Appendix D

Noise and vibration assessment

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Roads and Maritime Services

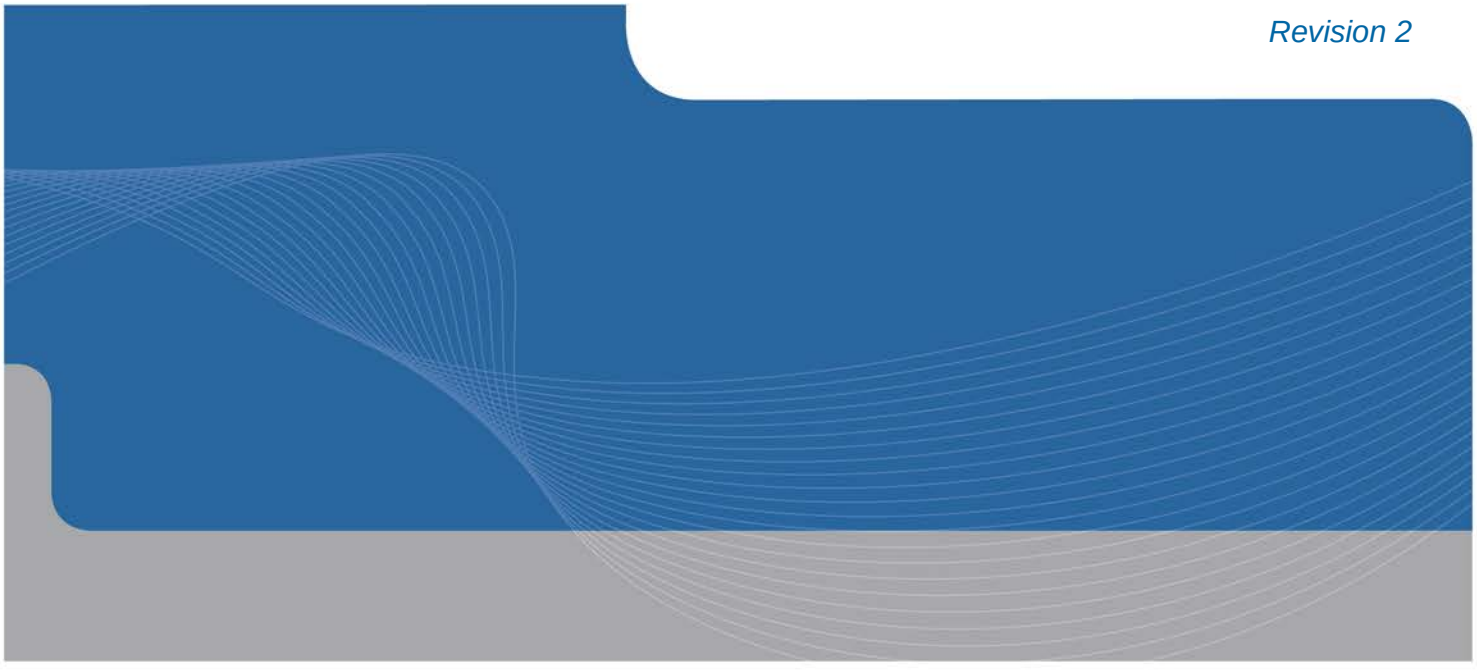
Report for Burrill Lake Bridge

Preliminary Environmental Investigation

Noise and Vibration Assessment

November 2012

Revision 2



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Glossary

Term	Description
dB	Decibel, which is 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a unit of sound.
dB(A)	Unit used to measure 'A-weighted' sound pressure levels.
DECC	Department of Environment and Climate Change (NSW Government), later known as the Department of Environment Climate Change and Water, and now known as the Office of Environment and Heritage (OEH).
Groundborne vibration	Groundborne vibration is vibration transmitted from source to receiver via the medium of the ground.
ICNG	Interim Construction Noise Guideline.
$L_{A90\ (Time)}$	The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise e.g. $L_{A90(15\ min)}$.
$L_{Aeq\ (Time)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{Aeq\ (15\ hr)}$	The L_{Aeq} noise level for the period 7:00 to 22:00 hours.
$L_{Aeq\ (9\ hr)}$	The L_{Aeq} noise level for the period 22:00 to 7:00 hours.
Mitigation	Reduction in severity.
Rating Background Level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period. This is the level used for assessment purposes.
Receiver	A noise modelling term used to describe a map reference point where noise is predicted. A sensitive receiver would be a home, work place, church, school or other place where people spend time.
rms or V_{rms}	Root Mean Square (velocity).
Short-term vibration	Vibration that occurs so infrequently that it does not cause structural fatigue nor does it produce resonance in the structure.
Tonality	Noise containing a prominent frequency or frequencies characterised by definite pitch.

Term	Description
Vibration	The variation of the magnitude of a quantity which is descriptive of the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference. Vibration can be measured in terms of its displacement, velocity or acceleration. The common units for velocity are millimetres per second (mm/s).
VDV	Vibration Dose Value (VDV) - As defined in BS6472 – 2008, VDV is given by the fourth root of the integral of the fourth power of the frequency weighted acceleration.
PPV	Current practices for assessments of the risk of structural damage to buildings use measurements of Peak Particle Velocity (PPV).

1. Introduction

The Roads and Maritime Services (RMS) propose to improve the safety of the Burrill Lake Bridge on the Princes Highway, in the City of Shoalhaven. This noise and vibration assessment forms a part of the Preliminary Environmental Investigation for the proposed upgrade or replacement of Burrill Lake Bridge (The proposal).

At present the proposal has not been developed, therefore the purpose of this report is to identify the potential receivers, assess the existing noise environment, outline the various criteria and guidelines which would apply to future works and present a qualitative review of construction and operational noise impacts.

The report has been prepared with consideration to the following NSW Office of Environment and Heritage (OEH) publications:

- *Interim Construction Noise Guideline* (ICNG), (DECC) 2009.
- *Road Noise Policy* (RNP), (OEH) 2011.
- Roads and Maritime Services *Environmental Noise Management Manual* (ENMM) (Roads and Traffic Authority) (2001).

1.1 Scope of Work

The scope of work for this Noise and Vibration Assessment comprised:

- Ambient noise monitoring at two receiver locations adjacent to the proposal site for a period of one week and concurrent traffic counts. Note that the traffic count data is being provided separately to RMS.
- Identification of surrounding sensitive receivers potentially impacted by construction and/or operational noise.
- Determination of operational noise criteria with consideration to the RNP, ENMM and ICNG guidelines.
- A qualitative review of potential operational noise impacts.
- Determination of the rating background levels (RBL) for the proposal from the noise monitoring data obtained at the selected two noise monitoring locations. The RBLs were then used to establish the construction noise management levels.
- A qualitative review of potential construction noise impacts.

2. Existing Environment

2.1 Proposal Location

Currently the proposal site spans the south east of Burrill Lake connecting the east and west of the Princes Highway in the Town of Burrill Lake. As the proposal is still to be finalised the site location is subject to change, this may include change of the alignment of the site.

The general site location is shown in Figure 2-1.

