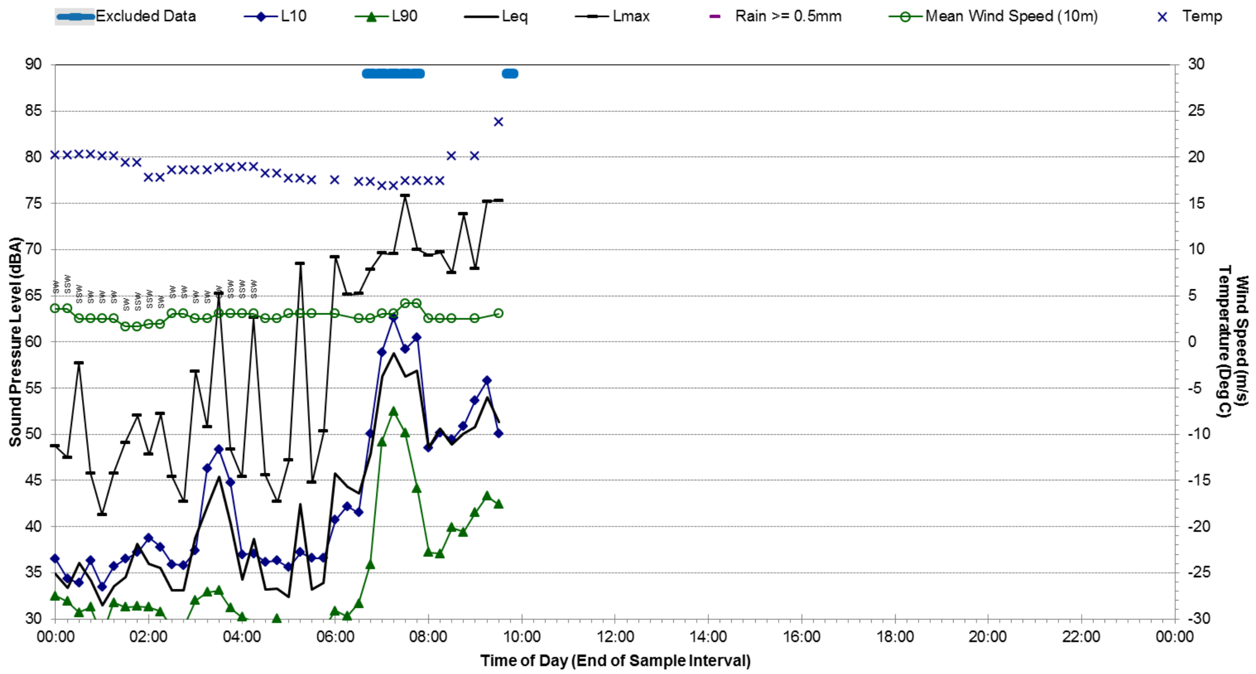
Statistical Ambient Noise Levels
18 Cobwell St - Tuesday, 24 February 2015

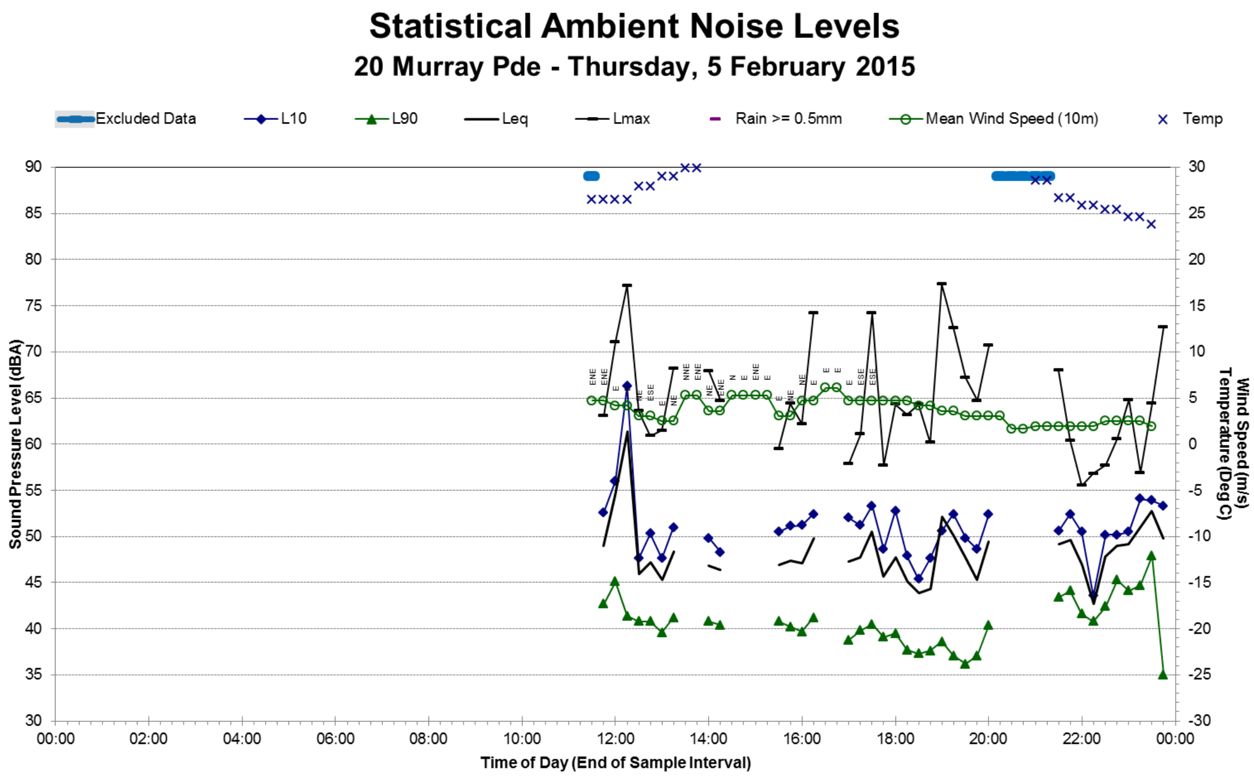


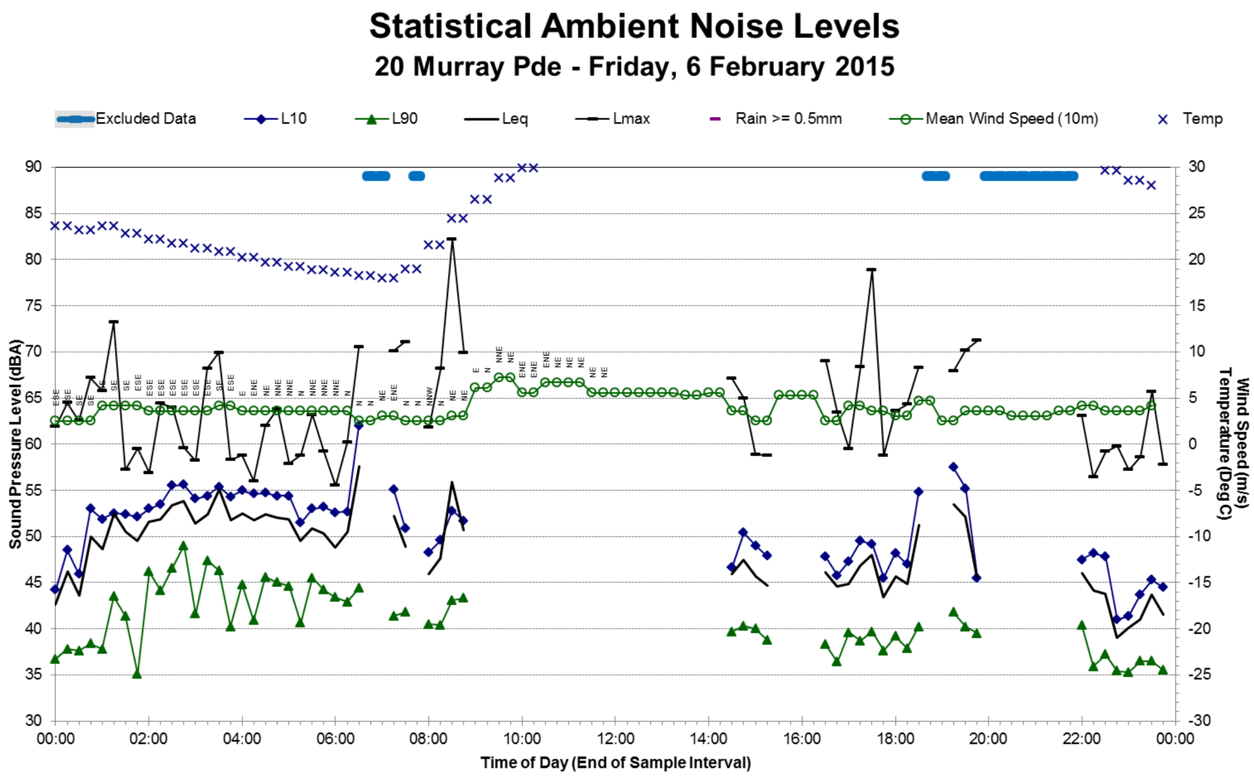
Statistical Ambient Noise Levels
18 Cobwell St - Wednesday, 25 February 2015

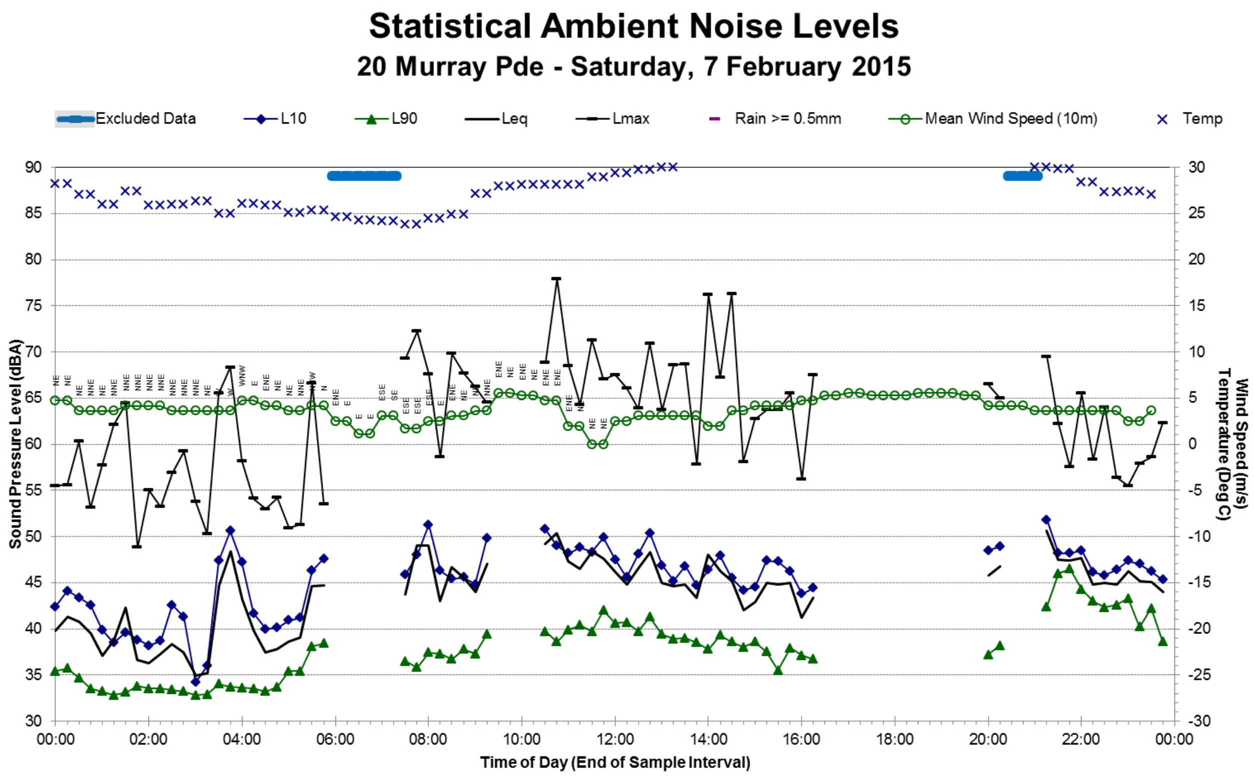


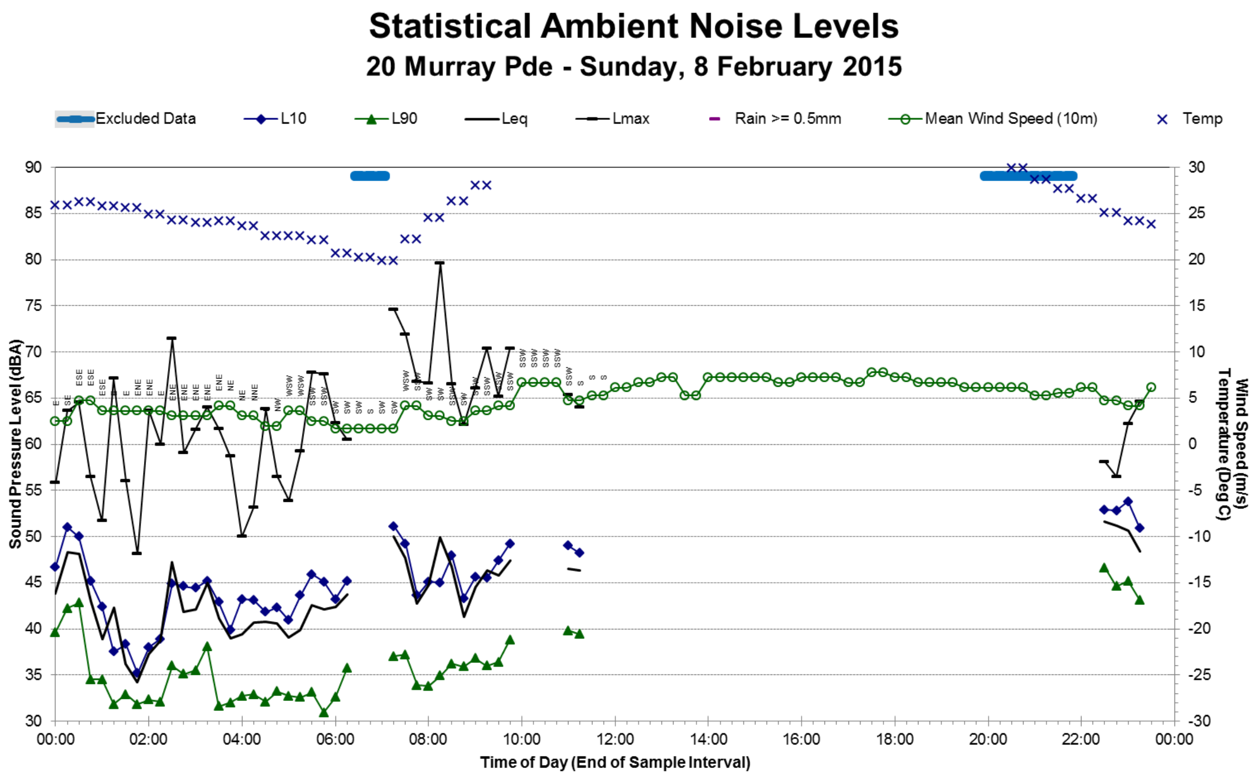
Statistical Ambient Noise Levels
18 Cobwell St - Thursday, 26 February 2015

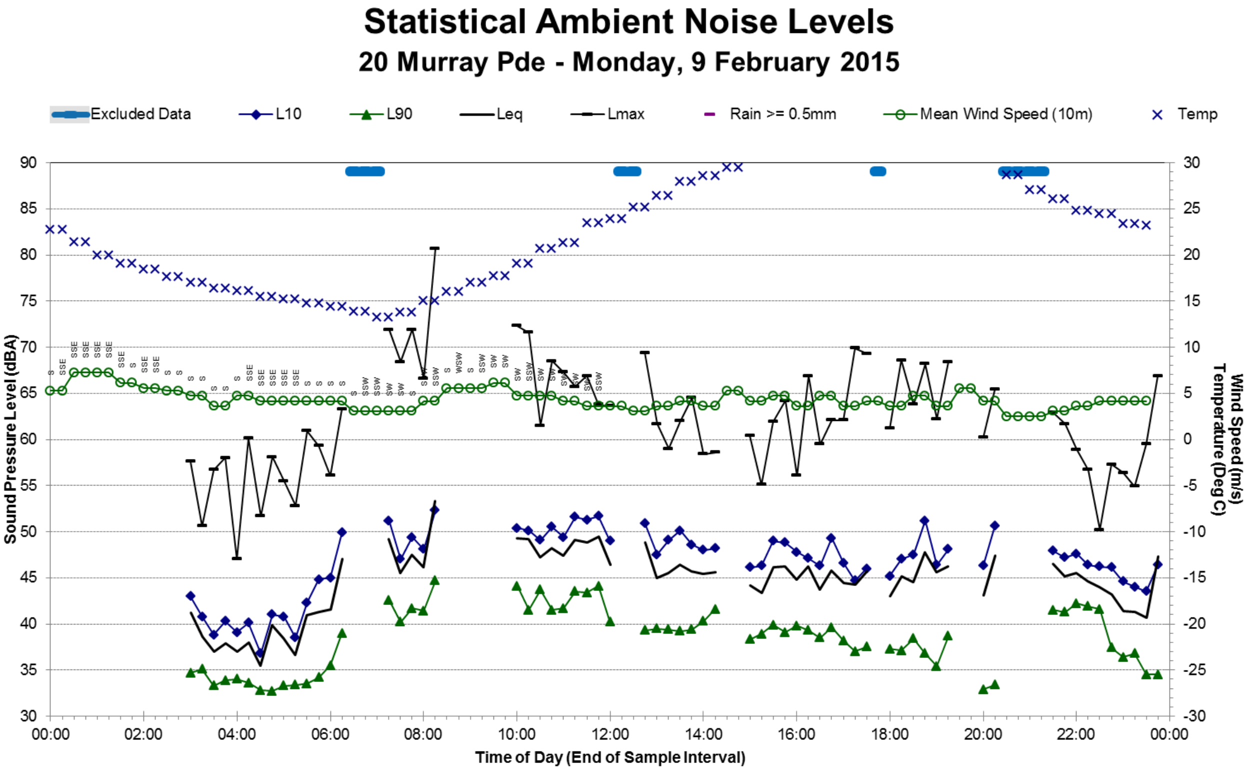


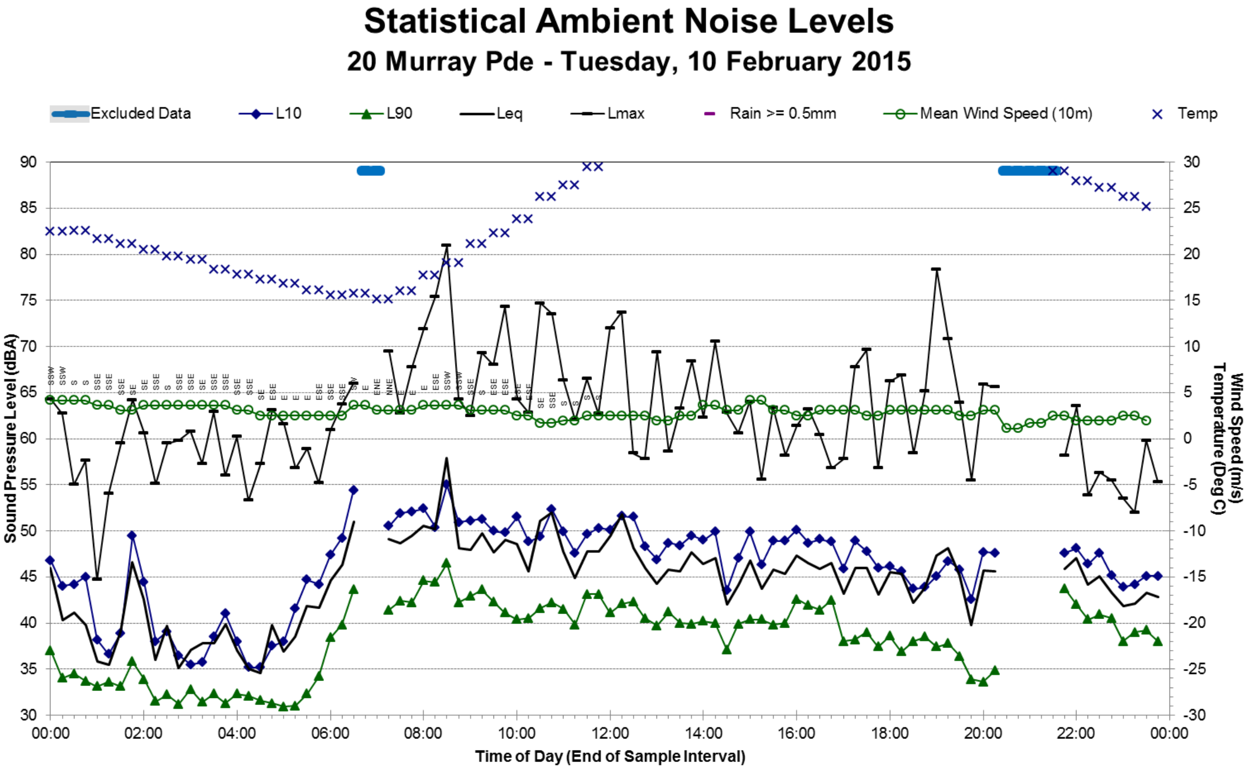

Statistical Ambient Noise Levels
20 Murray Pde - Thursday, 5 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