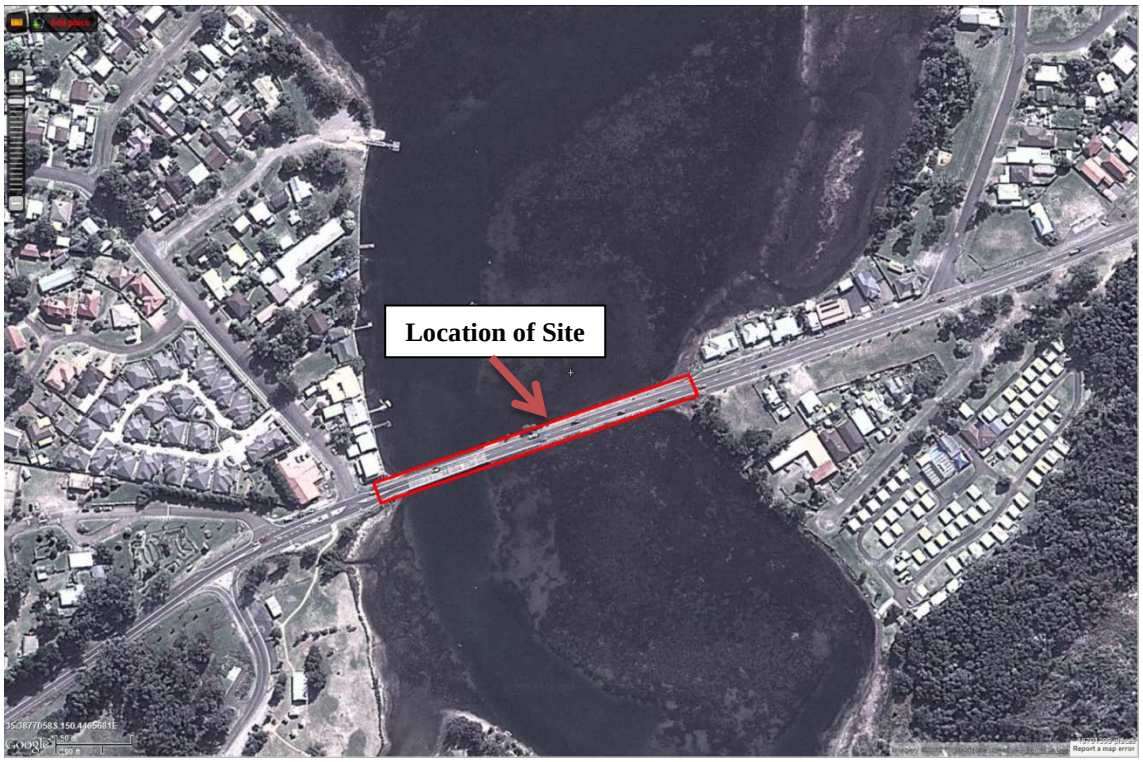


Figure 2-1 Site Location (Source: Wikimapia 2012)

2.2 Sensitive Receivers

The proposal is located within the rural town of Burrill Lake. On either side of the existing bridge are residential receivers.

The nearest sensitive receivers are detailed in Table 2-1 and shown Figure 2-2.

Table 2-1 Nearest Sensitive Receivers

Receiver	Distance to existing bridge (Minimum)	Address/Location/ Description	Type
R1	5 m	39 Balmoral Rd	Residential
R2	20 m	37 Balmoral Rd	Residential
R3	40 m	35 Balmoral Road	Residential
R4	60 m	33 Balmoral Road	Residential
R5	25 m	119 Princes Highway	Residential
R6	80 m	Balmoral Road Lakewood Grove Maria Avenue Rackham Crescent George Street Thistleton Drive Ronald Avenue	Residential
R7	5 m	113 Princes Highway	Residential
R8	40 m	111 Princes Highway	Residential
R9	50 m	107 Princes Highway – The Fish Shop	Commercial
R10	85 m	105 Princes Highway – Bait and Tackle	Commercial
R11	115 m	103 Princes Highway – Pigeon House Opportunity Shop	Commercial
R12	130 m	101 Princes Highway – Bottle Shop	Commercial
R13	10 m	122/124 Princes Highway	Residential
R14	35 m	118 Princes Highway	Residential
R15	100 m	7 Princess Avenue	Residential
R16	105 m	9 Princess Avenue	Residential
R17	110m	11 Princess Avenue	Residential
R18	120 m	13 Princess Avenue	Residential
R19	125 m	15 Princess Avenue	Residential
R20	100 m	108 Princes Highway	Residential
R21	50 m	5 Princess Avenue South	Residential

Receiver	Distance to existing bridge (Minimum)	Address/Location/ Description	Type
R22	75 m	3 Princess Avenue South	Residential
R23	75 m	1 Princess Avenue South	Residential
R24	120 m	8 Princess Avenue South	Residential
R25	175 m	Princess Avenue McDonald Parade Queanbeyan Avenue Federal Avenue Commonwealth Avenue	Residential
R26	350 m	Jorgy's Way	Residential
R27	75 m	109 Princes Highway – The Hot Glass Gallery and Studio	Commercial
A1	110 m	Princes Highway	Active Recreational Area
A2	210 m	McDonald Parade	Active Recreational Area
A3	415 m	Queanbeyan Avenue	Active Recreational Area
A4	225 m	Marina Avenue	Active Recreational Area
A5	205 m	Dolphin Point Road	Active Recreational Area
P1	5 m	Princes Highway	Passive Recreational Area

Figure 2-2 Sensitive Receivers (Source Google Earth 2012)

2.3 Unattended Noise Monitoring

Long term noise monitoring was conducted at 113 Princes Highway (R7/L1) and 39 Balmoral Rd (R1/L2), Burrill Lake using RION NL-21 noise loggers. The purpose of the noise logging was to determine the existing noise environment in the vicinity of the proposed site. The monitoring locations are shown in Figure 2-3.

Both noise loggers are capable of measuring continuous sound pressure levels and are able to record L_{A90}, $L_{A10,}$ L_{Aeq} and L_{Amax} noise descriptors. The instruments were programmed to accumulate environmental noise data continuously over sampling periods of 15 minutes for the entire monitoring period. Logging was conducted between 22 and 29 May 2012.

In total seven days of monitoring data, excluding anomalous data and data taken during periods of rain and/or wind speeds greater than 5 m/s, was logged and reviewed. Meteorological data for the monitoring period was sourced from the Bureau of Meteorology (BoM) Ulladulla Weather Station, set to record 30-minute averages. This Station is approximately 10 km from Burrill Lake.

Details of the noise loggers are provided in Table 2-2.

Figure 2-3 Noise Monitoring Locations (Source Wikimapia 2012)

Table 2-2 Unattended Noise Logger Details

Noise Logger	Location 1	Location 2
Monitoring location	113 Princes Highway, Burrill Lake	39 Balmoral Rd, Burrill Lake
Logger Type/ Serial No.	RION NL-21/00776884	RION NL-21/00365349
Measurement started	10:45 hours, 22 May 2012	12:00 hours 22 May 2012
Measurement ceased	09:00 hours 29 May 2012	09:15 hours 29 May 2012
Pre/Post calibration	93.7/93.7 @ 1 kHz	93.8/93.6 @ 1 kHz
Freq. weighting	A	A
Time response	Fast	Fast
Photographs		

2.4 Operator Attended Noise Monitoring

Operator attended noise monitoring was conducted at 113 Princes Highway, Burrill Lake on the 22 May 2012 for 15-minute durations immediately following logger placement to identify ambient noise sources and validate logger data. Measurements were conducted with considerations to AS 1044-1997 Acoustics – Description and Measurement of Environmental Noise.

Instantaneous noise levels for operator identified noise sources were observed and noted during measurements.

Noise measurements were conducted using a Bruel & Kjaer 2250 Sound Level Meter (SLM) calibrated using a Bruel and Kjaer Type 4231 sound level calibrator with a sound pressure level of 94 dB at 1 kHz immediately before and after the measurements. The response of the SLM was considered acceptable. Noise instrument details are provided in Table 2-3.

Table 2-3 Attended Monitoring Instrumentation Details

Instrument	Serial Number	Calibration Due Date
Bruel & Kjaer 2250 SLM	2506887	1/7/2012
Bruel & Kjaer 4231 acoustic calibrator	2542101	29/6/2012

2.5 Summary of Noise Monitoring Results

Attended and unattended noises monitoring results as well as site observations indicate that the existing noise environment is dominated by noise sources typical of a suburban environment. These include road traffic, birds and neighbourhood noise. Care was taken to position loggers away from domestic sources at the residences including air-conditioning and pumps.

2.5.1 Attended Noise Monitoring Results

A summary of attended noise monitoring results is provided in Table 2-4.