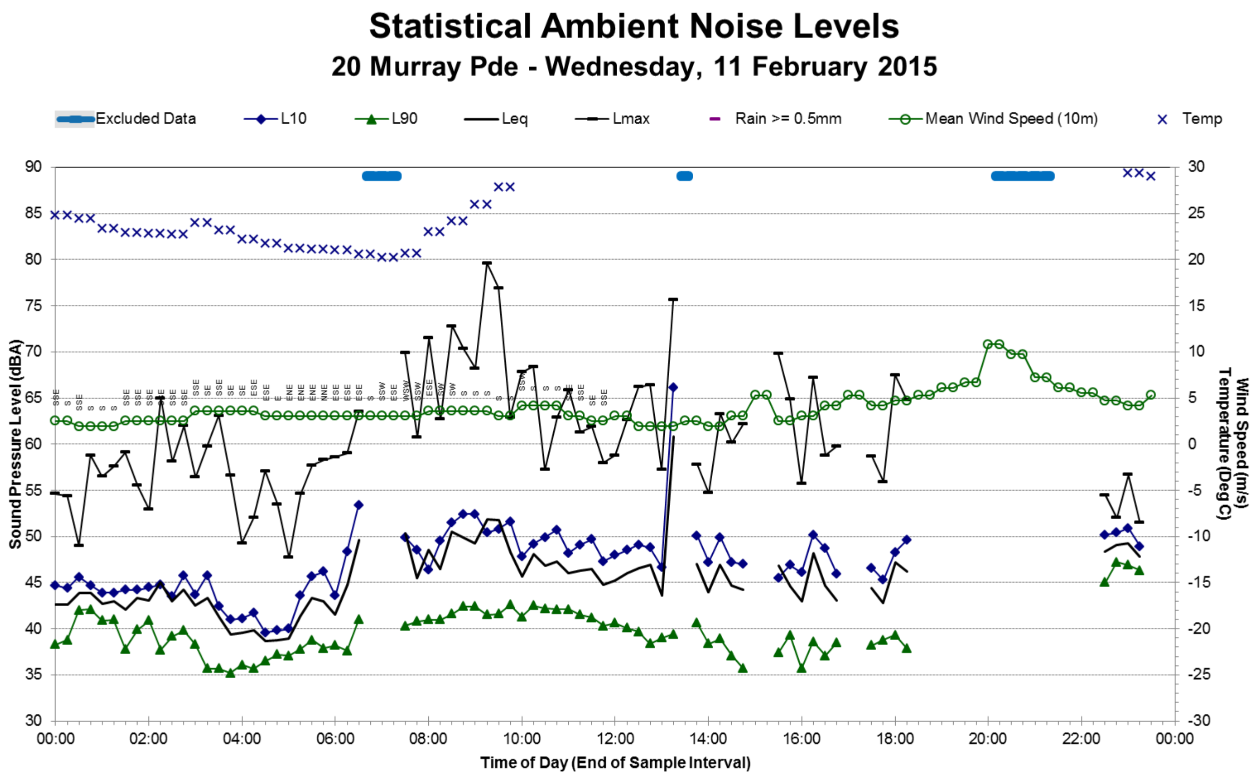

Statistical Ambient Noise Levels
20 Murray Pde - Friday, 6 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

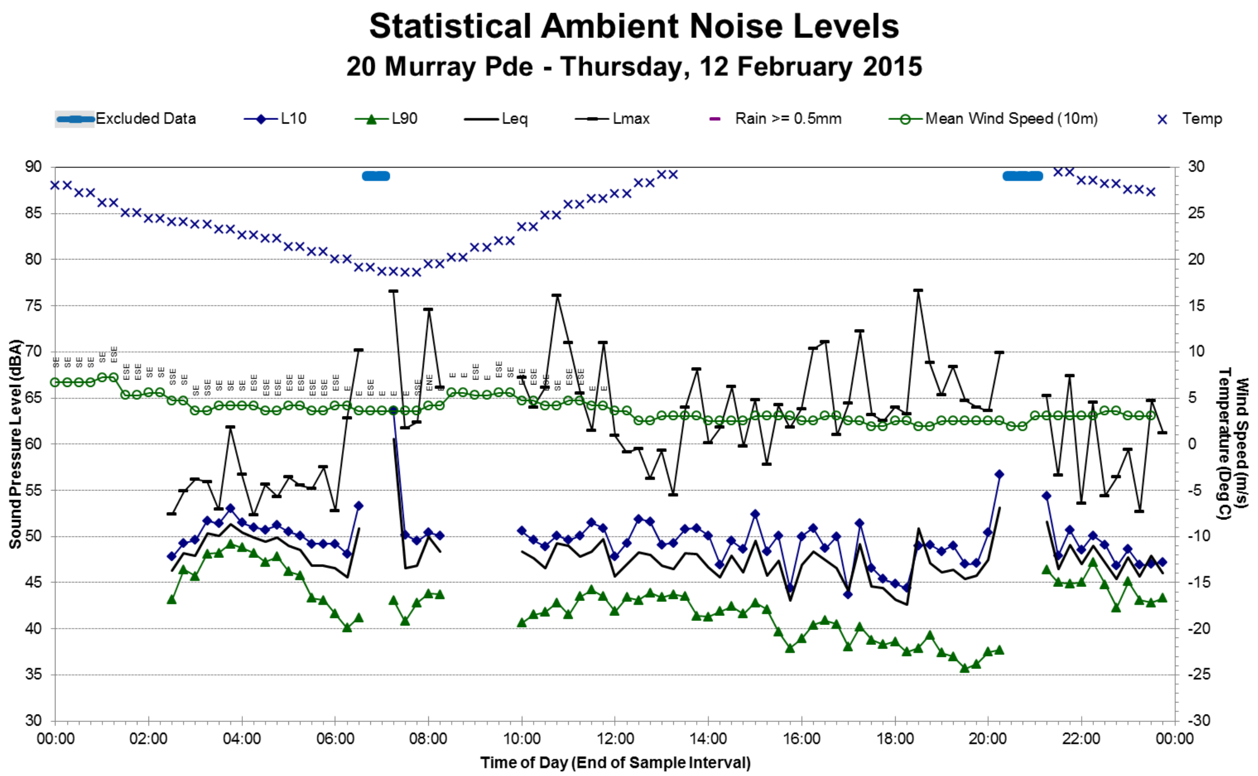

Statistical Ambient Noise Levels
20 Murray Pde - Saturday, 7 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
20 Murray Pde - Sunday, 8 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
20 Murray Pde - Monday, 9 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

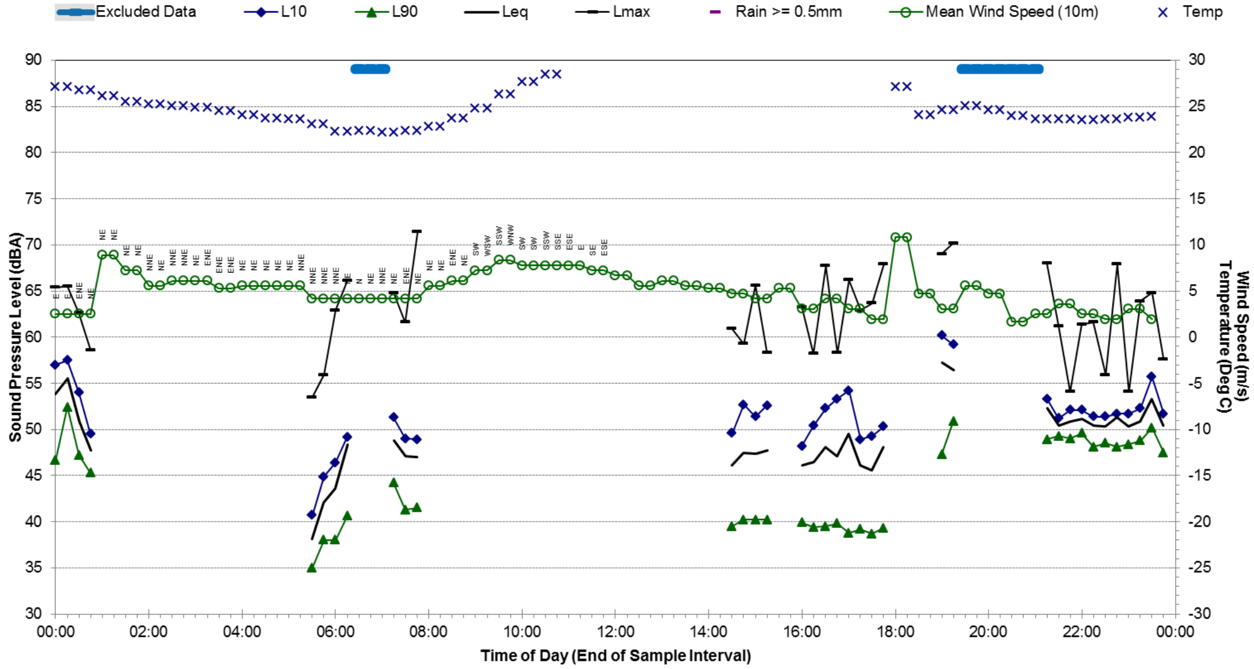

Statistical Ambient Noise Levels
20 Murray Pde - Tuesday, 10 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
20 Murray Pde - Wednesday, 11 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
20 Murray Pde - Thursday, 12 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

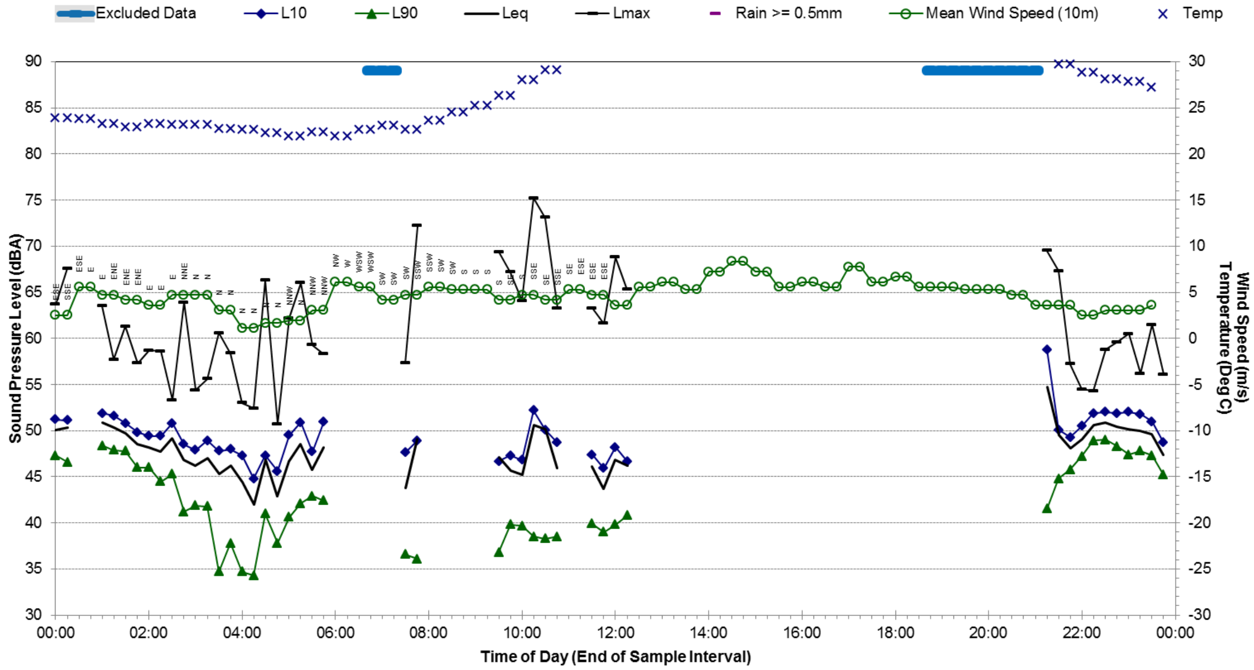
Statistical Ambient Noise Levels

20 Murray Pde - Friday, 13 February 2015



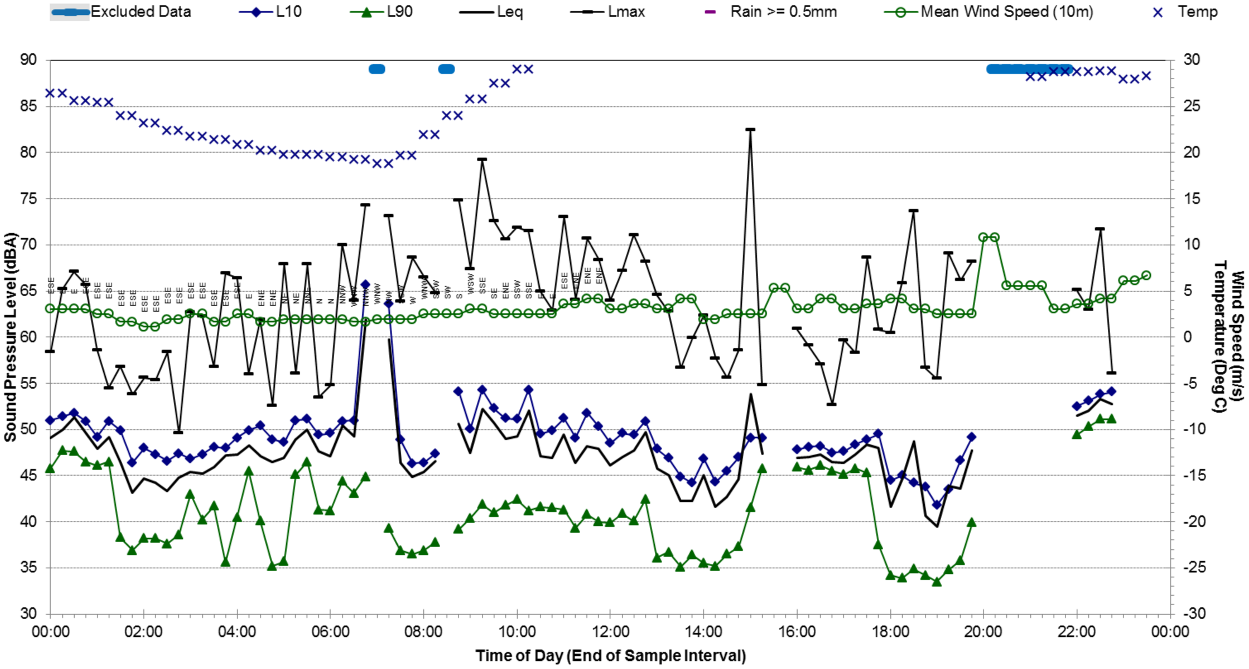
Statistical Ambient Noise Levels

20 Murray Pde - Saturday, 14 February 2015



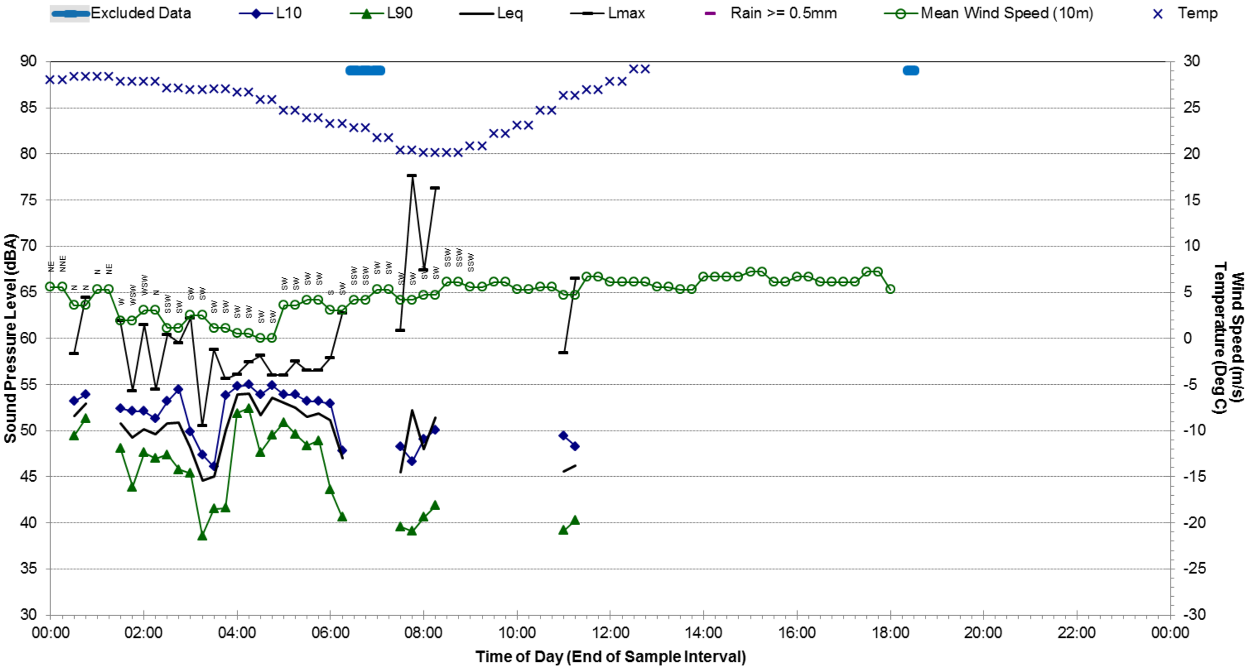
Statistical Ambient Noise Levels

20 Murray Pde - Sunday, 15 February 2015



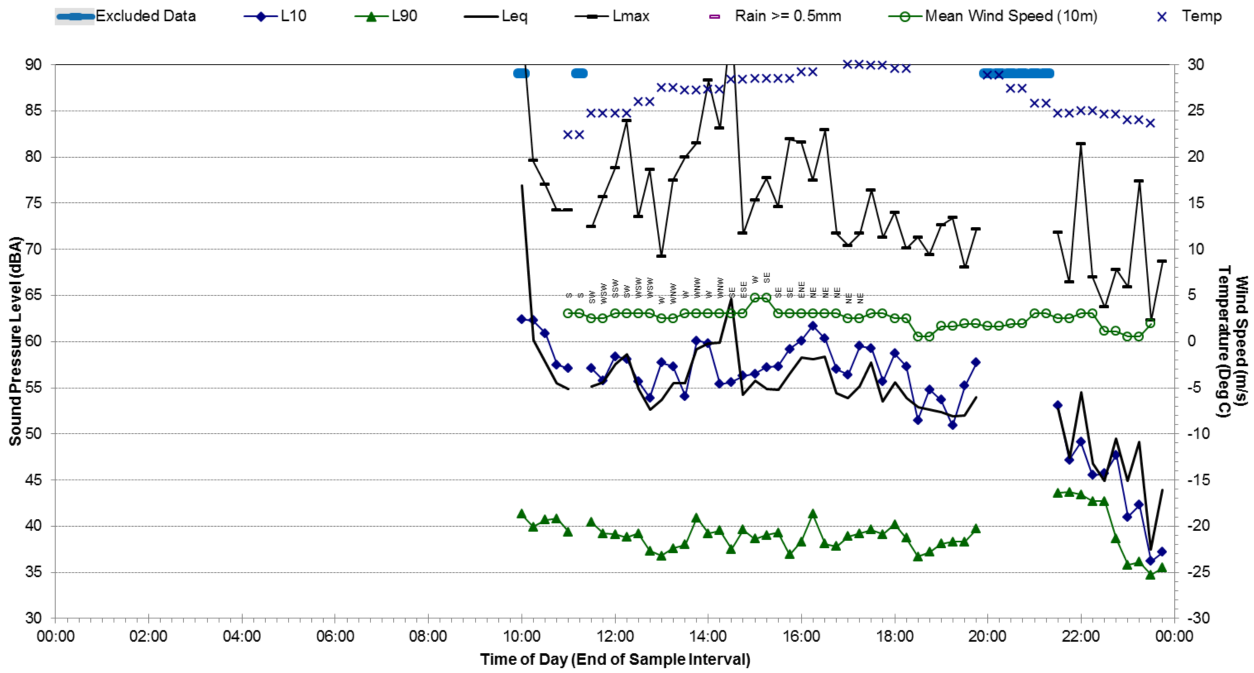
Statistical Ambient Noise Levels

20 Murray Pde - Monday, 16 February 2015



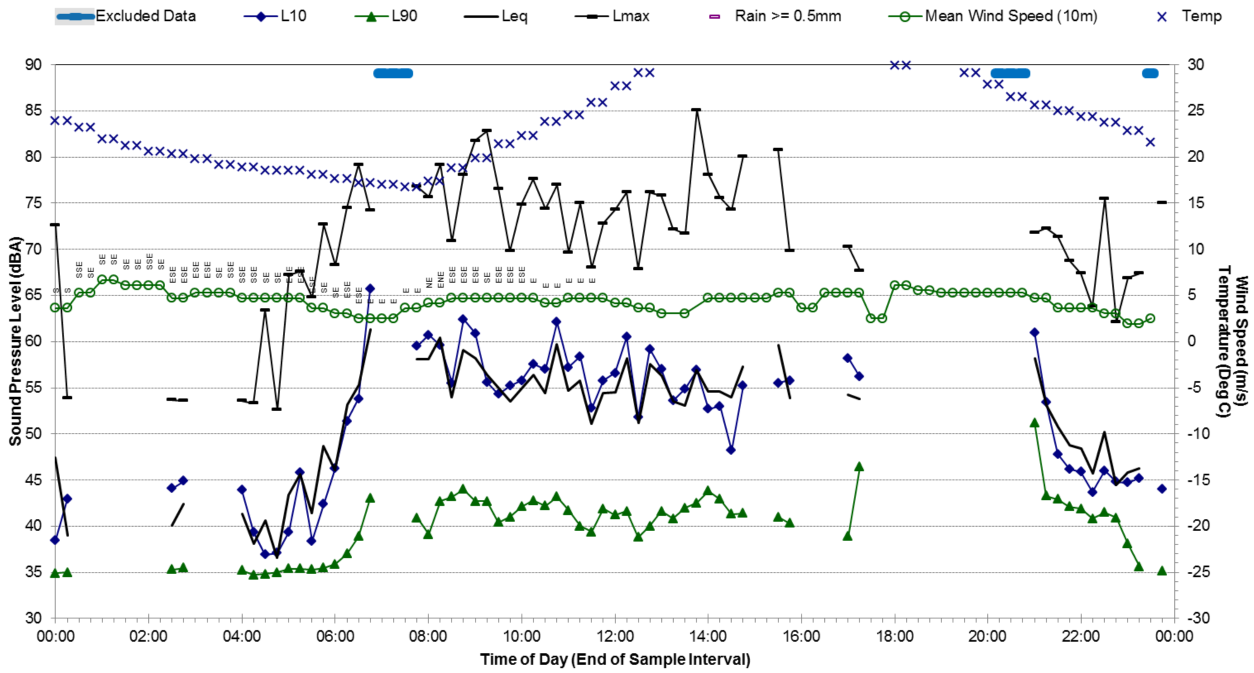
Statistical Ambient Noise Levels

34 Murray Pde - Tuesday, 17 February 2015

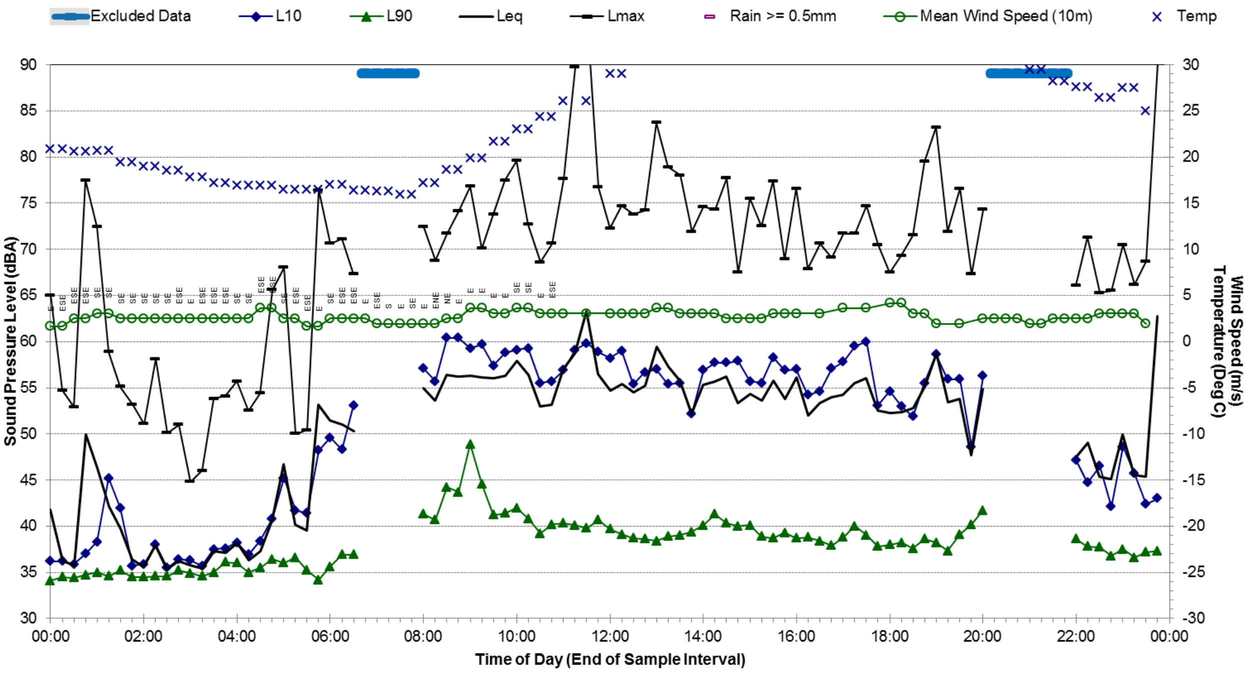


Statistical Ambient Noise Levels

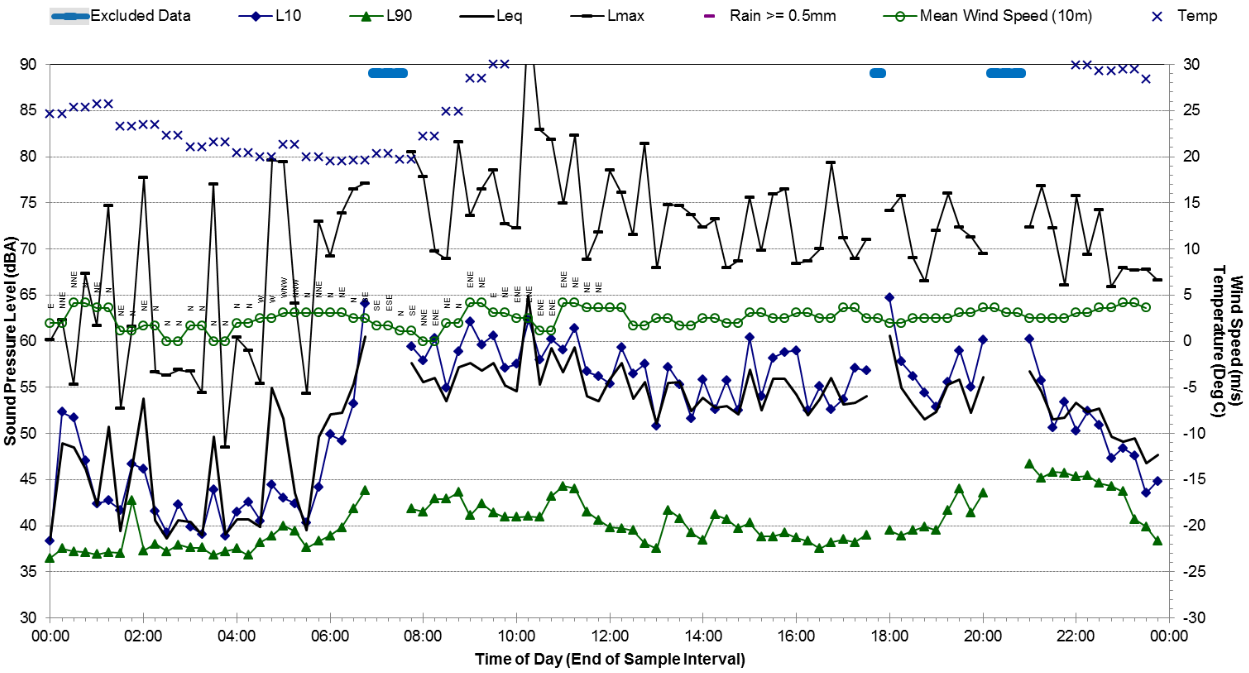
34 Murray Pde - Wednesday, 18 February 2015



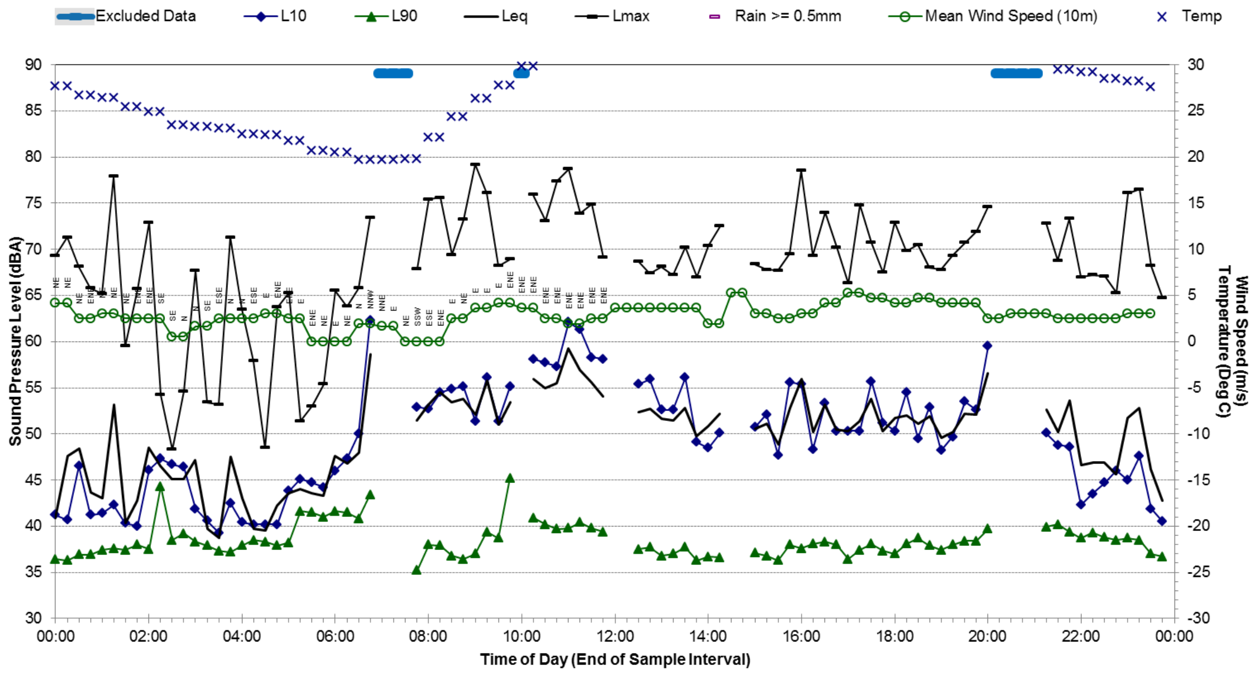
Statistical Ambient Noise Levels
34 Murray Pde - Thursday, 19 February 2015



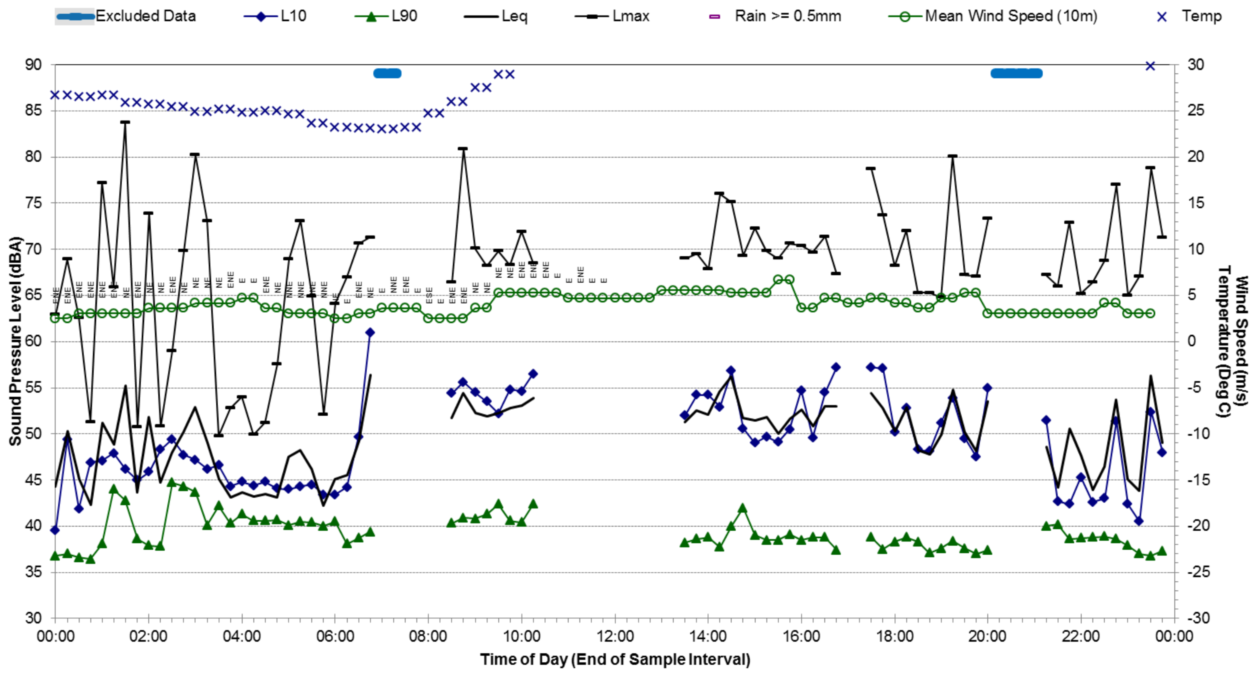
Statistical Ambient Noise Levels
34 Murray Pde - Friday, 20 February 2015