Table 2-4 Attended Noise Monitoring Results, 22 May 2012

Location	Measurement Start Time	Measured Noise Levels dB(A)			
		L_{90}	L_{10}	L_{1}	L_{eq}
113 Princes Highway, Burrill Lake	10:40hrs	47.3	69.2	76.3	65.4

2.5.2 Noise Logging Results

A summary of the calculated background L_{A90} noise levels (day, evening and night) for the monitoring period at Location 1 and Location 2 are provided in Table 2-5 and Table 2-6.

Table 2-5 Location 1 – Background L_{A90} Noise Levels, dB(A)

Date	RBL				L_{Aeq}			
	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am	$L_{Aeq(15\ hour)}$	$L_{Aeq(9\ hour)}$
Tuesday 22-May-12	47	35	32	66	61	61	65	61
Wednesday 23-May-12	45	36	34	67	63	61	66	61
Thursday 24-May-12	46	34	32	67	63	61	67	61
Friday 25-May-12	48	46	37	67	64	60	67	60
Saturday 26-May-12	49	38	36	66	62	58	65	57
Sunday 27-May-12	50	47	44	66	63	60	66	60
Monday 28-May-12	52	46	45	67	62	60	66	60
Tuesday 29-May-12	50	-	-	67	-	-	67	-
Rating Background Level (RBL)	**48**	**38**	**36**	**67**	**63**	**60**	**66**	**60**

Note: '-' Indicates that insufficient data measurements were taken during this period or excluded due to wind or rain influence.

Table 2-6 Location 2 – Background L_{A90} Noise Levels, dB(A)

Date	RBL				L_{Aeq}			
	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am	$L_{Aeq(15\ hour)}$	$L_{Aeq(9\ hour)}$
Tuesday 22-May-12	48	34	33	68	63	62	67	62
Wednesday 23-May-12	48	38	36	68	64	63	67	63
Thursday 24-May-12	48	37	35	69	64	63	68	63
Friday 25-May-12	49	43	36	69	65	60	68	60
Saturday 26-May-12	46	36	35	68	63	60	67	59
Sunday 27-May-12	48	46	43	68	64	62	67	62
Monday 28-May-12	51	45	44	68	64	62	67	62
Tuesday 29-May-12	49	-	-	69	-	-	69	-
Rating Background Level (RBL)	**48**	**38**	**36**	**68**	**64**	**62**	**68**	**62**

Note: '-' Indicates that insufficient data measurements were taken during this period or excluded due to wind or rain influence.

Appendix A and Appendix B shows statistical noise data in graphical form.

3. Proposal Specific Criteria

3.1 Construction Noise Management Levels

The ICNG provides recommended standard hours for construction activities as follows:

- Monday to Friday: 7:00 am to 6:00 pm.
- Saturday: 8:00 am to 1:00 pm.
- No work on Sunday or Public Holidays.

The ICNG acknowledges that the following activities have justification to be undertaken outside the recommended construction hours:

- The delivery of oversized plant or structure.
- Emergency work.
- Works for which it can be demonstrated that there is a need to operate outside the recommended standard hours.

Table 3-1 details the ICNG construction noise management levels at residential receivers. These management levels are to be calculated based on the RBL at nearby residential receivers.

Table 3-1 ICNG Construction Noise Management Levels at Residential Receivers dB(A)

Time Period	Management Level $L_{Aeq(15min)}$
Recommended standard hours	Noise affected level: RBL +10 Highly noise affected level: 75 dB(A)
Outside recommended standard hours	Noise affected level: RBL + 5

The 'noise affected' management level represents the point above which there may be some community reaction to noise. Where the noise affected management level is exceeded, all feasible and reasonable work practices to minimise noise would be applied and all potentially impacted residences would be informed of the nature of the works, expected noise levels, duration of works and a method of contact. The noise affected management level is the background noise level plus 10 dB(A) during recommended standard hours and the background noise level plus 5 dB(A) outside of recommended standard hours.

The 'highly noise affected' management level represents the point above which there may be strong community reaction to noise. Where noise is above this management level, any feasible and reasonable ways to reduce noise below this level would be carefully considered. If no quieter work method is feasible and reasonable, the impacted residence would be clearly explained the duration and noise levels of the works and any respite periods that will be provided. The highly noise affected management level is set at 75 dB(A).

Table 3-2 indicates the ICNG construction noise management levels at residential receivers. These levels are calculated based on the RBL's outlined in Section 2.5 of this document. The RBL is identical at residential receivers on either span of Burrill Lake Bridge. The ICNG

construction noise criteria for commercial, passive and recreational land use are independent of the RBL.

Table 3-2 ICNG Construction Noise Management Levels, dB(A)

Receiver Type	Background Level $L_{A90(period)}$ dB(A)			ICNG Management Level $L_{Aeq(15\ min)}$ dB(A)		
	Day	Evening	Night	Day (Background +10)	Evening (Background +5)	Night (Background +5)
Residential receivers, Princes Highway Burrill Lake	48	38	36	58	43	41
Active Recreational Areas	Not Applicable			65 (external noise level)		
Passive Recreational Areas				60 (external noise level)		
Commercial Receivers				70 (external noise level)		

3.2 Construction Vibration Criteria

With regards to vibration, this assessment will endeavour to meet the objectives of the following documents:

- Human exposure: Office of Environment and Heritage (OEH) *Assessing vibration: A technical guideline* 2006.
- Structural damage: German Standard DIN 4150-3: 1999 *Structural Vibration – Part 3: Effects of vibration on structures*.

3.2.1 Human Exposure

The OEH's publication, *Assessing vibration: A technical guideline* 2006 outlines methods of assessing potential vibration impacts and is based on guidelines contained in BS 6472 – 1992, *Evaluation of human exposure to vibration in buildings (1-80 Hz).*

Typically, construction works generate ground vibration of an intermittent nature. Under BS 6472-1992 intermittent vibration is assessed using the Vibration Dose Value (VDV). Acceptable VDV's for residential receivers, as outlined in *Assessing Vibration: A technical guideline* 2006, are presented in Table 3-3.

Table 3-3 Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26

3.2.2 Structural Damage

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to German Standard *DIN 4150-3: 1999-02 Structural Vibration – Part 3: Effects of vibration on structures.* Short-term vibration guideline values are presented in Table 3-4.

Table 3-4 Guideline Values for Short Term Vibration on Structures (DIN 4150-3)

Line	Type of Structure	Guideline Values for Velocity, vi(t)[1] [mm/s]		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50Hz to 100Hz[1]
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy.	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (such as heritage listed buildings under preservation order).	3	3 to 8	8 to 10

[1] The term v_i refers to vibration levels in any of the x, y or z axes.

[2] At frequencies above 100Hz the values given in this column may be used as minimum values.

3.3 Traffic Criteria

The OEH Road Noise Policy provides non-mandatory road traffic noise target levels for land use developments with the potential to create additional traffic on existing freeways/arterial/sub-arterial roads.

Based on the criteria outlined in Section 2.2.1 of the RNP the Princes Highway is classified as an arterial road. Table 3-5 to Table 3-7 set out the assessment criteria for residences to be applied to this proposal.

Table 3-5 RNP Road Traffic Noise Assessment Criteria for Residential Land Uses

Road Category	Type of project / Land use	Assessment criteria – dB(A)	
		Day (7 am–10 pm)	Night (10 pm–7 am)
Freeway/arterial/ sub-arterial roads	Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads.	60 $L_{Aeq\ (15\ hour)}$ (external)	55 $L_{Aeq\ (9\ hour)}$ (external)

In addition to the assessment criteria detailed in Table 3-5, Section 2.4 of the RNP requires that any increase in the total traffic noise levels due to the proposal be considered. Table 3-6 shows the criteria used to assess a development's potential to increase noise impacts based on increases in traffic caused by the proposed project. The relative increase criteria is intended to protect existing quiet areas from significant noise increases due to a road project which may adversely affect the amenity of those areas. A significant increase is not expected for the proposal and the existing noise levels are already elevated, however, the project should be assessed against this relative increase criteria along with the assessment criteria once the proposal has been decided.