Statistical Ambient Noise Levels
34 Murray Pde - Saturday, 21 February 2015

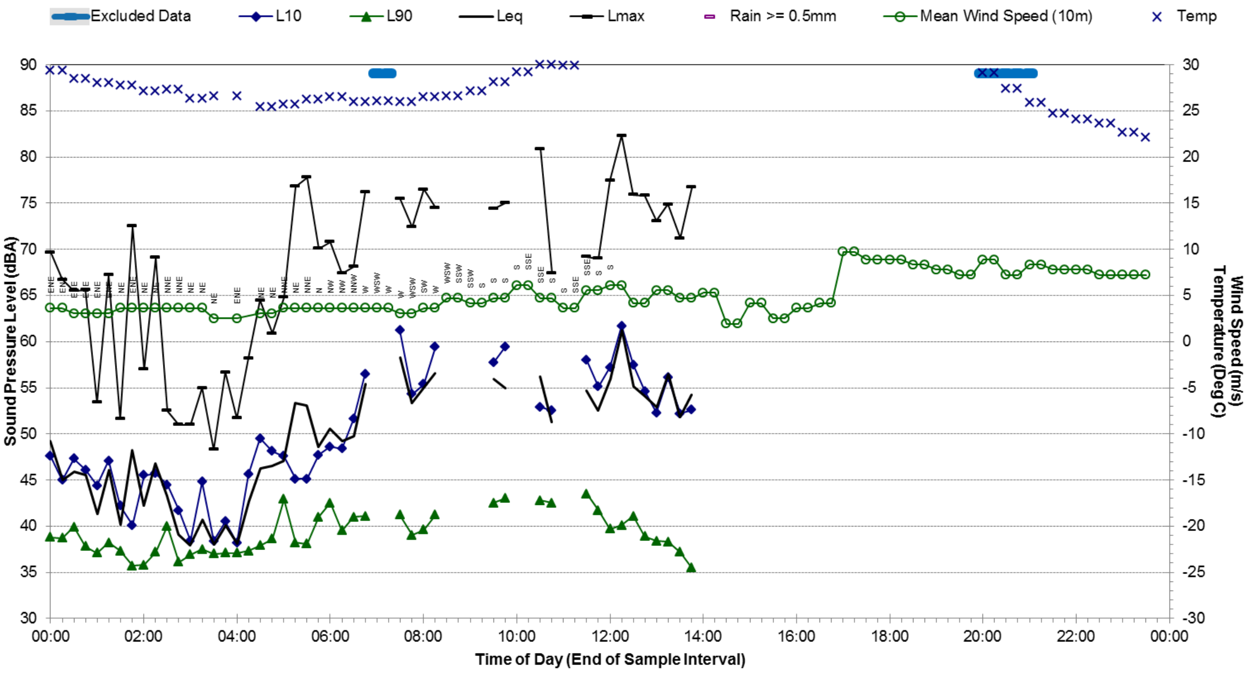


Statistical Ambient Noise Levels
34 Murray Pde - Sunday, 22 February 2015



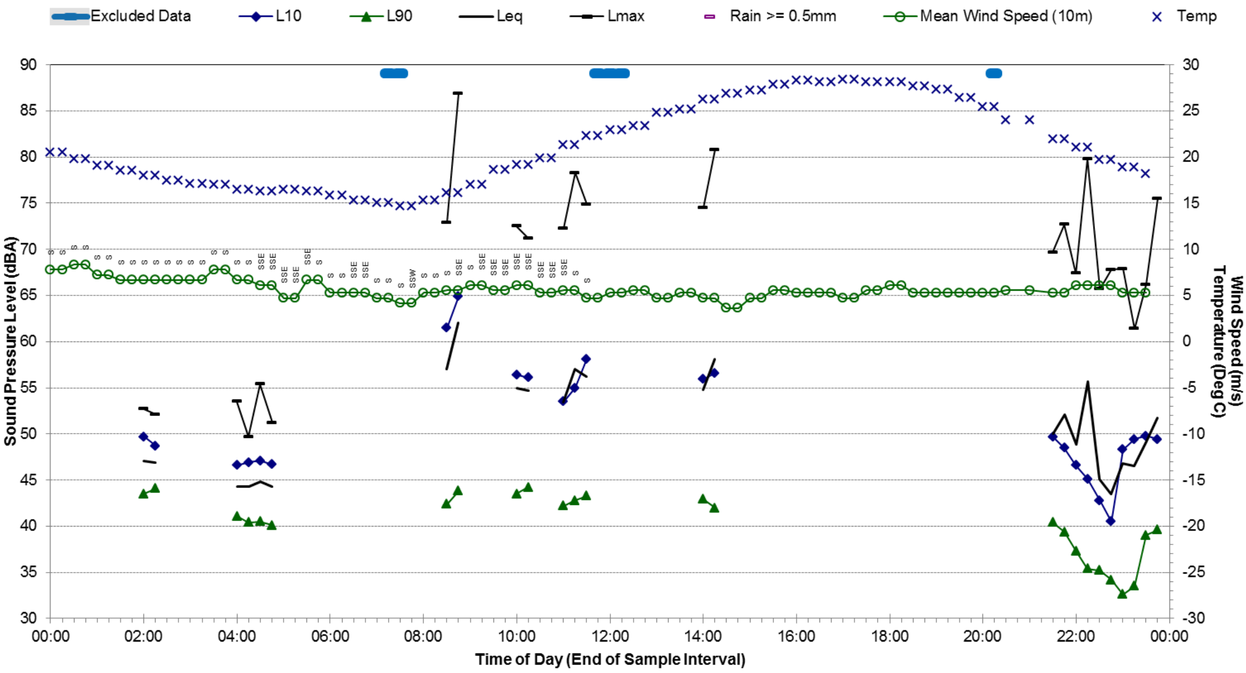
Statistical Ambient Noise Levels

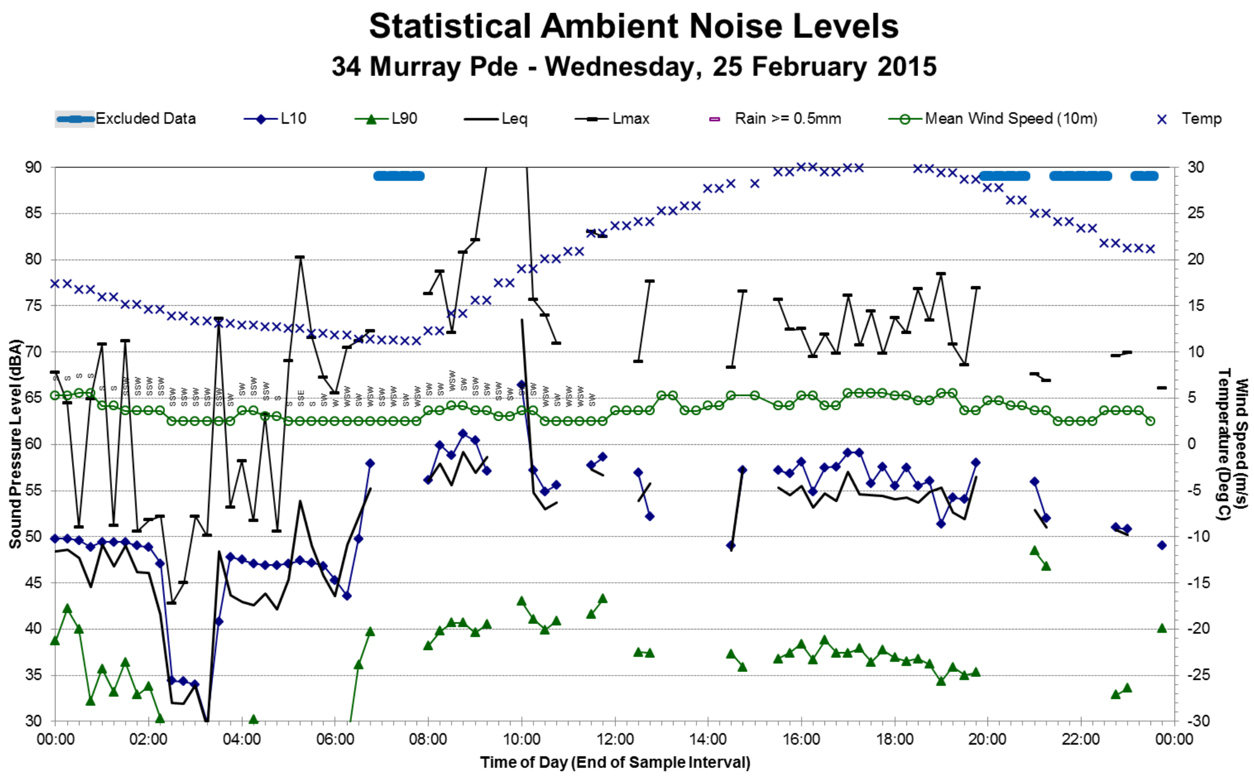
34 Murray Pde - Monday, 23 February 2015

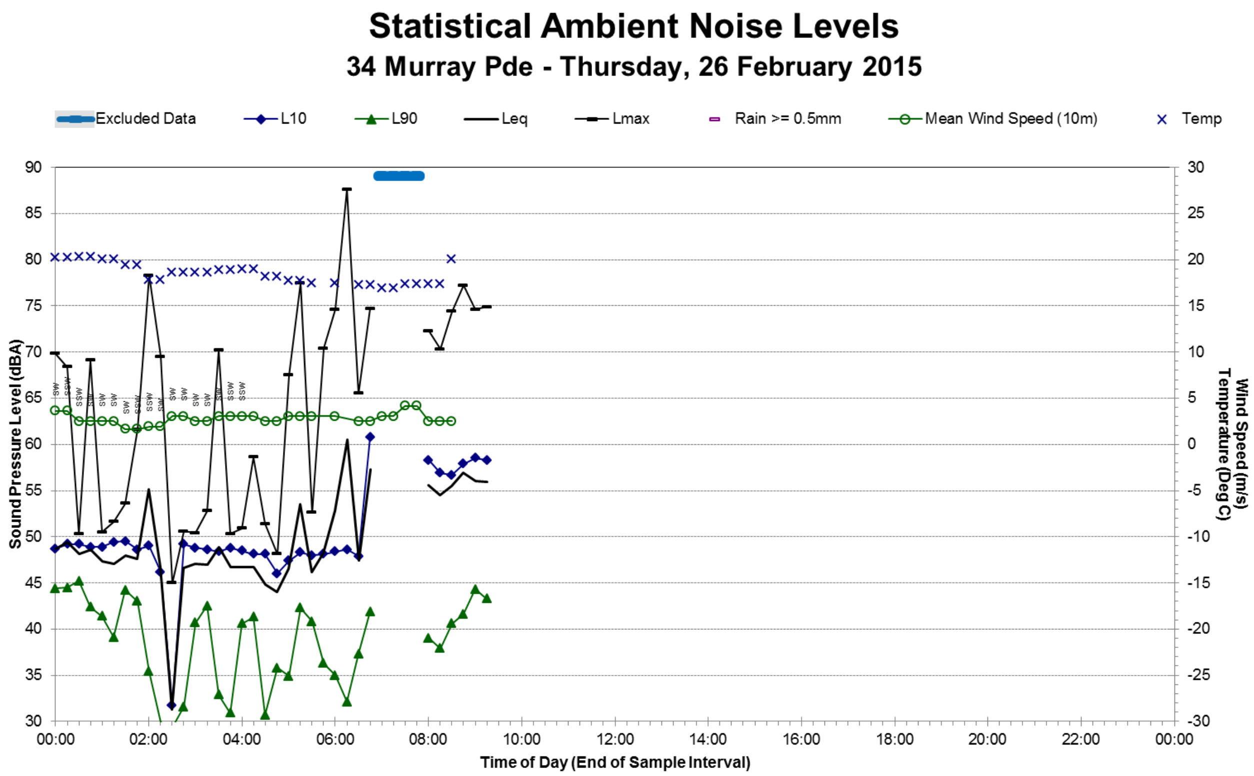


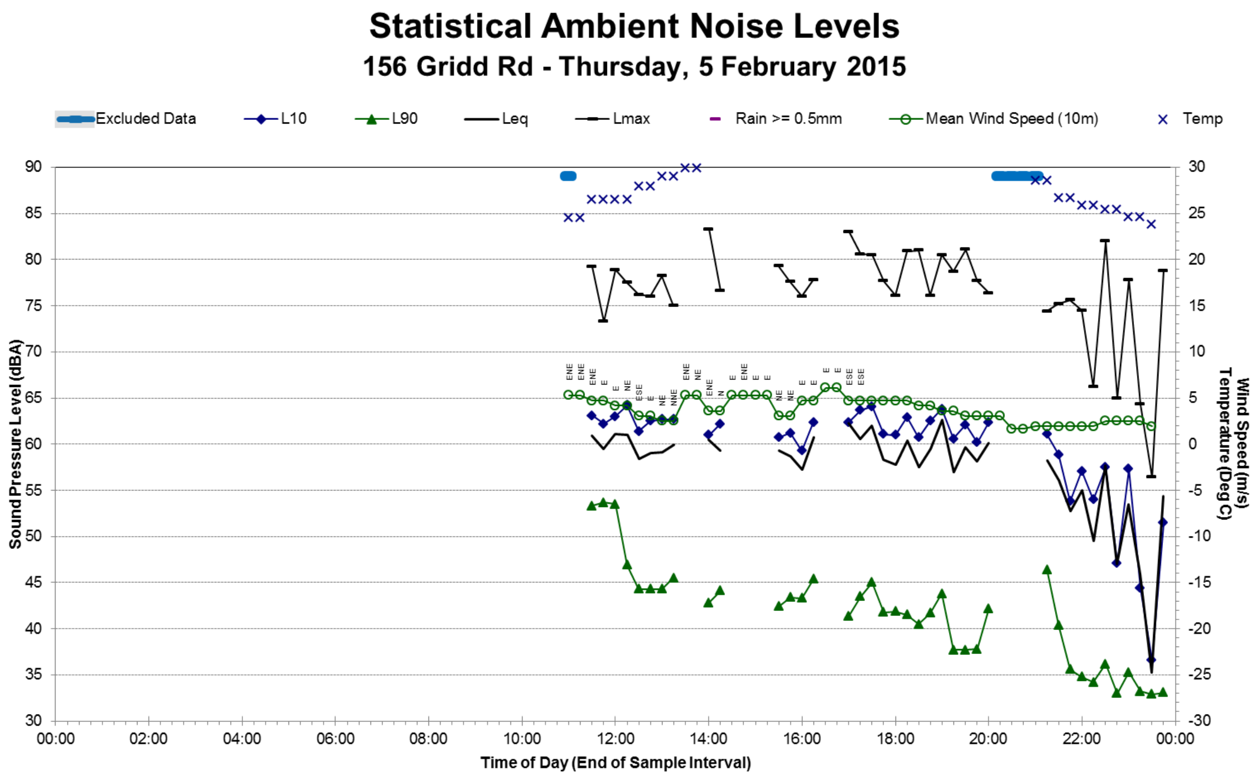
Statistical Ambient Noise Levels

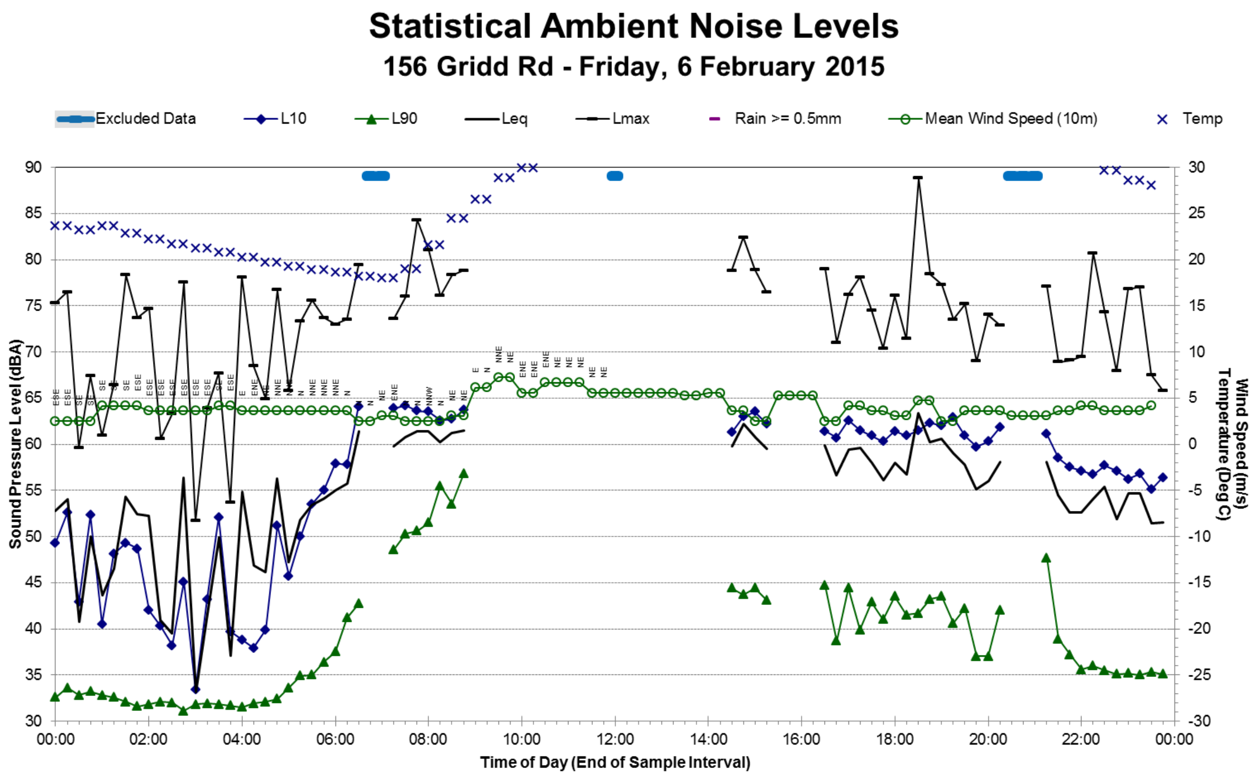
34 Murray Pde - Tuesday, 24 February 2015




Statistical Ambient Noise Levels
34 Murray Pde - Wednesday, 25 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

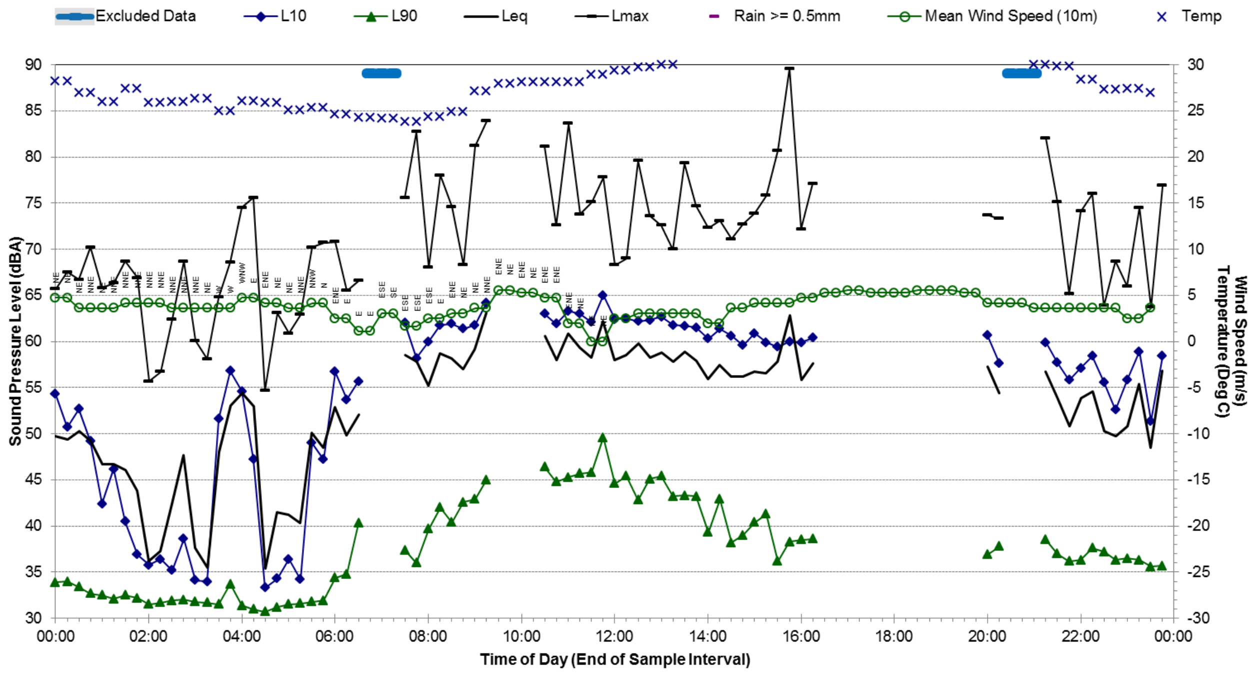

Statistical Ambient Noise Levels
34 Murray Pde - Thursday, 26 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
156 Gridd Rd - Thursday, 5 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
156 Gridd Rd - Friday, 6 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

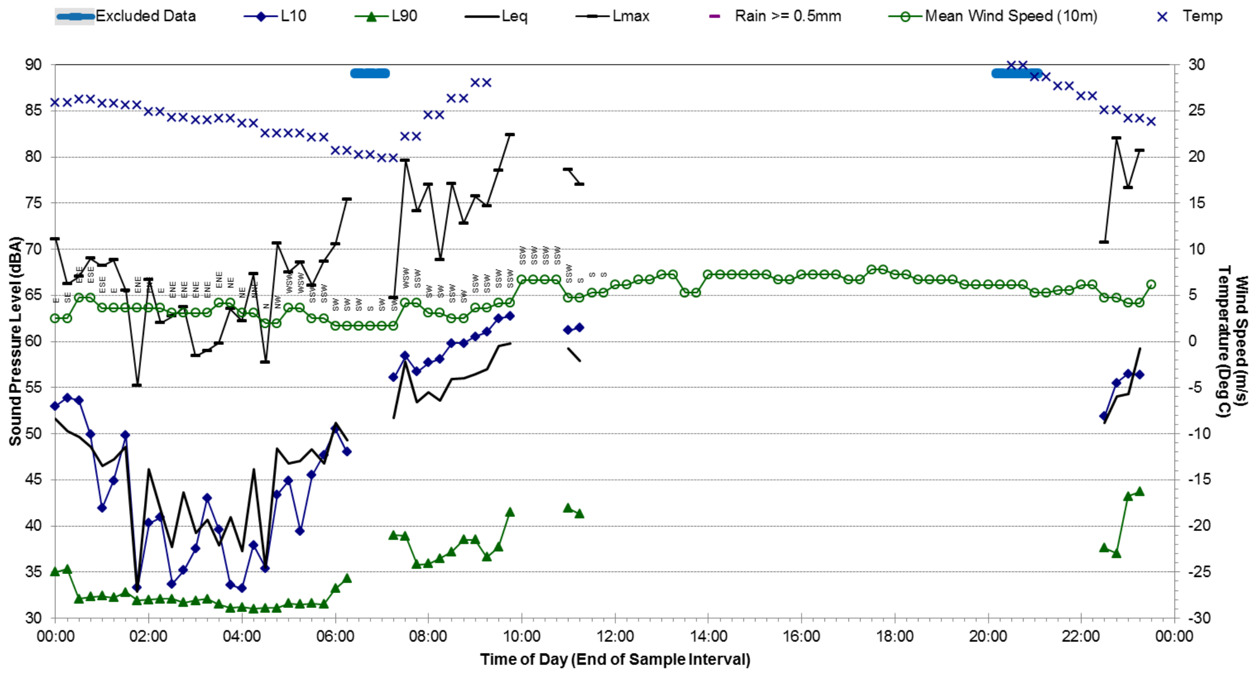
Statistical Ambient Noise Levels

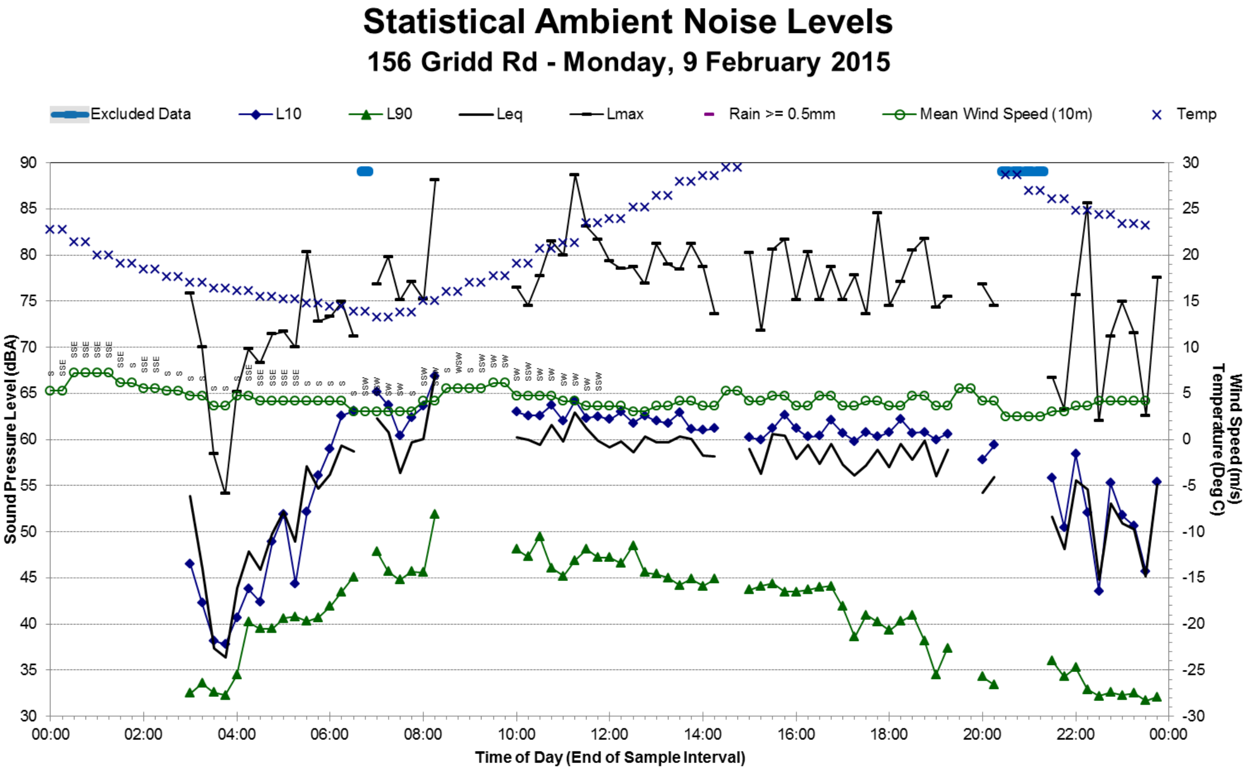
156 Gridd Rd - Saturday, 7 February 2015

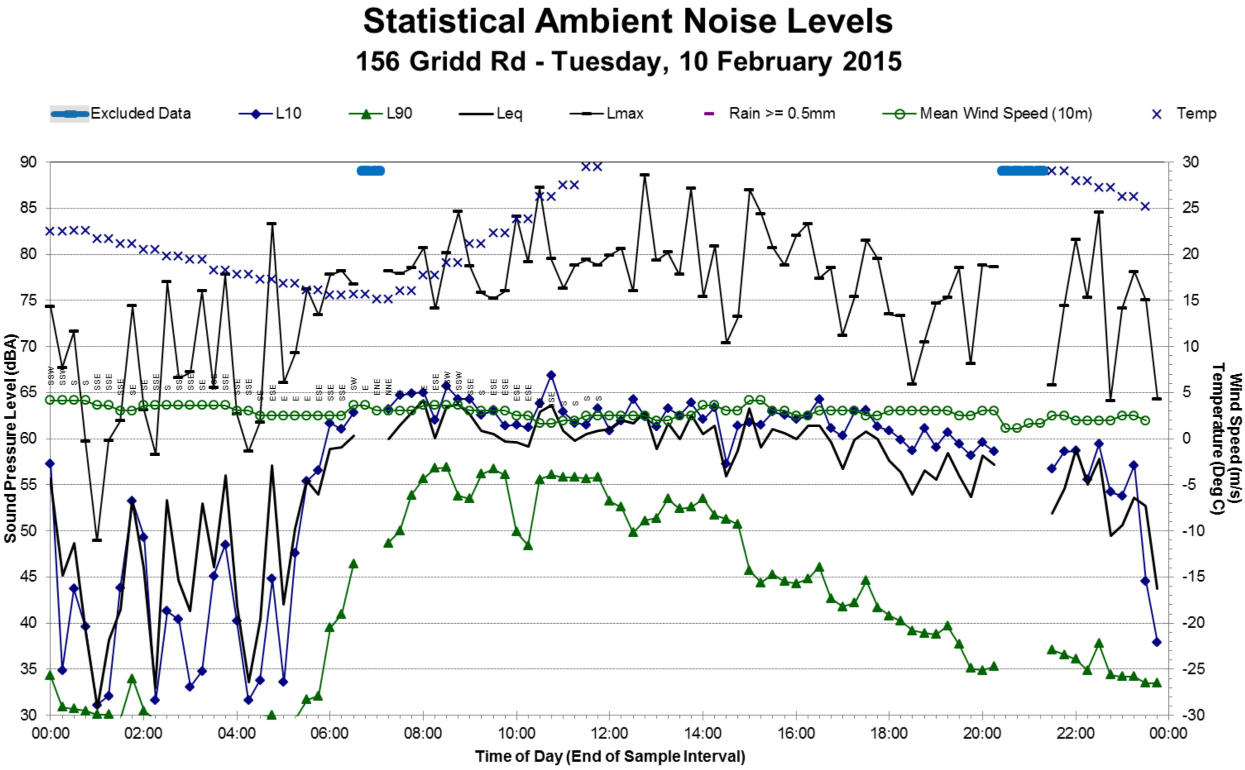


Statistical Ambient Noise Levels

156 Gridd Rd - Sunday, 8 February 2015

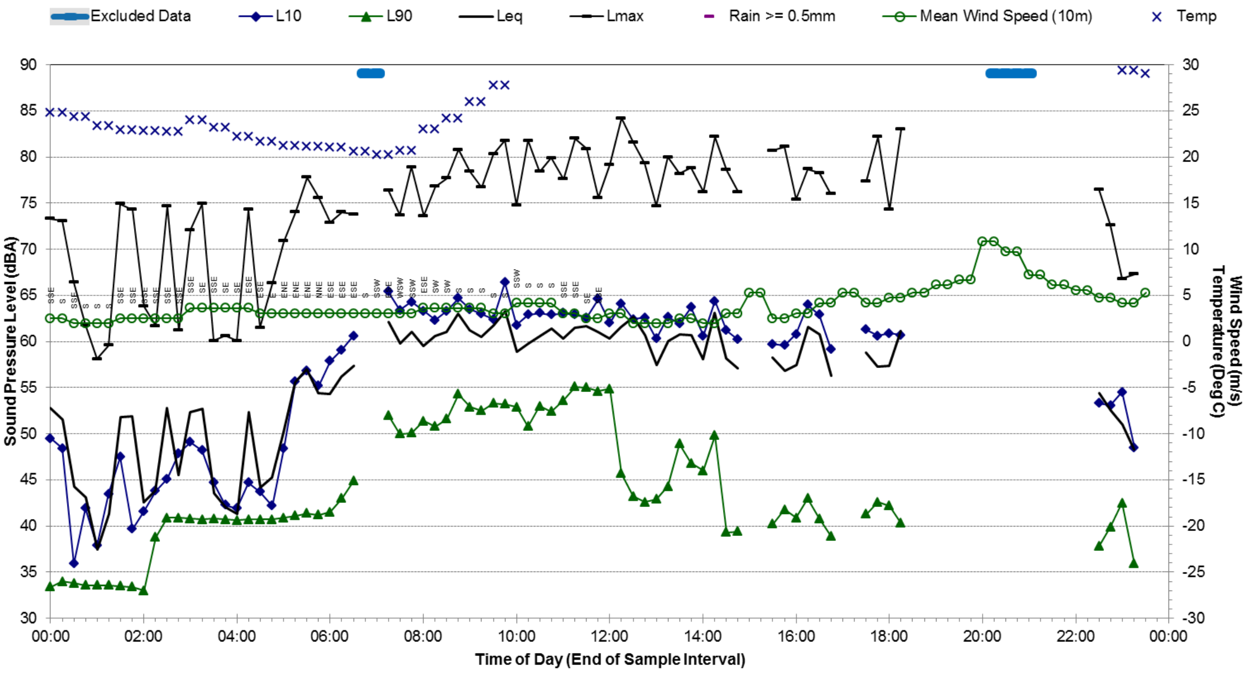



Statistical Ambient Noise Levels
156 Gridd Rd - Monday, 9 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
156 Gridd Rd - Tuesday, 10 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

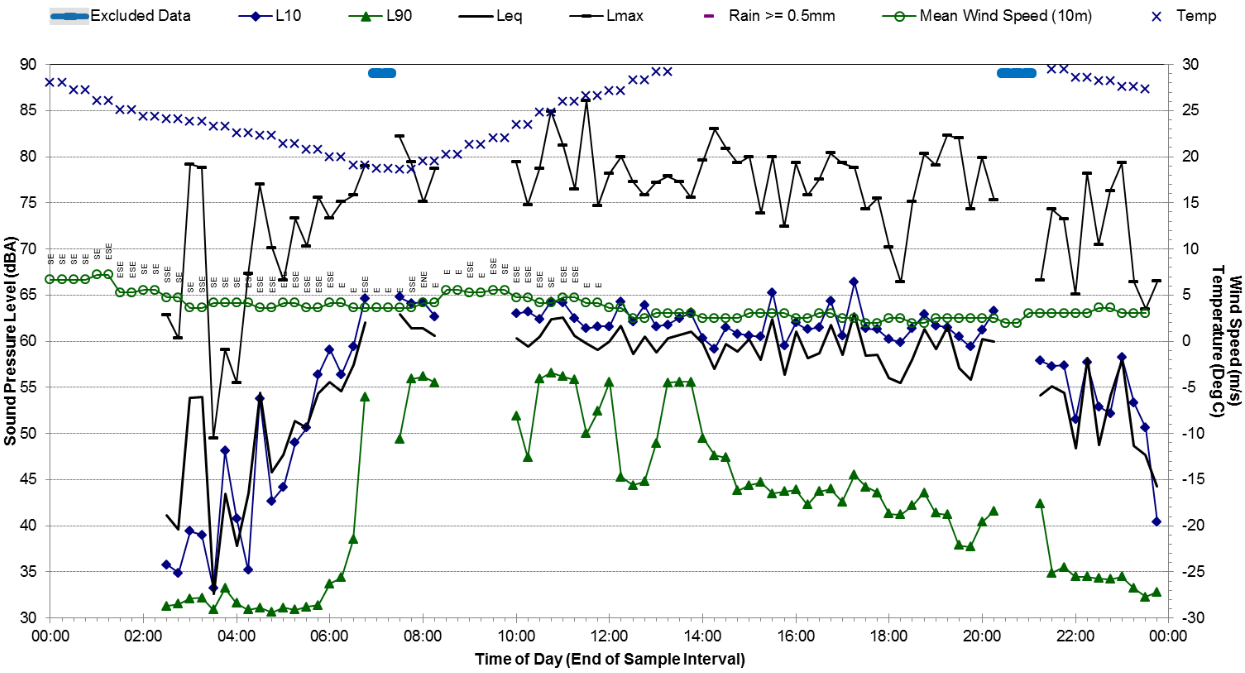
Statistical Ambient Noise Levels

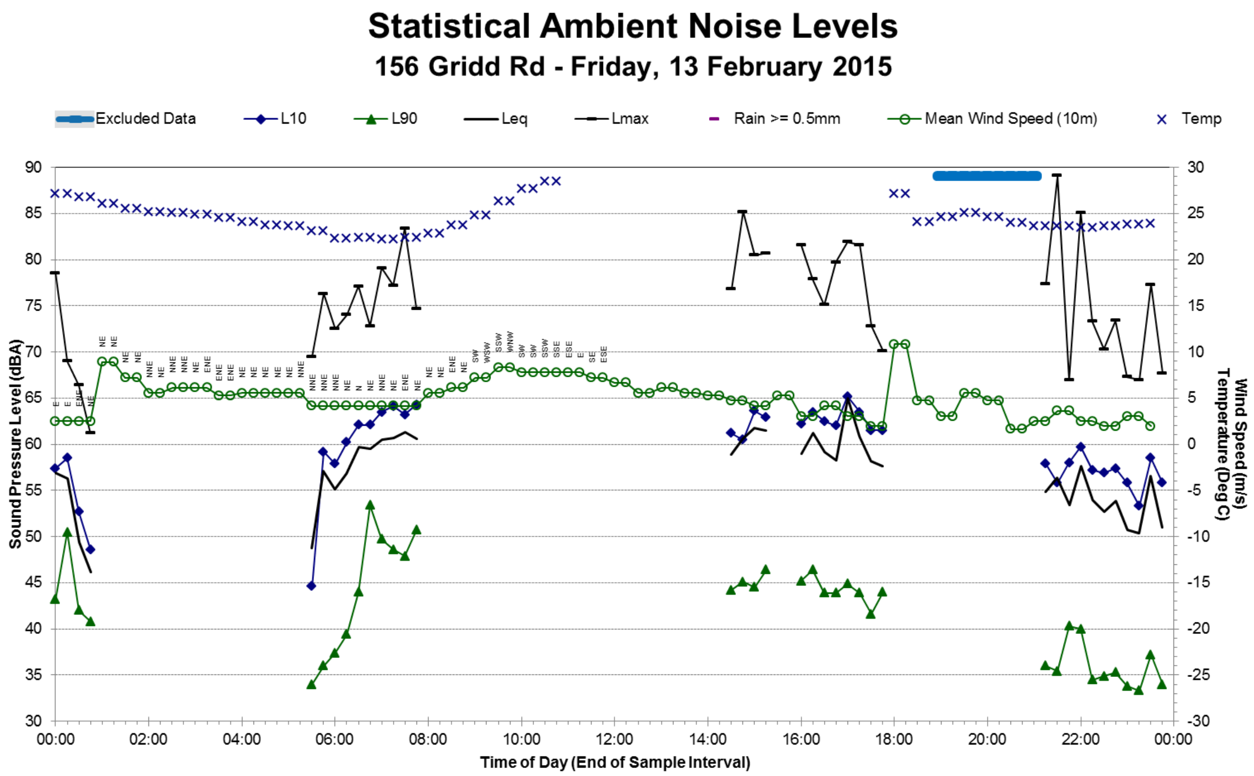
156 Gridd Rd - Wednesday, 11 February 2015