Table 3-6 RNP Relative Increase Criteria for Residential Land Uses

Road Category	Type of project/Land use	Total traffic noise level increase–dB(A)	
		Day (7 am–10 pm)	Night (10 pm–7 am)
Freeway/arterial/ sub-arterial roads	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing Traffic $L_{Aeq,\ (15\ hour)}$ +12dB (external)	Existing Traffic $L_{Aeq,\ (9\ hour)}$ +12dB (external)

Accepted application of Section 3.4 of the RNP is that where a road redevelopment causes an increase of more than 2 dB or acute levels of noise (65 dB(A) day or 60 dB(A) night) exist, reasonable and feasible noise mitigation measures be are to be considered.

Table 3-7 RNP Road traffic Noise Assessment Criteria for Non-residential Land Uses

Existing Sensitive Land Use	Day (7 am–10 pm)	Night (10 pm–7 am)	Additional Information
Open space (active use)	$L_{Aeq,(15\ hour)}$ 60 dB(A) (external) when in use	-	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. 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. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise instruction should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the most stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
Open space (passive use)	$L_{Aeq,(15\ hour)}$ 55 dB(A) (external) when in use	-	

3.3.1 Sleep Disturbance

The RNP states that the main noise factors that influence sleep disturbance during the night are "the number of noisy events heard distinctly above background level, the emergence of these events and the highest noise level". Although sleep assessment goals are not defined in the RNP, it does conclude, based on the research to date, that:

- Maximum internal noise levels below 50 - 55 dB(A) are unlikely to awaken people from sleep.
- One or two noise events per night, with maximum internal noise levels of 65 – 70 dB(A), are not likely to affect health and wellbeing significantly.

The RNP also recommends that an assessment of maximum noise levels be conducted where impacts may occur at night. The procedure for this assessment is provided in the RMS Environmental Noise Management Manual (ENMM) in Practice Note III (PN-III). PN-III recommends that:

- At locations where road traffic is continuous rather than intermittent, the $L_{eq(9hr)}$ (night) target noise levels should sufficiently account for sleep disturbance impacts.
- However, where the emergence of L_{max} over the ambient L_{eq} is equal to or greater than 15 dB(A), the $L_{eq(9hr)}$ criteria may not sufficiently account for sleep disturbance impacts.

3.4 Blasting Criteria

As it is not anticipated that any blasting works will be undertaken for the proposed upgrade or replacement of the Burrill Lake Bridge, blasting criteria has not been considered for this assessment.

4. Construction Noise and Vibration Assessment

4.1 Assessment Methodology

The ICNG provides a framework for identification and minimisation of noise from construction projects. Assessment methodology depends on the duration of a project – the more detailed quantitative assessment is prescribed for major projects such as those subject to an EIA process, while qualitative assessment approach is conducted for short-term projects which are not likely to impact on sensitive receivers for greater than three weeks duration.

RMS has not yet determined if the bridge is to be replaced or upgraded, and therefore design/upgrade details, construction/maintenance methodology, and duration of the proposed works is unknown. At this point a qualitative review of construction noise impacts has been carried out. If the works are to be carried out for a period longer than three weeks and/or works are carried out at night, then a quantitative assessment should be carried out using the criteria supplied in Section 3.

If the works are to last less than three weeks, then a qualitative method can be adopted. The qualitative assessment as described in the ICNG consists of the following approach:

- Identification of sensitive land uses and receivers potentially affected by noise from the project.
- Identification of planned construction work hours for the project.
- Preparation of a construction noise and vibration management plan (CNVMP) where required. This document would present the following information:
  - Sensitive receivers and locations.
  - Proposed and approved work hours.
  - Details of works to be undertaken.
  - Details of reasonable and feasible actions to be undertaken to minimise noise and vibration impacts on sensitive receivers.
  - A complaints handling process.

4.2 Typical Construction Noise

Typical plant equipment used in construction activities are shown in Table 4-1. Typical construction equipment noise levels have been primarily obtained from ‘AS 2436 – 2010, Guide to noise and vibration control on construction, demolition and maintenance sites. Other equipment may be used, however it is anticipated that they would produce similar noise emissions. As the proposal mechanical plant has yet to be finalised, the equipment shown may vary.

Table 4-1 Typical Construction Equipment Sound Levels – AS2436-2010

Description of Works	Typical Noise Levels L_W dB(A) ref: 10^{-12} W
Asphalt paver	108
Asphalt rotomill	111
Generator (diesel)	99
Roller (vibratory)	108
Truck (>20 tonne)	107
Excavator (small)	97
Excavator (medium)	107
Grader	110
Water Cart	107
Impact Piling (one cycle)	124

The magnitude of the off-site noise impact associated with construction and/or maintenance activities would be dependent upon a number of factors:

- The intensity and location of construction activities.
- The type of equipment used.
- Existing local noise sources.
- Intervening terrain.
- The prevailing weather conditions.

Construction machinery will likely move about the proposal area altering noise impacts with respect to the identified noise sensitive receiver. During any given period, the machinery items to be used in the proposal area will operate at maximum sound power levels for only brief stages. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time and certain types of construction machinery will be present in the proposal area near to the receiver for only brief periods during construction and/or maintenance activities. Therefore the predictions should be considered as conservative estimates.

4.3 Predicted Construction Noise Levels

Construction noise impacts associated with the proposal were estimated using the well-known distance attenuation relationship described in Equation 1.

$$SPL = SWL - 20Log(d) + 10Log(Q) - 11$$ Equation (1)

Where *d = distance (m) between source and receiver*

Q = Directivity index (2 for a flat surface)

SPL = sound pressure level at the distance d from the source

SWL = sound power level of the source

The equipment noise levels were distance attenuated from the current bridge. Propagation calculations take into account sound intensity losses due to hemispherical spreading, with additional minor losses such as atmospheric absorption, directivity, ground absorption and shielding ignored in the calculations. This is considered a conservative approach.

The predicted noise levels at distance are shown in Table 4-2.

Table 4-2 Estimated Equipment Noise Levels at Distance, dB(A)

Equipment	Estimated Noise Level at Distance from Noise Source									
	5 m	10 m	15 m	25 m	50 m	75 m	100 m	150 m	200 m	250 m
Asphalt paver	**86**	**80**	**76**	72	66	62	60	56	54	52
Asphalt rotomill	**89**	**83**	**79**	75	69	65	63	59	57	55
Generator (diesel)	**77**	71	67	63	57	53	51	47	45	43
Roller (vibratory)	**86**	**80**	**76**	72	66	62	60	56	54	52
Truck (>20 tonne)	**85**	**79**	75	71	65	61	59	55	53	51
Excavator (small)	75	69	65	61	55	51	49	45	43	41
Excavator (medium)	**85**	**79**	75	71	65	61	59	55	53	51
Grader	**88**	**82**	**78**	74	68	64	62	58	56	54
Water Cart	**85**	**79**	75	71	65	61	59	55	53	51
Piling (impact)	**106**	**100**	**96**	**92**	**86**	**82**	**80**	**76**	74	72

Note: Red indicates exceedance of noise affected Construction Noise Management Levels (CNML) and red bold indicates exceedance of highly affected CNML

Table 4-2 indicates that during recommended standard hours, the majority of construction activities are expected to exceed the noise affected CNML at various receivers located within 150 m (R1-R24, R27, P1 and A1) of the anticipated construction area. Within 25 m (R1, R2, R4, R7, R13 and P1) certain construction activities will exceed the highly noise affected level and within 10 m (R1, R7, R13 and P1) the majority of construction activities are expected to exceed this level. Implementation of typical mitigation measures detailed in Section 6 should be considered, where feasible and reasonable, to minimise noise impacts.

As the potential for significant impacts exists due to construction of the proposal, a detailed assessment of construction noise is recommended once the proposal has been defined and details of construction activities are known. This would be prepared as a Construction Noise and Vibration Management Plan (CNVMP) forming part of a Construction Environmental Management Plan for the project (CEMP).

5. Construction Vibration Assessment

Vibration impacts focus on potential structural damage to properties in close proximity to construction activities.

Furthermore, it is possible that local sensitive receivers may perceive construction vibration at times. The level of annoyance, however, will depend on individuals.

Table 5-1 outlines typical vibration levels for different plant activities sourced from the RMS Environmental Noise Management Manual (ENMM).

Table 5-1 Typical Vibration Levels – Construction Equipment

Item	Peak Particle Velocity at 10 m (mm/s)
Loader Breaking Kerbs	6-8
15 Tonne Compactor	7-8
7 Tonne Compactor	5-7
Roller	5-6
Pavement Breaker	4.5-6
Dozer	2.5-4
Backhoe	1
Jackhammer	0.5
Piling	12 - 30

As stated in the RMS' ENMM, it can be assumed that the vibration level is inversely proportional to distance. Field variations show that the distance relationship generally varies between $d^{-0.8}$ and $d^{-1.6}$, rather than d^{-1}. On that basis, maximum vibration levels were estimated at each receiver using a factor of $d^{-0.8}$.

Based on the vibration levels stated in Table 5-1, the maximum potential vibration impacts of the above sources at various distances are shown in Table 5-2.

Table 5-2 Typical Vibration Levels at Distance ($k/d^{-0.8}$)

Vibration Source	Distance to Source (m) / Peak Particle Velocity (mm/s)					
	5	10	20	50	100	150
Loader Breaking Kerbs	13.9	8.0	4.6	2.2	1.3	0.9
15 Tonne Compactor	13.9	8.0	4.6	2.2	1.3	0.9
7 Tonne Compactor	12.2	7.0	4.0	1.9	1.1	0.8
Roller (vibratory)	10.4	6.0	4.0	1.9	1.1	0.8
Pavement Breaker	10.4	6.0	3.4	1.7	1.0	0.7
Dozer	7.0	4.0	3.4	1.7	1.0	0.7
Backhoe	1.7	1.0	2.3	1.1	0.6	0.5
Jackhammer	0.9	0.5	0.3	0.1	0.1	0.1
Piling	52.2	30.0	17.2	8.3	4.8	3.43

Building Damage

Figures for predicted vibration levels presented in Table 5-2 indicate that buildings classified as dwellings or buildings of similar construction (DIN4150-3 'line 2' buildings) within approximately 20 m will experience vibration approaching the 5 mm/s PPV recommended limit. As some dwellings are located within 10 m from the proposed construction works, there is potential for adverse vibration impacts. These dwellings are exposed to levels (6 mm/s) during certain construction activities which are above the 5 mm/s PPV recommended limit. Within 5 m these levels are double the limit. When construction and/or maintenance activities have been confirmed further vibration impact assessment should be carried out. Additionally, vibration sensitive businesses in the area should be considered in the detailed vibration impact statement.

For construction activities or equipment that is not listed in Table 5-1 or Table 5-2 and is planned for the proposed work, it is recommended that predictions of vibration be undertaken prior to commencement of works to ensure building damage criteria are not exceeded.

Human Perception

Humans are capable of detecting vibration at levels well below those causing risk of damage to a building. The degrees of perception for human are suggested by the vibration level categories given in British Standard BS5228:2009 *Code of practice for noise and vibration control on construction and open sites – Part 2: vibration* as shown below in Table 5-3.

Table 5-3 Guidance on the Effects of Vibration Levels

Approximate Vibrations Level	Degree of Perception
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies, people are less sensitive to vibration
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.00 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10.00 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level

Based on the activities and conservative estimates in Table 5-2, it is possible that construction vibration may be perceptible at times at distances up to 100 m from the works. Therefore it is recommended that the mitigation measures detailed in Section 6 be considered and implemented where feasible and reasonable.

6. Road Traffic Noise Assessment

6.1 Noise Modelling Methodology

Road traffic noise predictions were undertaken using the United Kingdom Department of Transport's 'Calculation of Road Traffic Noise' (CoRTN) algorithm. CoRTN is recognised and accepted by RMS and adapted to Australian conditions through research undertaken by the Australian Road Research Board (ARRB).

Noise predictions were undertaken for the Year 2022 using traffic volume counts provided by RMS with a projected annual growth rate of 1.2 per cent calculated from the RMS annual average daily traffic (AADT) Princes Highway Burrill Lake (2006).

The additional impacts of increased traffic volume were estimated using the derived CoRTN relationship described in Equation 2.

$$\Delta dB = 10Log\left(\frac{V+T}{V}\right)$$ Equation (2)

Where V = existing traffic volume

T = predicted increase in traffic volume

ΔdB = increase in road traffic impact

6.2 Modelling Inputs and Assumptions

Traffic data used in the road traffic assessment is shown in Table 6-1. Predicted vehicle count data was determined from RMS data for 2000-2006.

Table 6-1 Existing and Future Traffic Volumes

Direction	Averaged Vehicle Counts (AADT)	Predicted Vehicle Count (AADT)	Predicted Increase
Northbound	3960	4462	502
Southbound	3878	4369	491
Combined	7838	8831	993

Based on the above traffic data, the increase in noise levels is expected to be in the order of 0.5 dB. This increase is due to the predicted traffic growth based on historical data. It does not consider the impacts of a future bridge design. As such, the operational noise levels at all receivers are predicted to increase by less than 2 dB and is not considered a significant increase.

The noise survey undertaken as part of this assessment indicated that existing road traffic noise levels are at a level of acute impact, however changes in road alignment and/or levels may cause significant variations in noise due to changes in road proximity and line of sight, therefore once the proposal is decided an operational noise assessment should be undertaken to determine any predicted changes in noise levels due to the proposal and whether mitigation measures should be considered.

7. Construction Noise and Vibration Mitigation Measures

As per the ICNG guidelines it should be ensured that every feasible and reasonable and measure be applied to mitigate the noise and vibration impacts of construction activities on local residences. A CNVMP which includes requirements for noise monitoring at sensitive receivers and a community consultation programme is recommended to be developed as part of a CEMP for the project's construction stages. The mitigation measures outlined in the sections below are typical of those that would be required for a CNVMP and are relevant to construction activities anticipated to be associated with the proposal.

7.1 Noise Mitigation Measures

It is recommended that the following construction noise mitigation measures be implemented, where reasonable and feasible, to reduce the impact on the surrounding noise sensitive receivers during construction:

- The noisiest construction activities should be scheduled during the recommended construction hours.
- Turn off plant that is not being used.
- The use of alternative work practices which generate less noise, such as using hydraulic rock splitters instead of rock breakers or using electric equipment instead of diesel powered equipment should be examined and implemented.
- Silenced equipment should be used and stationary plant (such as generators and lighting plant) should have acoustic enclosures.
- Noisy plant should be located away from potentially noise affected residences or behind barriers.
- Machines found to produce excessive noise compared to normal industry expectations should be removed from the site or stood down until repairs or modifications can be made.
- To reduce the annoyance associated with reversing alarms, broadband reversing alarms (audible movement alarms) are preferred for all site equipment. Satisfactory compliance with occupational health and safety requirements would need to be achieved and a safety risk assessment may need to be undertaken to determine that safety is not compromised. (Refer to Appendix C of the ICNG for more information.)
- The work site should be arranged in such a way as to reduce the use of movement alarms on vehicles and mobile plant.

7.2 Work Ethics

All site workers should be sensitised to the potential for noise impacts on local residents and businesses and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities. This should include:

- Avoid the use of radios during non-standard work hours.
- Avoid shouting and slamming doors.
- Where practical, machines should be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods.
- Minimise reversing.
- Avoid dropping materials from height and avoid metal to metal contact.