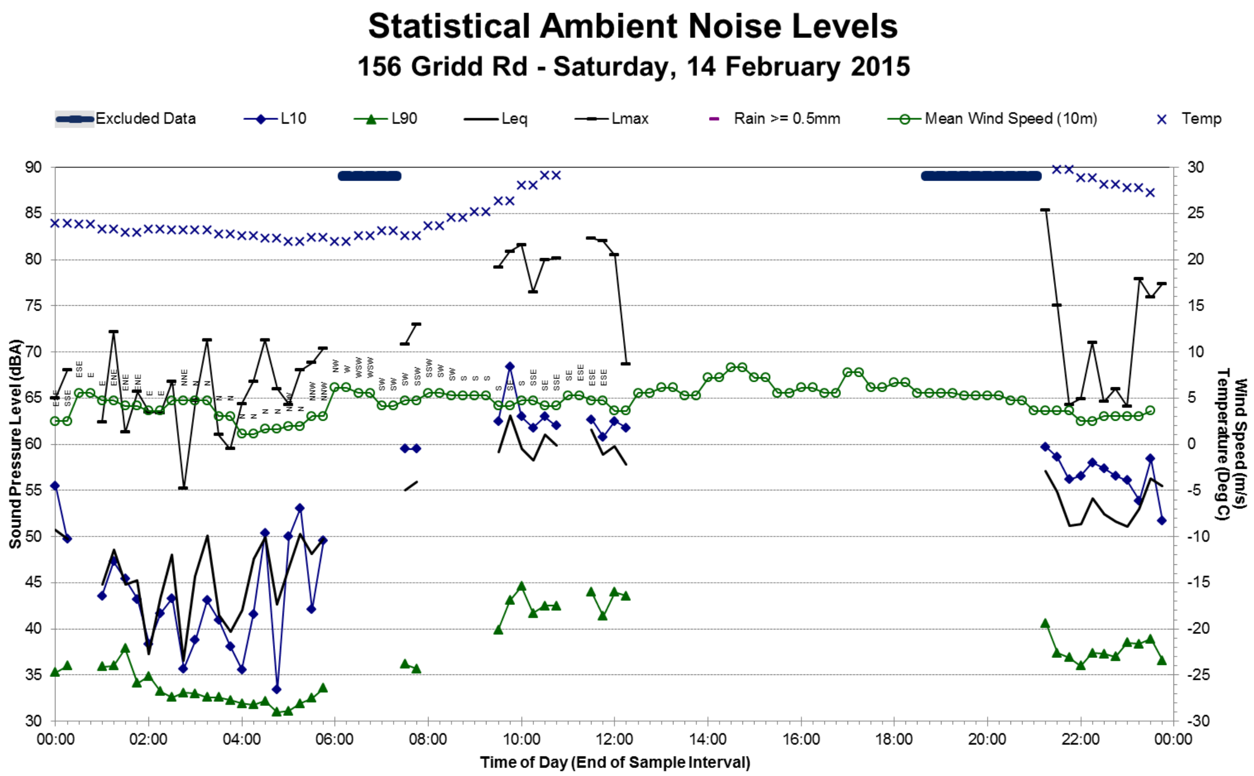


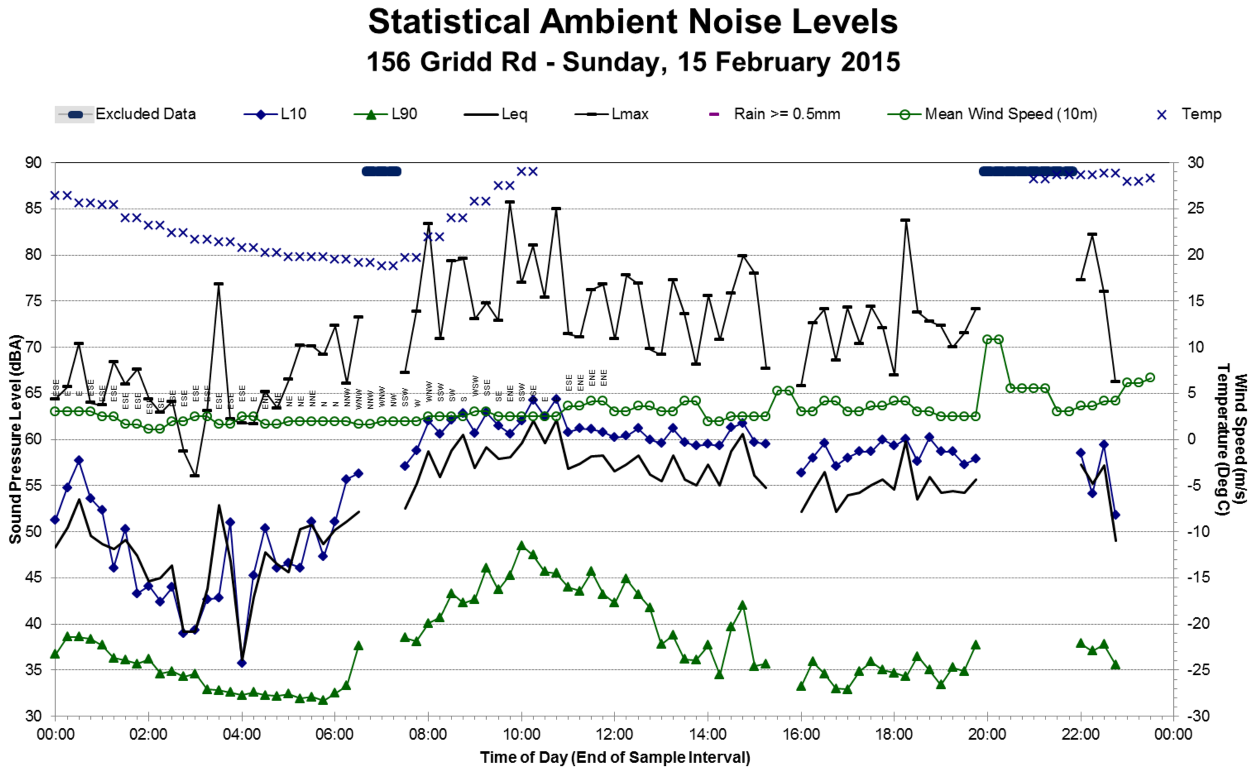
Statistical Ambient Noise Levels

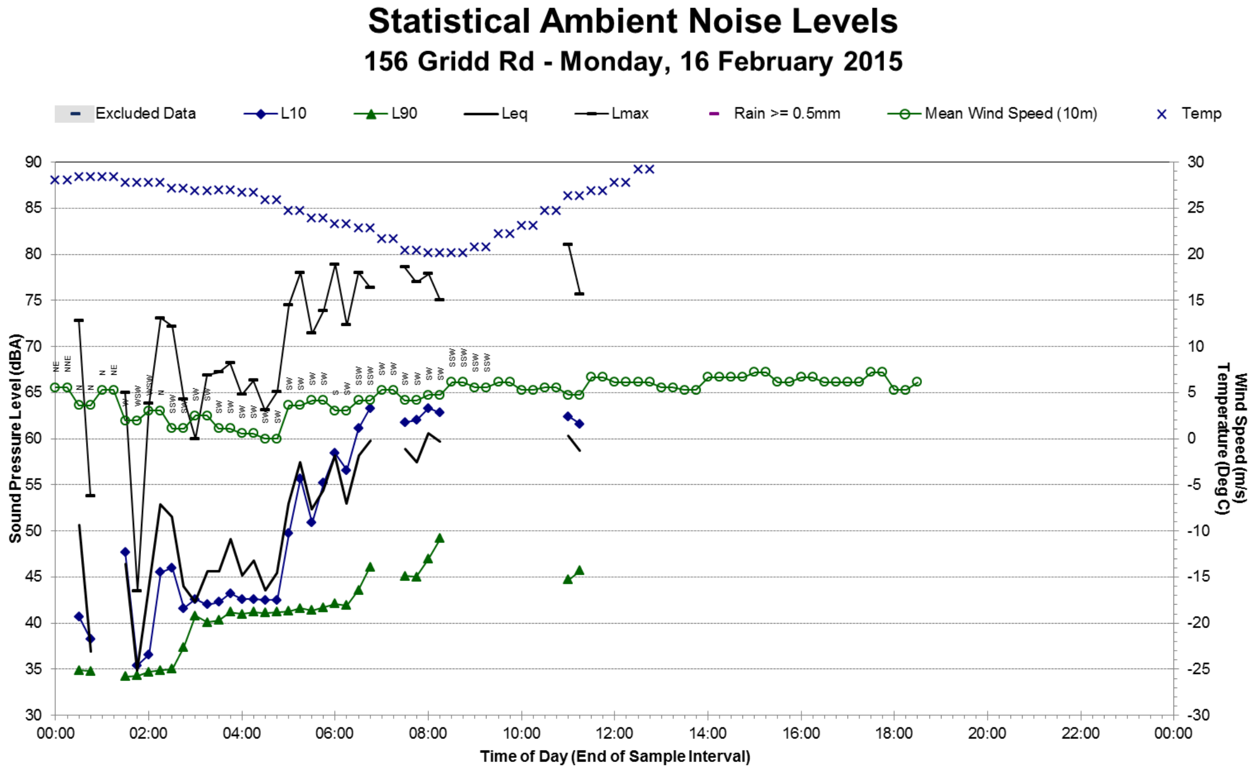
156 Gridd Rd - Thursday, 12 February 2015

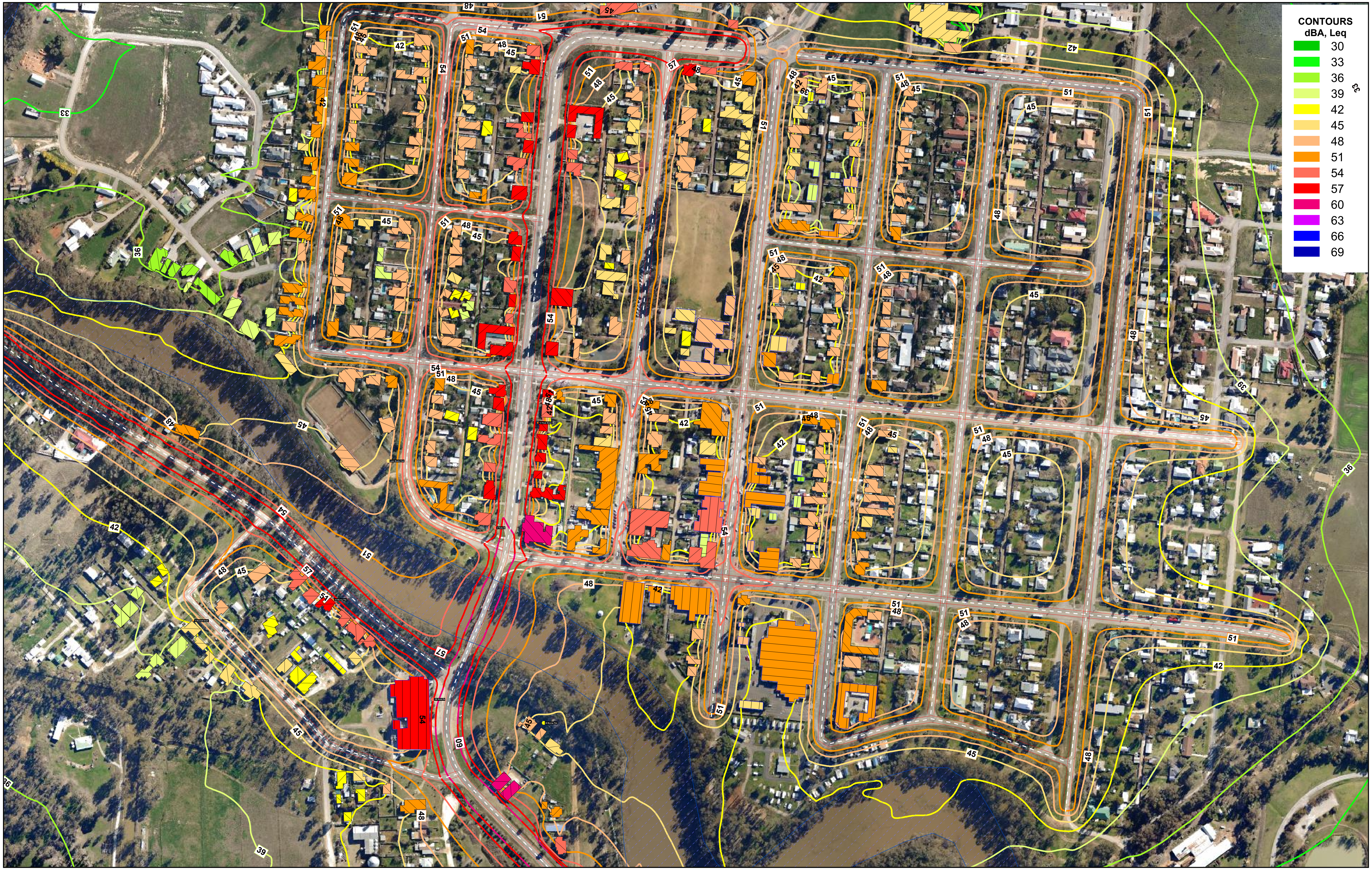



Statistical Ambient Noise Levels
156 Gridd Rd - Friday, 13 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
156 Gridd Rd - Saturday, 14 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
156 Gridd Rd - Sunday, 15 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
156 Gridd Rd - Monday, 16 February 2015
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)



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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

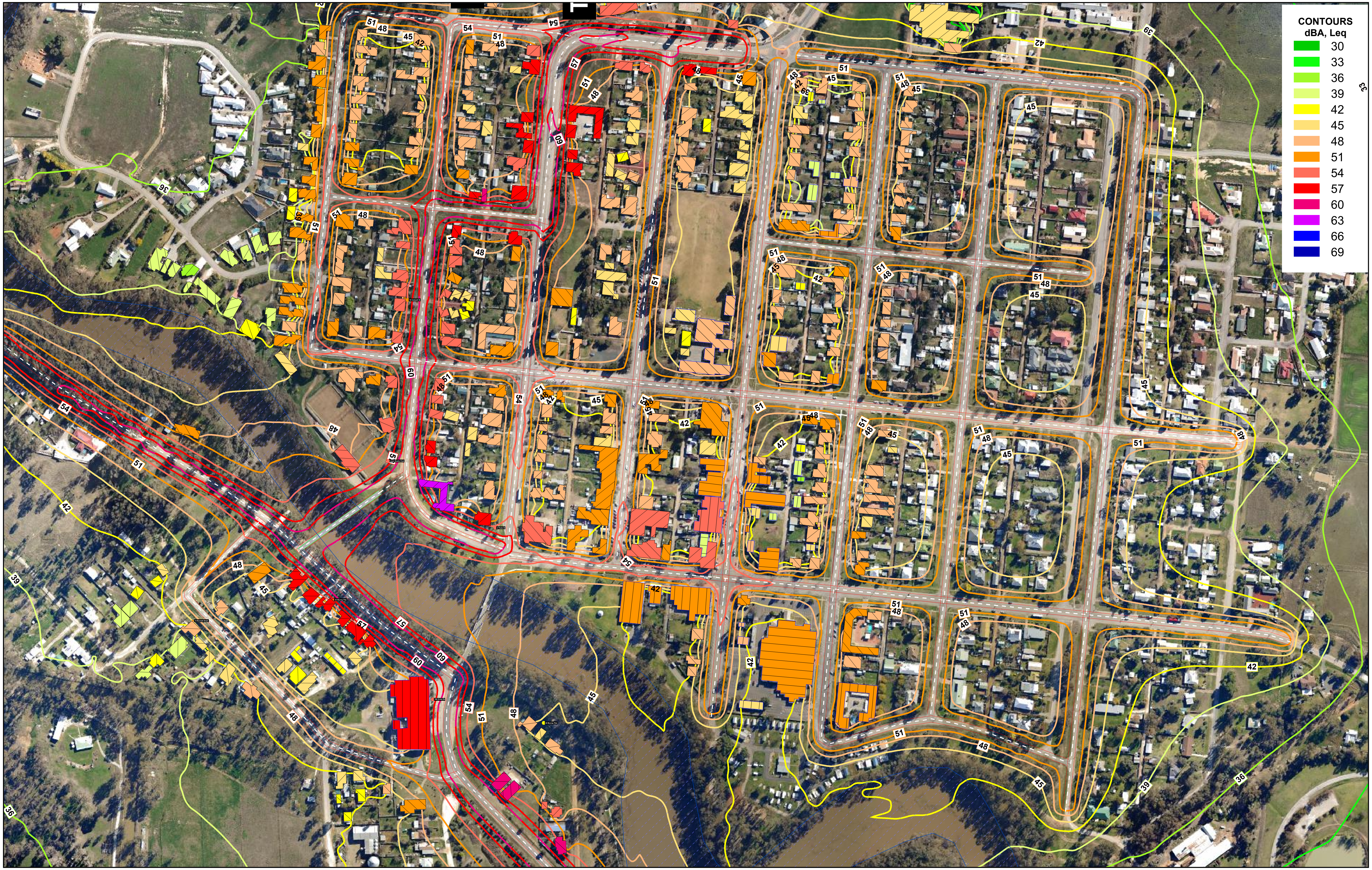
- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Existing Alignment

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
001



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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Option 1 - Leq15h dBA

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
002

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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Option 2 - Leq15h

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
003

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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

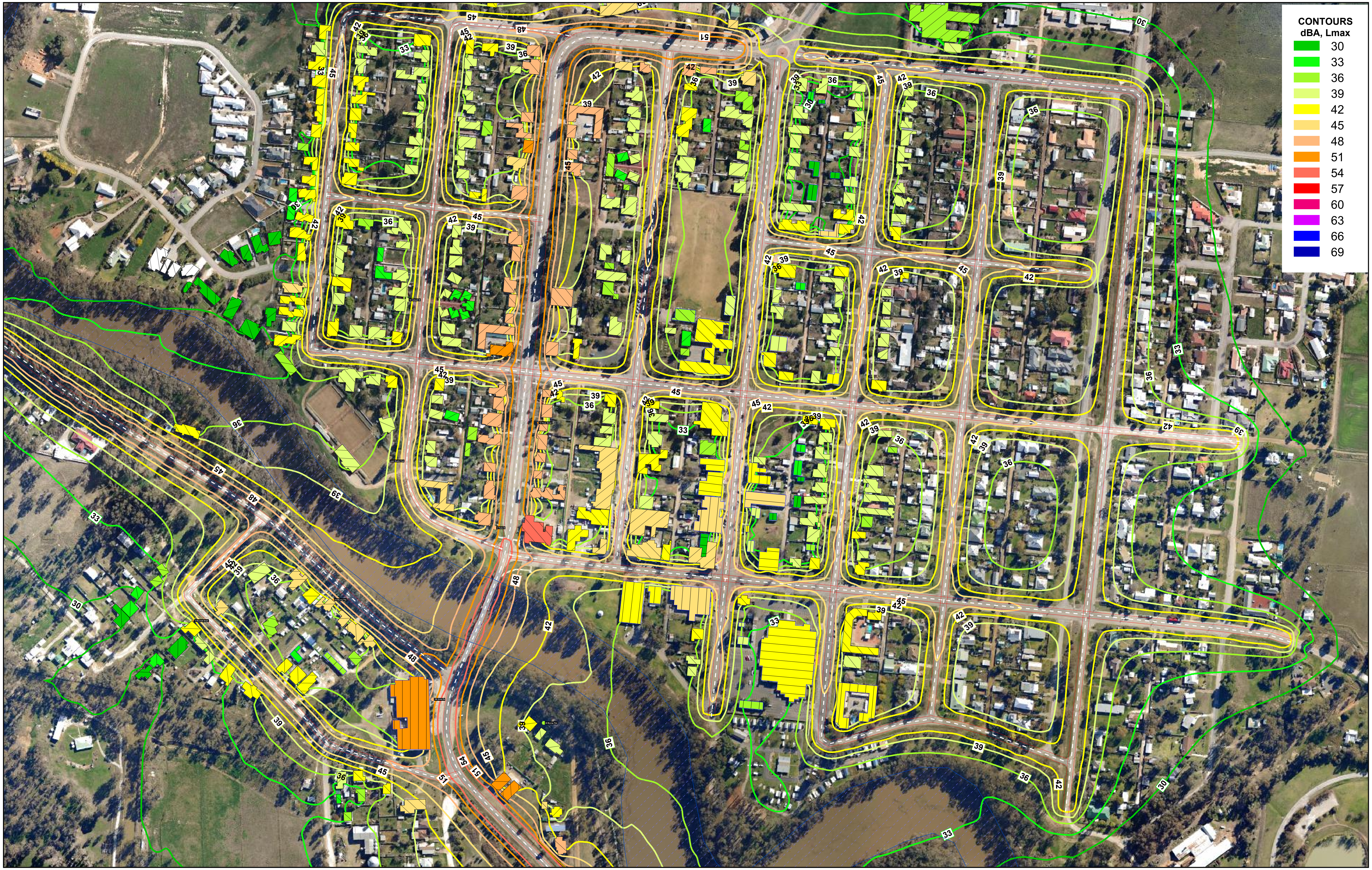
- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Option 3 - Leq15h dBA

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
004



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SCALE 0 20 40 80 120 160 200 240 m

ORIENTATION N

LEGEND
- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Existing Scenario - Leq9h dBA

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX C

MAP NO. 005

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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

- Point receiver
- Limit line
- Emission line
- Surface
- Main building
- Area
- Central reservation
- Bridge
- Wall
- inside tunnels
- Auxiliary building
- School
- Base line
- Wall
- Transparency wall areas
- Sloped wall areas
- Ground absorption
- additional 1
- Facade point
- Facade point with conflic
- Free field point
- Free field point with confl
- Facade with conflict
- Start marking
- Geometry bitmap

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Option 1 - Leq9h dBA

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
006

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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Option 2 - Leq9h dBA

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
007

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SCALE

0 20 40 80 120 160 200 240 m

ORIENTATION

N

LEGEND

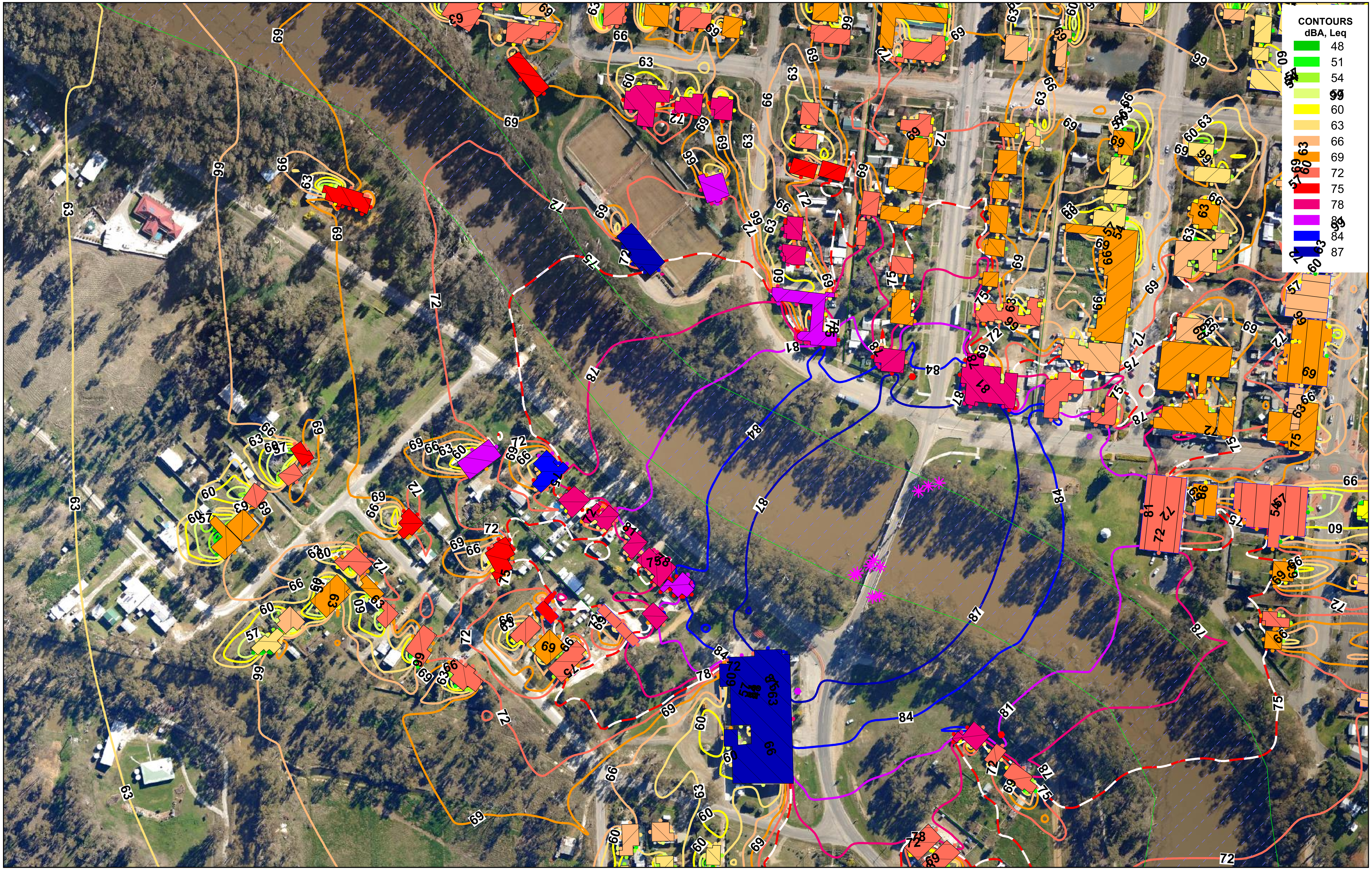
- Point receiver
- Limit line
- Emission line
- Surface
- Main building