7.3 Community Consultation Procedures

The ENMM Practice Note (vii) provides community consultation procedures for road works outside normal working hours. This includes the following:

- Contacts the local community potentially affected by the proposed works and inform them by letter of the proposed work, location, type of work, traffic detours, days and dates of work, hours, and likely noise impacts involved. The contact should be made at least five days prior to commencement of works.
- A suitable advertisement should be placed in local papers including a reference to construction hours and Proposal duration.
- A 24-hour community liaison phone number and permanent site contact should be provided so that complaints can be received and addressed in a timely manner.
- Complaints should be reviewed in a timely manner to determine if monitoring should be undertaken and reported as soon as possible. If exceedances are detected, the situation should be reviewed in order to identify means to attempt to reduce the impact to acceptable levels.

7.4 Compliance Noise and Vibration Monitoring

Attended compliance noise or vibration monitoring should be undertaken to confirm the predicted noise or vibration levels upon receipt of a complaint. The ICNG guidelines state that complaint monitoring measurements should be taken at the complainant's location and the monitoring should cover the time of day when the impacts were reported to occur.

In the case that exceedances of the relevant annoyance criteria levels listed in this report are detected in relation to the complaint, the situation should be reviewed in order to identify means to minimise the impacts to residences.

Where construction activities generating vibration are to be undertaken at a distance of less than 30 m from a building, vibration monitoring should be conducted during these activities at the most susceptible building. Where exceedances of the vibration criteria outlined in Section 3.2 are recorded, the situation should be reviewed in order to identify the measures that can be taken to minimise the impacts to buildings and prevent structural damage. The review may result in a requirement to modify work practices or use alternative, low-vibration methods and equipment.

In all cases, noise or vibration monitoring should be undertaken by a suitably qualified professional with in accordance with ICNG guidelines.

7.5 Building Condition Inspections (Vibration)

Building Condition Inspections are recommended for any utility, structure or building when vibration generating activities are planned within 50 m. Any utility, structure or building requiring a building inspection will be determined prior to construction works commencement.

Building condition inspection reports should also classify building structure and susceptibility to damage in accordance with the DIN4150-3 classifications. The resulting building classifications are to be used for determination of the applicable DIN4150-3 vibration criteria curves.

Condition inspections are to identify high-risk buildings where additional vibration restrictions and more stringent criteria may apply.

7.6 Human Comfort Impacts (vibration)

The construction works are considered short term by the OEH Assessing Vibration A Technical Guideline (AVTG), therefore where alternative non-vibration inducing construction methods are impractical, the following principles from the AVTG can be utilised to assist with minimisation of adverse reactions from the community.

- Confining vibration-generating operations to the least vibration-sensitive part of the day– which could be when the background disturbance is highest.
- Determining an upper level for vibration impact also considering what is achievable using feasible and reasonable mitigation.
- Consulting with the community regarding the proposed events.

8. Recommendations and Conclusions

The RMS has proposed to upgrade or replace the Burrill Lake Bridge on the Princes Highway in the City of Shoalhaven. This noise and vibration assessment presents relevant noise and vibration criteria for the proposal including criteria for operational road traffic noise as per the RNP and EMMM and criteria for construction noise and vibration as per the ICNG.

A set of standard mitigation measures for construction noise and vibration have been provided based on the anticipated requirements of the project, however a CNVMP which includes requirements for noise monitoring at sensitive receivers and a community consultation programme is recommended to be developed as part of a CEMP for the project's construction stages.

Existing noise levels obtained through short term attended and long term unattended noise monitoring indicate that the noise environment is dominated by traffic from the Princes Highway, which was measured to be greater than the RNP noise guideline values. These existing road traffic noise levels are at a level of acute impact, however changes in road alignment and/or levels may cause significant variations in noise due to changes in road proximity and line of sight, therefore once the proposal is decided an operational noise assessment should be undertaken to determine any predicted changes in noise levels due to the proposal and whether mitigation measures should be considered.

9. Limitations

This Noise and Vibration Assessment ("Report"):

- Has been prepared by GHD Pty Ltd ("GHD") for the Roads and Maritime Services (RMS).
- May only be used and relied on by RMS.
- Must not be copied to, used by, or relied on by any person other than RMS without the prior written consent of GHD.
- May only be used for the purpose of the scope of work outlined in Section 1.1 of this report (and must not be used for any other purpose).

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than RMS arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in Section 1 of this Report.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to):

- Noise prediction modelling assumptions detailed in Section 4 and Section 6 of this report.

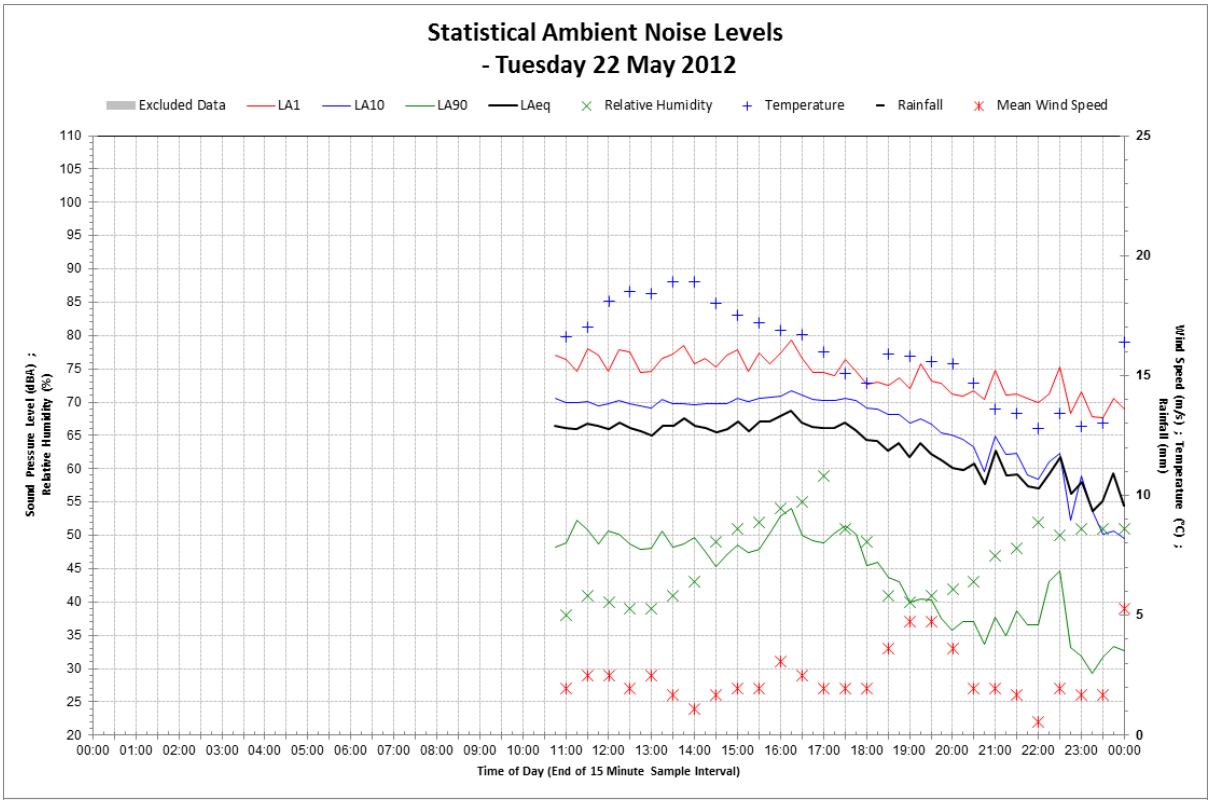
GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation of this Report.

Appendix A

Noise Monitoring Charts

Location 1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Temperature
Rainfall
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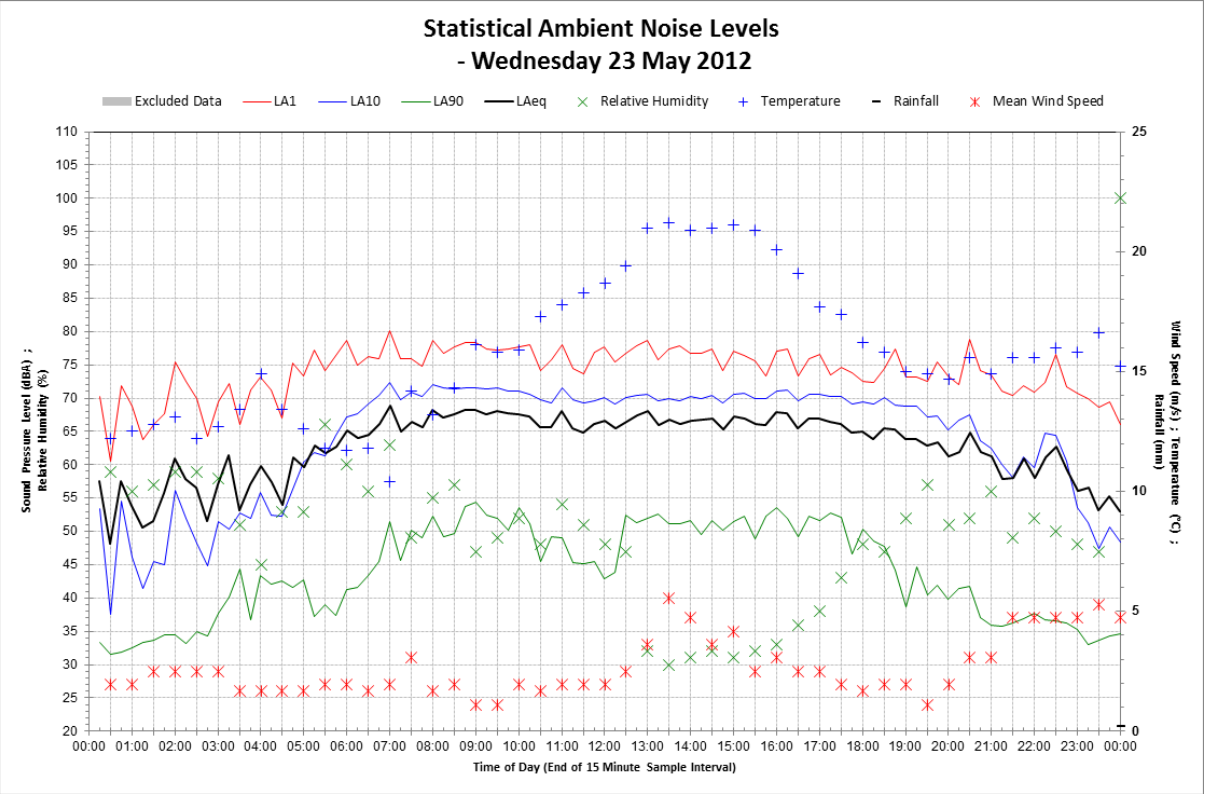
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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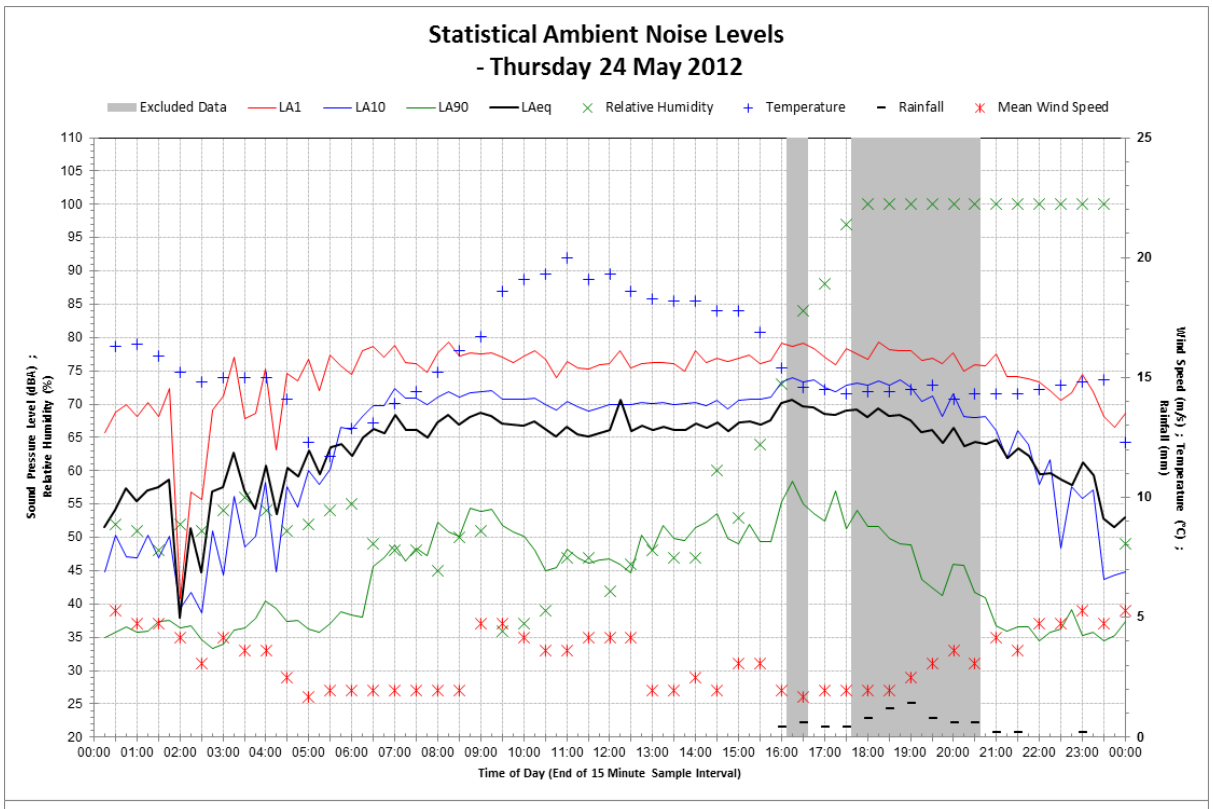
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Temperature
Rainfall