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Option 3 - Leq9h dBA

Date: 10/06/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CORTN
Prepared By: PS
Prediction Height: 1.5 m

APPENDIX
C

MAP NO.
008



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SCALE
0 12.5 25 50 75 100 125 150 m

ORIENTATION
N

LEGEND
- Wall
- Emission line
- Point source
- Main building
- Highly Noise Affected Zone

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Construction Stage 1 - Installation of new piles for temporary bridge and coffer dam

Date: 22/09/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CONCAWE
Prepared By: PS
Prediction Height: 2.0 m

APPENDIX
D

MAP NO.
001

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SCALE

0 12.5 25 50 75 100 125 150 m

ORIENTATION

N

LEGEND

- Wall
- Emission line
- Point source
- Main building
- Highly Noise Affected Zone

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Construction Stage 2 - Install span to temporary bridge

Date: 22/09/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CONCAWE
Prepared By: PS
Prediction Height: 2.0 m

APPENDIX
D

MAP NO.
002

SLR

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SCALE

0 12.5 25 50 75 100 125 150 m

ORIENTATION

N

LEGEND

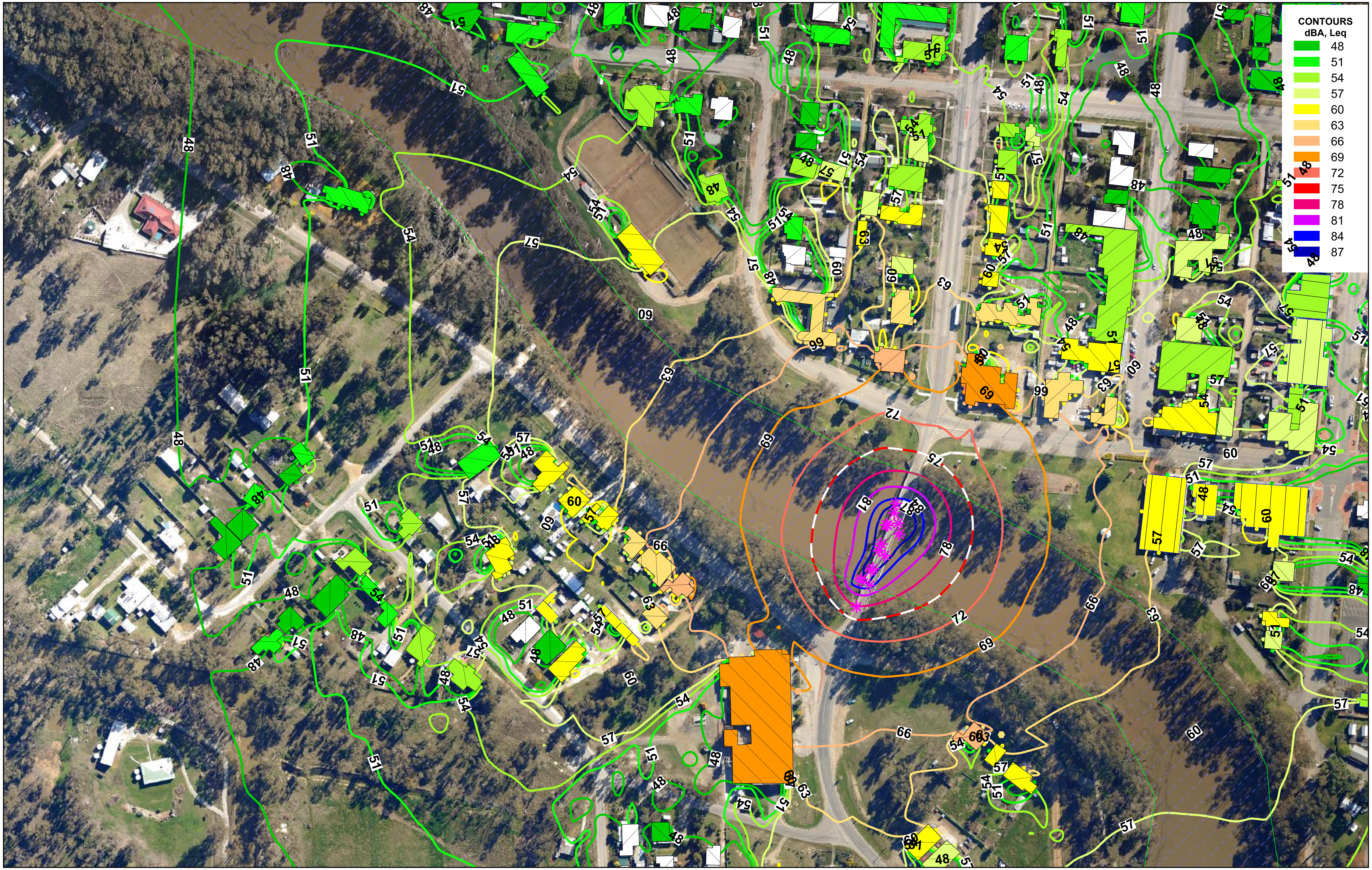
- Wall
- Emission line
- Point source
- Main building
- Highly Noise Affected Zone

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Construction Stage 3 - Remove old timber decking & clean metalwork, rust etc.

Date: 22/09/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CONCAWE
Prepared By: PS
Prediction Height: 2.0 m

APPENDIX
D

MAP NO.
003



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SCALE

0 12.5 25 50 75 100 125 150 m

ORIENTATION

N

LEGEND

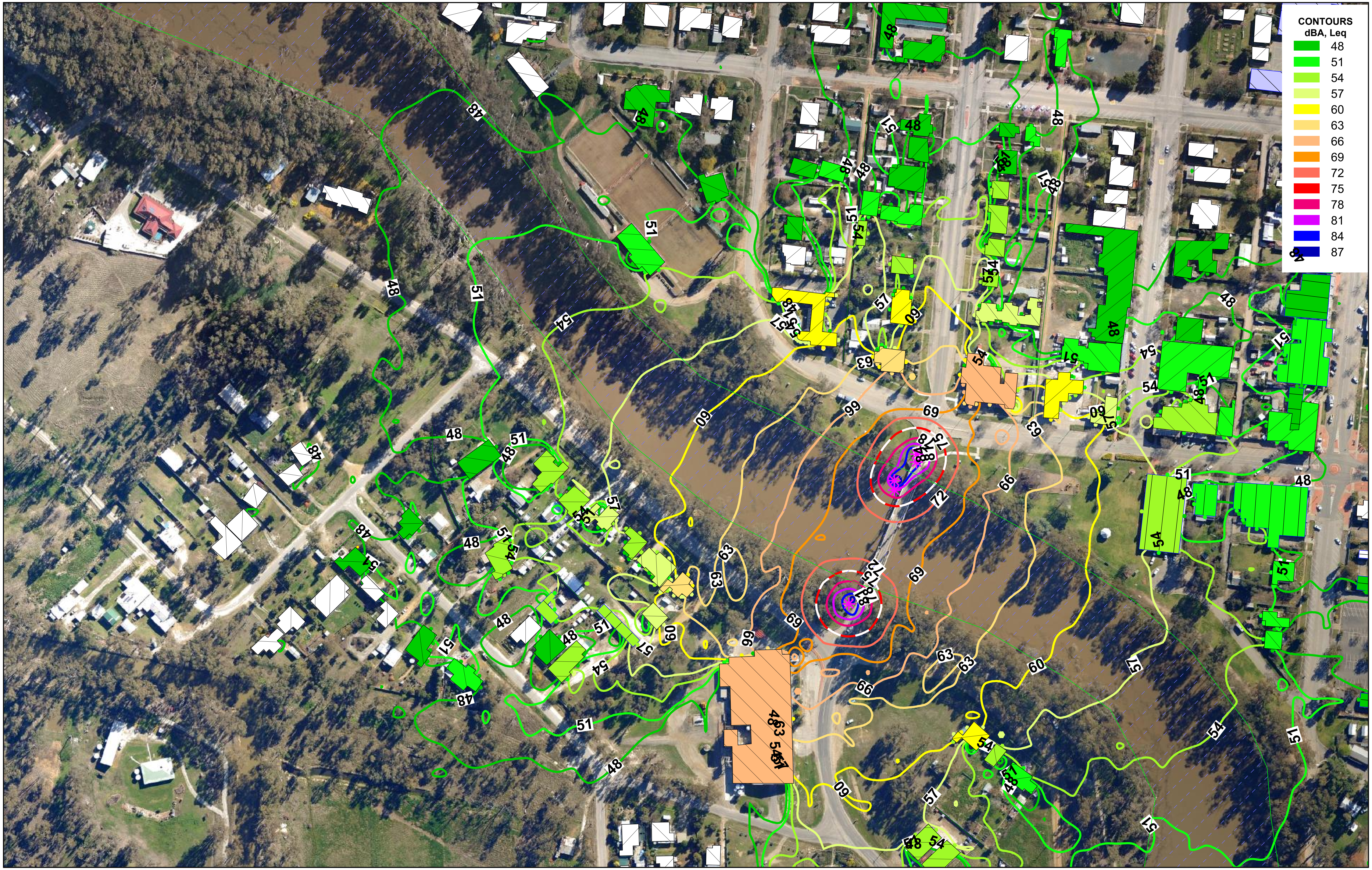
- Wall
- Emission line
- Point source
- Main building
- Highly Noise Affected Zone

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Construction Stage 4 - Install new timber decking

Date: 22/09/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CONCAWE
Prepared By: PS
Prediction Height: 2.0 m

APPENDIX
D

MAP NO.
004



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SCALE

0 12.5 25 50 75 100 125 150 m

ORIENTATION

N

LEGEND

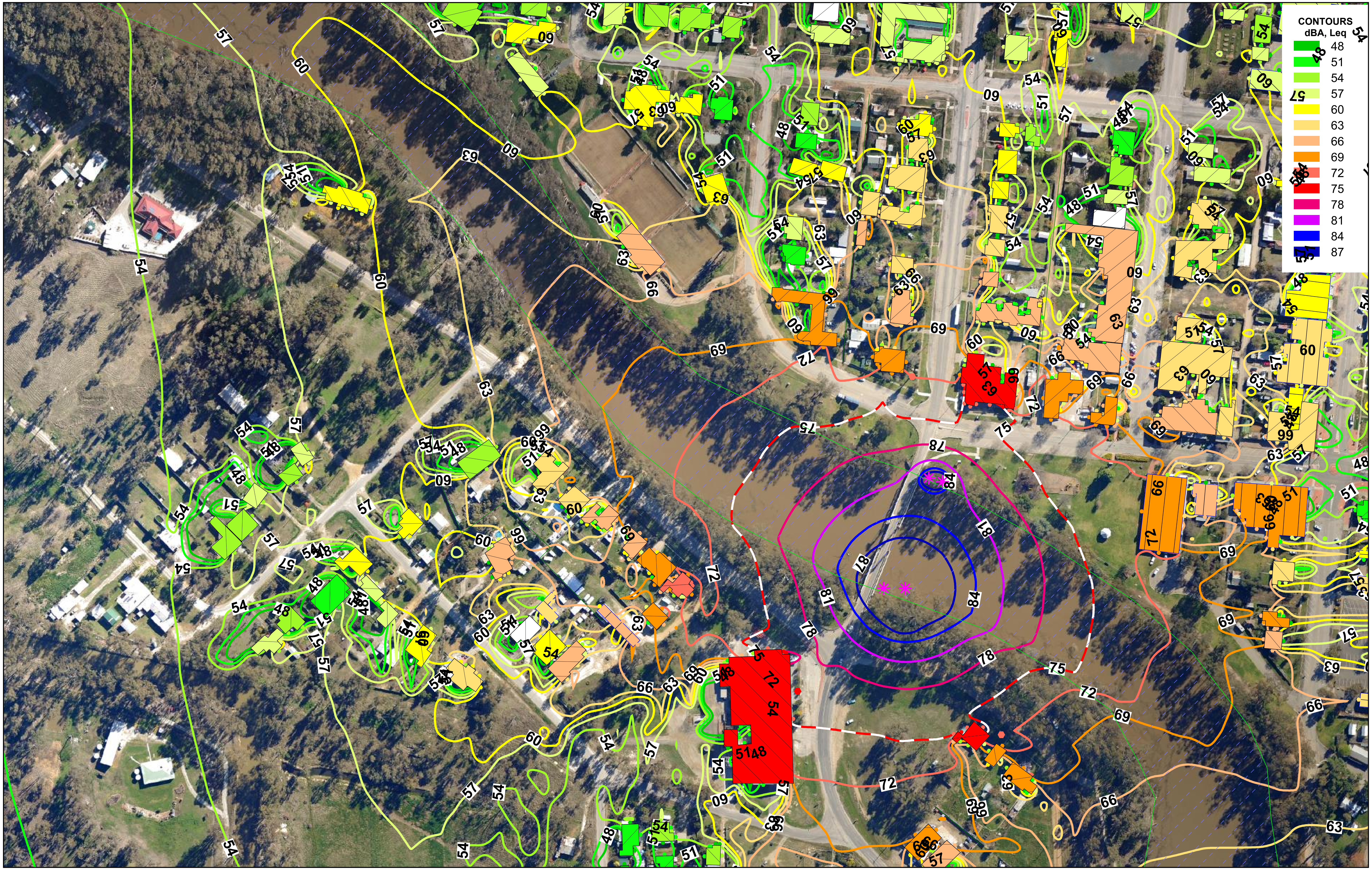
- Wall
- Emission line
- Point source
- Main building
- Point receiver
- Limit line
- Auxiliary building
- School

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Construction Stage 5 - Install trusses to bridge

Date: 22/09/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CONCAWE
Prepared By: PS
Prediction Height: 2.0 m

APPENDIX
D

MAP NO.
005



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SCALE

0 12.5 25 50 75 100 125 150 m

ORIENTATION

N

LEGEND

- Wall
- Emission line
- Point source
- Main building
- Highly Noise Affected Zone

PROJECT	Barham Bridge
CLIENT	ngh environmental
DESCRIPTION	Construction Stage 6 - Remove temporary bridge

Date: 22/09/2015
Project No.: 640.10996
Report No.: 640.10996-R1
Prediction Method: CONCAWE
Prepared By: PS
Prediction Height: 2.0 m

APPENDIX
D

MAP NO.
006

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
1	2 Thule St	GR	56	49	55	41	49	4fdpa0	56	49
2	2 Thule Street	GR	56	49	51	39	48	39	57	49
20	12 Burnett Street	GR	48	44	48	47	60	53	58	51
25	13 Thule Street	GR	58	50	50	41	49	41	58	50
28	18 Cobwell St	GR	48	39	54	46	54	46	48	39
29	18 Cobwell Street	GR	50	42	56	49	56	49	50	41
35	20 Murray Pde	GR	44	37	45	37	43	35	46	38
53	34 Murray Pde	GR	57	47	59	52	57	48	45	37
54	156 Gridd Rd	GR	56	49	55	48	46	38	51	44
65	Building637	GR	48	45	48	47	60	53	58	52
73	Building638	GR	46	44	46	47	60	53	57	51
75	Building639	GR	44	42	45	45	58	51	56	50
88	Building640	GR	45	43	45	45	59	51	56	50
94	Building644	GR	43	39	43	42	54	47	52	46
108	Building645	GR	50	48	50	51	64	57	62	56
116	Building646	GR	50	41	53	45	53	44	48	40
129	Building647	GR	57	47	60	52	57	48	46	38
130	Building649	GR	47	44	47	47	59	52	57	51
138	Building652	GR	45	41	46	44	57	49	54	48
150	Building653	GR	55	45	57	50	55	46	44	36
158	Building656	GR	57	47	59	52	57	47	45	37
159	Building658	GR	57	47	59	52	57	47	46	38
181	Building659	GR	57	47	59	52	57	47	46	38
187	Building660	GR	40	32	41	35	45	37	43	36
188	Building661	GR	42	34	42	36	47	39	45	38
200	Building662	GR	40	32	40	33	45	38	44	37
215	Building663	GR	45	39	46	41	54	46	51	45

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
220	Building665	GR	58	50	50	40	49	40	58	50
232	Building666	GR	56	49	48	39	48	39	56	49
233	Building667	GR	57	49	49	40	49	40	57	49
246	Building668	GR	45	37	43	35	42	34	45	37
247	Building669	GR	56	49	49	40	48	39	56	49
257	Building670	GR	57	50	50	41	49	40	57	50
265	Building671	GR	57	50	51	42	50	41	57	50
280	Building672	GR	51	43	54	46	54	46	51	42
282	Building675	GR	50	42	56	49	56	49	50	41
286	Building676	GR	50	41	57	49	56	49	50	41
293	Building677	GR	43	35	47	39	48	40	43	35
299	Building678	GR	50	41	57	49	57	49	49	41
309	Building679	GR	50	41	58	49	57	49	49	41
330	Building681	GR	54	45	62	47	54	46	53	45
346	Building682	GR	49	41	56	48	56	48	49	41
348	Building683	GR	51	43	55	47	55	47	51	42
357	Building685	GR	50	42	52	43	51	43	50	41
368	Building686	GR	50	42	51	42	51	42	50	41
389	Building687	GR	48	39	56	48	57	49	46	38
396	Building689	GR	51	43	54	46	54	46	51	43
405	Building690	GR	50	42	51	43	51	43	50	41
406	Building691	GR	50	41	50	42	51	42	50	41
412	Building692	GR	52	43	52	43	52	43	52	43
420	Building696	GR	50	42	56	49	56	49	50	41
430	Building697	GR	50	42	56	49	56	49	50	41
442	Building698	GR	41	33	46	39	46	39	41	33
451	Building699	GR	42	34	46	39	46	39	42	33

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
452	Building700	GR	49	41	56	48	56	48	49	40
473	Building701	GR	50	41	56	48	56	48	48	40
478	Building702	GR	49	41	49	40	49	40	49	40
483	Building703	GR	51	42	51	42	51	42	51	42
492	Building704	GR	50	42	50	41	50	41	50	41
500	Building705	GR	48	39	49	41	49	40	41	32
515	Building706	GR	52	44	52	44	52	44	52	43
524	Building708	GR	50	42	56	48	56	48	50	41
533	Building709	GR	49	41	55	48	55	48	49	40
536	Building710	GR	58	51	51	42	50	41	58	51
547	Building711	GR	59	51	52	43	51	42	59	51
557	Building712	GR	57	49	50	41	49	41	57	49
565	Building713	GR	46	38	43	33	41	33	45	38
567	Building714	GR	42	34	43	34	42	34	41	33
576	Building715	GR	43	35	48	40	48	40	43	34
581	Building716	GR	50	42	56	49	56	49	50	41
587	Building718	GR	49	41	56	48	56	48	49	40
593	Building719	GR	43	34	48	40	48	40	43	34
603	Building720	GR	42	34	45	38	45	37	42	34
612	Building721	GR	42	34	43	35	43	35	41	33
616	Building722	GR	57	50	50	42	50	41	57	50
618	Building723	GR	57	49	50	42	50	41	57	49
626	Building724	GR	47	39	53	46	53	46	47	38
632	Building725	GR	57	50	52	44	51	43	57	50
633	Building726	GR	48	40	54	47	54	47	48	39
640	Building727	GR	48	40	55	47	55	47	48	39
650	Building728	GR	50	42	58	50	58	50	45	37

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
660	Building729	GR	57	50	54	46	54	46	57	49
665	Building730	GR	58	50	59	51	58	51	58	50
670	Building731	GR	51	42	59	52	59	51	44	36
678	Building732	GR	53	44	61	54	61	53	46	38
683	Building733	GR	49	40	51	43	51	43	48	39
691	Building737	GR	49	41	51	42	51	42	49	40
696	Building738	GR	48	40	49	40	49	40	48	39
711	Building739	GR	55	48	56	48	55	48	55	48
713	Building740	GR	58	51	59	52	58	51	58	51
717	Building741	GR	57	49	58	50	57	49	57	49
730	Building742	GR	42	38	43	41	53	45	51	45
735	Building743	GR	40	34	41	37	49	42	47	41
736	Building744	GR	40	34	42	37	48	40	46	40
745	Building745	GR	39	33	40	35	47	39	45	38
751	Building746	GR	46	42	46	45	57	50	55	49
754	Building747	GR	47	39	48	41	48	40	46	39
766	Building748	GR	53	43	54	44	54	44	53	44
775	Building749	GR	57	50	58	50	57	50	57	50
781	Building750	GR	48	40	47	39	47	38	48	39
790	Building753	GR	49	41	49	40	49	40	49	40
800	Building754	GR	49	40	49	40	49	40	49	40
810	Building755	GR	50	42	50	41	50	41	50	41
814	Building756	GR	52	43	51	42	51	42	52	43
823	Building757	GR	51	42	50	42	50	41	51	42
831	Building758	GR	57	50	58	51	57	50	57	50
833	Building759	GR	47	40	48	40	47	40	47	40
836	Building760	GR	56	48	56	49	56	48	56	48

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
845	Building761	GR	44	37	46	38	45	38	44	37
856	Building762	GR	49	41	50	41	49	41	49	40
862	Building763	GR	52	44	52	43	52	43	51	42
871	Building764	GR	52	43	52	43	52	43	52	43
881	Building765	GR	52	43	52	43	52	43	52	43
892	Building766	GR	50	42	50	41	50	42	50	41
898	Building767	GR	50	42	50	41	50	41	50	41
899	Building768	GR	50	42	51	42	51	42	50	41
909	Building769	GR	50	42	50	41	50	42	50	41
924	Building770	GR	50	42	50	41	50	41	50	41
940	Building771	GR	50	42	50	41	50	41	50	41
951	Building773	GR	50	42	50	41	50	41	50	41
953	Building774	GR	49	41	52	44	52	44	49	40
957	Building775	GR	49	40	50	42	50	42	48	40
975	Building776	GR	49	41	50	42	50	42	49	40
976	Building777	GR	48	40	49	40	49	40	48	40
986	Building778	GR	48	40	49	40	48	40	48	40
990	Building779	GR	49	41	49	40	49	40	49	40
991	Building780	GR	49	41	49	41	49	40	49	41
1013	Building781	GR	49	41	49	40	49	40	49	40
1018	Building782	GR	51	42	50	42	50	42	51	42
1023	Building783	GR	50	43	50	43	49	41	52	45
1030	Building785	GR	48	41	48	41	47	40	50	42
1033	Building786	GR	48	40	48	41	48	40	49	41
1041	Building787	GR	61	53	61	53	61	53	61	53
1046	Building788	GR	61	53	61	53	61	53	61	54
1054	Building789	GR	52	45	54	47	53	45	53	45

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
1063	Building790	GR	53	46	54	46	53	46	54	46
1079	Building791	GR	56	48	61	53	56	48	56	48
1089	Building792	GR	62	54	54	43	52	43	62	54
1089	Building792	GR	61	54	55	45	53	44	61	54
1131	Building793	GR	58	51	50	41	49	40	58	50
1139	Building794	GR	57	50	50	41	49	40	57	50
1147	Building795	GR	57	50	50	41	49	40	57	50
1153	Building796	GR	58	51	50	41	49	41	58	51
1156	Building798	GR	57	49	50	41	49	40	57	49
1167	Building799	GR	57	50	51	42	51	42	57	50
1177	Building800	GR	52	45	51	42	51	42	52	44
1187	Building801	GR	51	43	50	41	50	41	51	42
1188	Building802	GR	58	51	51	43	51	42	58	51
1192	Building803	GR	49	41	44	35	44	35	48	41
1199	Building804	GR	58	50	51	43	51	42	58	50
1202	Building805	GR	57	49	57	50	57	49	57	49
1215	Building806	GR	57	49	57	50	57	49	57	49
1216	Building807	GR	58	50	59	51	58	50	58	50
1220	Building808	GR	58	50	58	51	58	50	58	50
1231	Building809	GR	51	42	50	42	50	41	51	42
1235	Building810	GR	45	37	45	37	45	37	45	37
1238	Building811	GR	55	47	56	48	55	47	55	47
1256	Building812	GR	55	48	56	48	55	48	55	48
1268	Building813	GR	56	48	57	49	56	48	56	48
1269	Building814	GR	48	41	49	40	49	40	48	40
1281	Building815	GR	48	40	48	40	48	39	48	39
1301	Building816	GR	48	40	48	39	48	39	48	39

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
1305	Building817	GR	48	40	48	39	48	39	48	39
1314	Building818	GR	49	40	49	40	49	40	49	40
1320	Building819	GR	42	35	43	35	43	35	42	35
1322	Building820	GR	45	38	46	38	46	38	45	37
1328	Building821	GR	44	36	45	38	45	38	43	36
1331	Building822	GR	48	40	49	40	48	40	48	40
1339	Building823	GR	47	40	49	42	49	41	47	40
1349	Building824	GR	49	41	49	40	49	40	49	40
1360	Building825	GR	44	36	44	36	44	36	44	36
1364	Building826	GR	47	39	48	40	48	40	47	39
1369	Building827	GR	48	40	48	39	48	39	48	39
1380	Building828	GR	45	37	45	38	45	37	45	37
1385	Building829	GR	48	39	48	39	48	39	48	39
1392	Building830	GR	46	38	46	37	46	37	46	37
1397	Building831	GR	48	40	48	39	48	39	48	39
1403	Building832	GR	52	44	52	43	52	43	52	43
1409	Building833	GR	50	42	50	41	50	41	50	41
1415	Building834	GR	49	40	49	40	49	40	49	40
1423	Building835	GR	48	40	48	39	48	39	48	39
1447	Building836	GR	53	45	53	44	53	44	53	44
1452	Building837	GR	52	43	52	43	52	43	52	43
1473	Building838	GR	54	46	54	45	53	44	54	45
1489	Building839	GR	53	45	52	43	52	43	53	45
1493	Building840	GR	46	38	47	38	47	38	46	37
1498	Building883	GR	47	43	47	46	59	51	56	50
1504	Building884	GR	50	44	49	46	58	51	56	50
1512	Building885	GR	44	38	44	39	50	42	48	42

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
1524	Building886	GR	45	41	45	44	56	49	54	48
1526	Building887	GR	43	35	43	36	45	38	44	37
1530	Building888	GR	45	38	45	38	46	39	46	39
1542	Building889	GR	53	46	53	46	54	46	55	47
1572	Building900	GR	50	42	50	41	50	41	50	41
1572	Building900	GR	51	42	51	42	51	42	51	42
1580	Building901	GR	50	42	50	41	50	41	50	41
1586	Building902	GR	48	40	48	39	48	39	48	39
1602	Building907	GR	52	44	52	43	52	43	52	43
1666	Building948	GR	53	45	53	44	53	44	53	44
1680	Building949	GR	49	41	50	41	49	41	49	40
1692	Building950	GR	52	44	52	44	52	44	52	43
1698	Building952	GR	53	45	53	44	53	44	53	44
1710	Building954	GR	53	45	53	45	53	45	53	44
1723	Building955	GR	51	42	51	42	51	42	51	42
1733	Building956	GR	53	44	53	44	53	44	52	43
1742	Building957	GR	42	33	43	35	43	34	39	30
1751	Building958	GR	53	44	53	44	53	44	53	44
1759	Building959	GR	42	34	44	35	43	34	41	32
1770	Building960	GR	53	45	53	44	53	44	53	44
1780	Building961	GR	52	44	53	44	53	44	52	43
1790	Building962	GR	52	44	53	44	53	44	52	43
1794	Building963	GR	45	37	46	37	46	37	45	36
1799	Building964	GR	53	44	53	44	53	44	52	43
1803	Building965	GR	52	44	53	44	53	44	52	43
1813	Building966	GR	52	44	52	43	52	43	52	43
1819	Building967	GR	53	44	53	44	53	44	53	44

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
1825	Building968	GR	51	43	51	42	51	42	51	42
1832	Building969	GR	50	42	50	41	50	41	50	41
1843	Building970	GR	52	44	52	43	52	43	52	43
1860	Building971	GR	55	47	55	46	55	46	55	46
1861	Building972	GR	52	44	52	43	52	43	52	43
1867	Building973	GR	55	47	55	46	55	46	55	46
1877	Building974	GR	49	41	49	40	49	40	49	40
1881	Building975	GR	53	45	53	44	53	44	53	44
1908	Building977	GR	49	41	49	41	49	40	49	41
1911	Building978	GR	50	41	50	41	50	41	50	41
1915	Building979	GR	53	44	53	44	52	43	53	44
1922	Building980	GR	56	47	56	47	56	47	56	47
1963	Building984	GR	46	38	46	37	46	37	46	37
1967	Building985	GR	52	44	52	43	52	43	52	43
2012	Building987	GR	44	36	44	35	44	35	44	35
2014	Building988	GR	45	37	45	36	45	36	45	37
2018	Building989	GR	48	39	48	39	48	39	48	39
2034	Building992	GR	48	40	48	39	48	39	48	39
2043	Building993	GR	48	39	48	39	48	39	48	39
2049	Building994	GR	48	39	48	39	48	39	48	39
2053	Building995	GR	47	39	47	38	47	38	47	38
2058	Building996	GR	48	39	48	39	48	39	48	39
2064	Building997	GR	48	39	48	39	48	39	48	39
2084	Building998	GR	47	39	47	39	47	39	47	39
2093	Building999	GR	53	45	53	46	53	45	53	45
2095	Building1000	GR	49	41	49	40	49	40	49	40
2112	Building1001	GR	49	41	49	41	49	40	49	40

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
2118	Building1002	GR	49	41	49	41	49	40	49	40
2126	Building1003	GR	43	35	43	35	43	35	43	35
2131	Building1004	GR	51	43	51	42	51	42	51	42
2147	Building1005	GR	51	43	51	43	51	42	51	42
2151	Building1006	GR	56	49	57	50	56	49	56	49
2161	Building1007	GR	57	50	58	51	57	50	57	50
2165	Building1008	GR	55	47	55	48	55	47	55	47
2178	Building1010	GR	39	30	40	31	40	31	39	30
2186	Building1011	GR	38	29	39	31	39	31	38	30
2190	Building1012	GR	38	29	39	31	40	31	38	30
2202	Building1013	GR	38	29	39	30	39	31	38	29
2211	Building1014	GR	39	31	41	32	41	32	40	31
2222	Building1015	GR	40	31	41	33	41	33	40	31
2230	Building1016	GR	39	31	41	32	41	33	39	31
2238	Building1017	GR	39	30	40	32	40	32	39	30
2244	Building1018	GR	39	30	40	31	41	32	39	31
2253	Building1019	GR	39	30	41	32	41	32	40	31
2258	Building1020	GR	40	31	41	33	42	33	40	32
2266	Building1021	GR	41	33	44	36	44	36	41	33
2272	Building1022	GR	39	30	41	32	42	33	39	31
2328	Building1464	GR	49	41	49	41	49	41	50	41
2342	Building1467	GR	50	41	50	41	50	41	50	41
2345	Building1468	GR	49	41	49	40	49	40	49	40
2356	Building1469	GR	51	42	51	42	51	42	50	42
2361	Building1471	GR	52	44	52	43	52	43	52	43
2376	Building1472	GR	50	42	50	41	50	41	50	41
2384	Building1474	GR	48	40	48	39	48	39	48	39

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
2388	Building1475	GR	48	40	48	39	48	39	48	39
2392	Building1476	GR	48	40	48	39	48	39	48	39
2398	Building1477	GR	49	41	49	40	49	40	49	40
2406	Building1478	GR	48	40	48	39	48	39	48	39
2407	Building1479	GR	49	41	49	41	49	40	49	40
2412	Building1480	GR	49	41	49	41	49	40	49	40
2428	Building1483	GR	48	40	48	39	48	39	48	39
2438	Building1484	GR	49	41	49	41	49	40	49	40
2442	Building1485	GR	49	41	49	40	49	40	49	40
2445	Building1486	GR	49	41	49	40	49	40	49	40
2458	Building1487	GR	49	41	49	40	49	40	49	40
2480	Building1491	GR	49	41	49	40	49	40	49	40
2485	Building1492	GR	50	42	50	41	50	41	50	41
2498	Building1493	GR	51	43	51	42	51	42	51	42
2509	Building1495	GR	51	43	51	42	51	42	51	42
2515	Building1496	GR	49	40	49	40	49	40	49	40
2523	Building1497	GR	48	40	48	39	48	39	48	39
2530	Building1498	GR	49	40	49	40	49	40	49	40
2536	Building1499	GR	50	41	50	41	50	41	50	41
2548	Building1500	GR	50	42	50	41	50	41	50	41
2555	Building1501	GR	50	42	50	41	50	41	50	41
2559	Building1502	GR	50	42	50	41	50	41	50	41
2563	Building1503	GR	50	42	50	41	50	41	50	41
2571	Building1505	GR	51	43	51	42	51	42	51	42
2578	Building1506	GR	52	44	52	43	52	43	52	43
2586	Building1507	GR	50	42	50	41	50	41	50	41
2594	Building1508	GR	50	41	50	41	50	41	50	41

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
2612	Building1512	GR	49	41	49	40	49	40	49	40
2618	Building1513	GR	50	41	50	41	50	41	50	41
2628	Building1514	GR	50	42	50	41	50	41	50	41
2642	Building1516	GR	48	40	48	39	48	39	48	39
2655	Building1517	GR	49	40	49	40	49	40	49	40
2660	Building1518	GR	51	43	51	42	51	42	51	42
2665	Building1519	GR	50	42	50	41	50	41	50	41
2679	Building1521	GR	50	42	50	41	50	41	50	41
2681	Building1522	GR	52	44	52	43	52	43	52	43
2693	Building1523	GR	50	42	50	41	50	41	50	41
2697	Building1524	GR	51	43	51	42	51	42	51	42
2712	Building1525	GR	49	41	49	40	49	40	49	40
2718	Building1526	GR	52	44	52	43	52	43	52	43
2722	Building1527	GR	47	39	47	38	47	38	47	38
2732	Building1528	GR	48	40	48	39	48	39	48	39
2746	Building1529	GR	50	41	50	41	50	41	50	41
2759	Building1530	GR	49	41	49	40	49	40	49	40
2763	Building1531	GR	49	41	49	40	49	40	49	40
2767	Building1532	GR	45	37	46	37	45	36	46	37
2770	Building1533	GR	49	41	49	40	49	40	49	40
2778	Building1534	GR	52	43	52	43	52	43	52	43
2786	Building1535	GR	49	41	49	40	49	40	49	40
2792	Building1536	GR	49	41	49	41	49	41	50	41
2798	Building1537	GR	49	41	49	40	49	40	49	40
2800	Building1538	GR	49	41	49	40	49	40	49	40
2806	Building1539	GR	50	42	50	41	50	41	50	41
2807	Building1540	GR	51	42	51	42	51	42	51	42

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
2815	Building1541	GR	52	44	52	43	52	43	52	43
2826	Building1542	GR	50	41	50	41	50	41	50	41
2838	Building1543	GR	49	40	49	40	49	40	49	40
2848	Building1544	GR	49	41	49	40	49	40	49	40
2861	Building1545	GR	49	41	49	40	49	40	49	40
2869	Building1546	GR	49	41	49	40	49	40	49	40
2870	Building1547	GR	48	40	48	39	48	39	48	39
2885	Building1548	GR	49	41	49	40	49	40	49	40
2892	Building1549	GR	49	41	49	41	49	40	49	41
2900	Building1550	GR	50	41	50	41	50	41	50	41
2903	Building1551	GR	49	41	49	41	49	41	49	41
2939	Building1553	GR	46	38	46	37	46	37	46	37
1497	Building871	Industrial	45	37	45	39	49	41	47	40
1543	Building890	Industrial	42	36	44	39	50	43	48	41
1549	Building896	Industrial	52	44	53	43	52	43	52	44
1553	Building898	Industrial	53	44	53	44	53	44	53	44
1553	Building898	Industrial	54	45	54	45	54	45	54	45
1565	Building899	Industrial	50	42	50	41	50	41	50	41
1565	Building899	Industrial	51	43	52	42	51	42	51	42
1592	Building903	Industrial	47	39	47	38	47	38	47	38
1608	Building908	Industrial	50	41	50	41	50	41	50	41
1612	Building909	Industrial	50	42	50	41	50	41	50	41
1622	Building910	Industrial	53	44	53	44	53	44	53	44
1622	Building910	Industrial	53	44	53	44	53	44	53	44
1658	Building911	Industrial	52	43	52	43	52	43	52	43
1658	Building911	Industrial	53	44	53	44	53	44	53	44

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
1944	Building981	Industrial	55	47	55	46	55	46	55	46
1953	Building982	Industrial	52	43	52	43	52	43	52	43
1955	Building983	Industrial	52	44	52	43	52	43	52	43
2280	Building1456	Industrial	50	41	50	41	50	41	50	41
2282	Building1457	Industrial	53	44	53	44	53	44	53	44
2290	Building1458	Industrial	51	43	51	42	51	42	51	42
2291	Building1459	Industrial	40	32	40	32	40	31	41	33
2299	Building1460	Industrial	41	33	41	32	41	32	41	32
2306	Building1461	Industrial	47	39	47	39	47	38	48	39
2307	Building1462	Industrial	53	45	53	44	53	44	53	45
2322	Building1463	Industrial	53	45	53	44	53	44	53	44
2338	Building1466	Industrial	48	39	48	39	48	39	48	39
2357	Building1470	Industrial	43	35	43	35	43	35	43	34
2380	Building1473	Industrial	41	32	41	32	41	32	41	32
2422	Building1481	Industrial	43	34	43	34	43	34	43	34
2424	Building1482	Industrial	40	31	40	31	40	31	40	31
2463	Building1488	Industrial	39	31	39	31	40	31	39	31
2468	Building1489	Industrial	40	32	40	31	40	31	40	31
2476	Building1490	Industrial	50	41	50	41	50	41	50	41
2507	Building1494	Industrial	53	45	53	44	53	44	53	44
2568	Building1504	Industrial	51	43	51	42	51	42	51	42
2600	Building1509	Industrial	43	35	44	35	43	35	43	35
2601	Building1510	Industrial	42	34	42	33	42	33	42	33
2608	Building1511	Industrial	39	31	39	30	39	30	39	31
2633	Building1515	Industrial	40	32	40	31	40	31	40	31
2673	Building1520	Industrial	47	39	47	38	47	38	47	38

No.	Name	Usage	Existing dBA		Route Option 1 dBA		Route Option 2 dBA		Route Option 3 dBA	
			15 h	9 h	15 h	9 h	15 h	9 h	15 h	9 h
2947	Orange Factory	Industrial	59	52	58	50	49	41	54	47
1988	Building986	School	51	43	51	42	51	42	51	42
2024	Building990	School	46	37	46	37	46	37	46	37
2030	Building991	School	49	40	49	40	49	40	49	40
2332	Building1465	School	52	44	52	43	52	43	52	43
55	AFL_ground	Sport	45	37	46	38	45	37	45	37
56	AFL_ground	Sport	47	40	48	40	47	40	47	40
2945	Lawn Bowls Club	Sport	47	39	56	48	55	48	47	38