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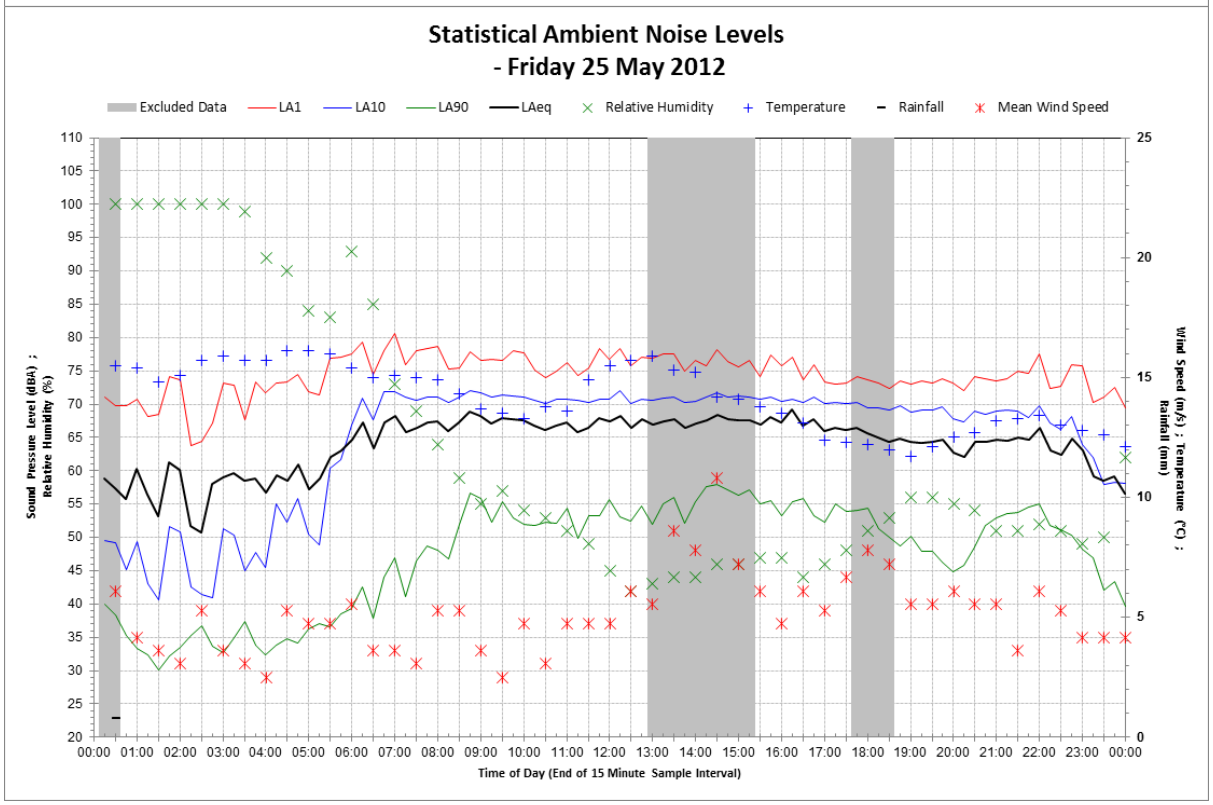
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Rainfall
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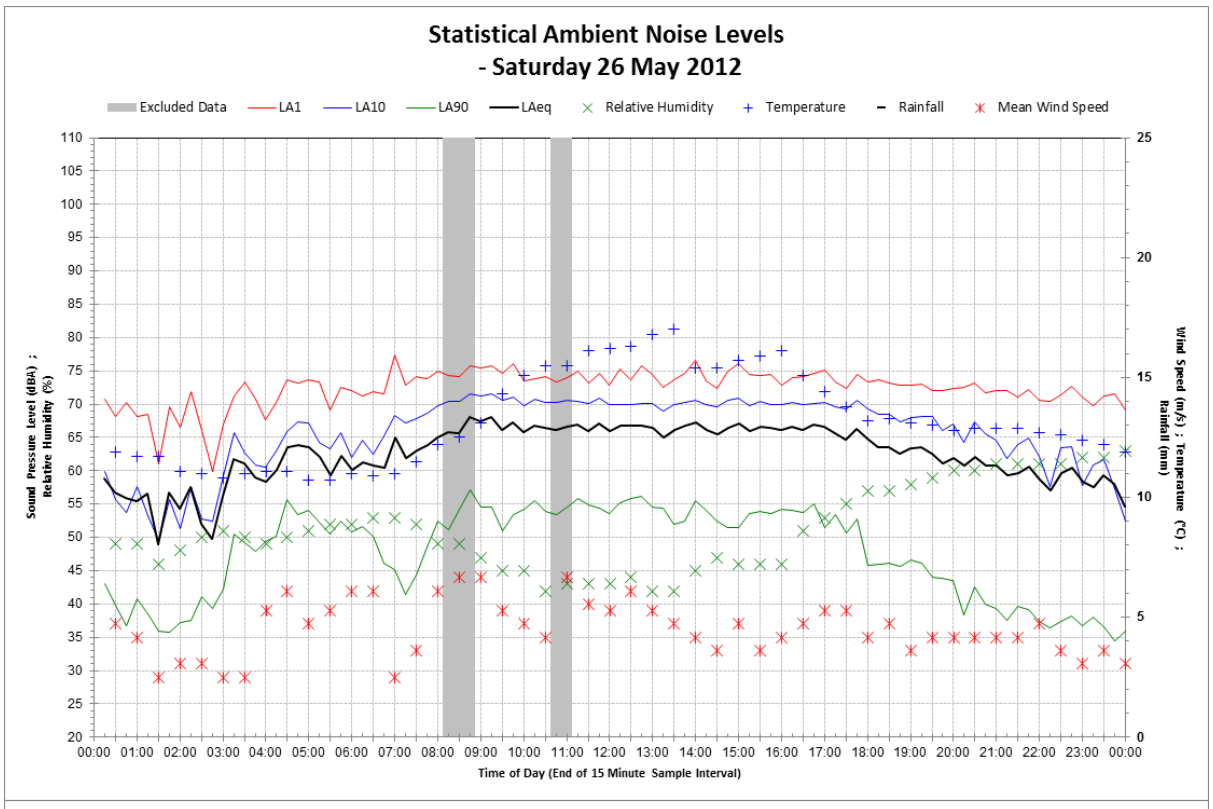
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Rainfall
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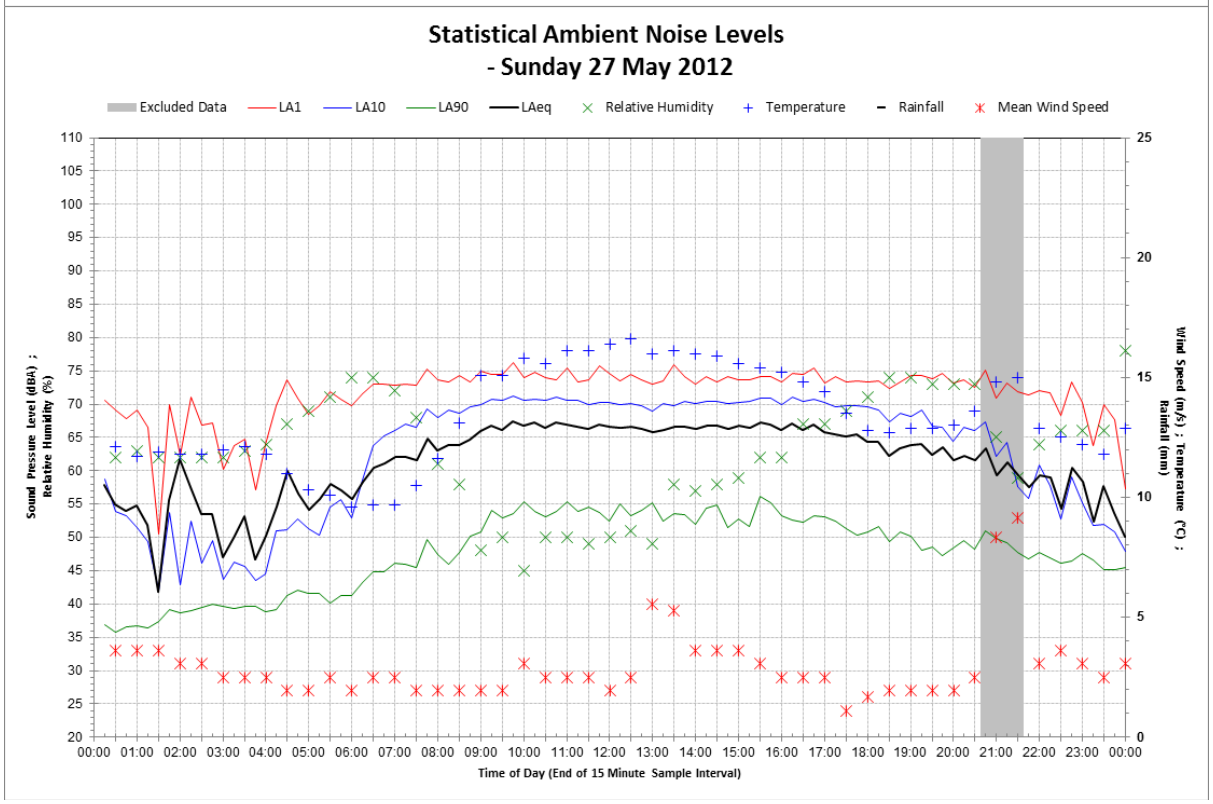
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
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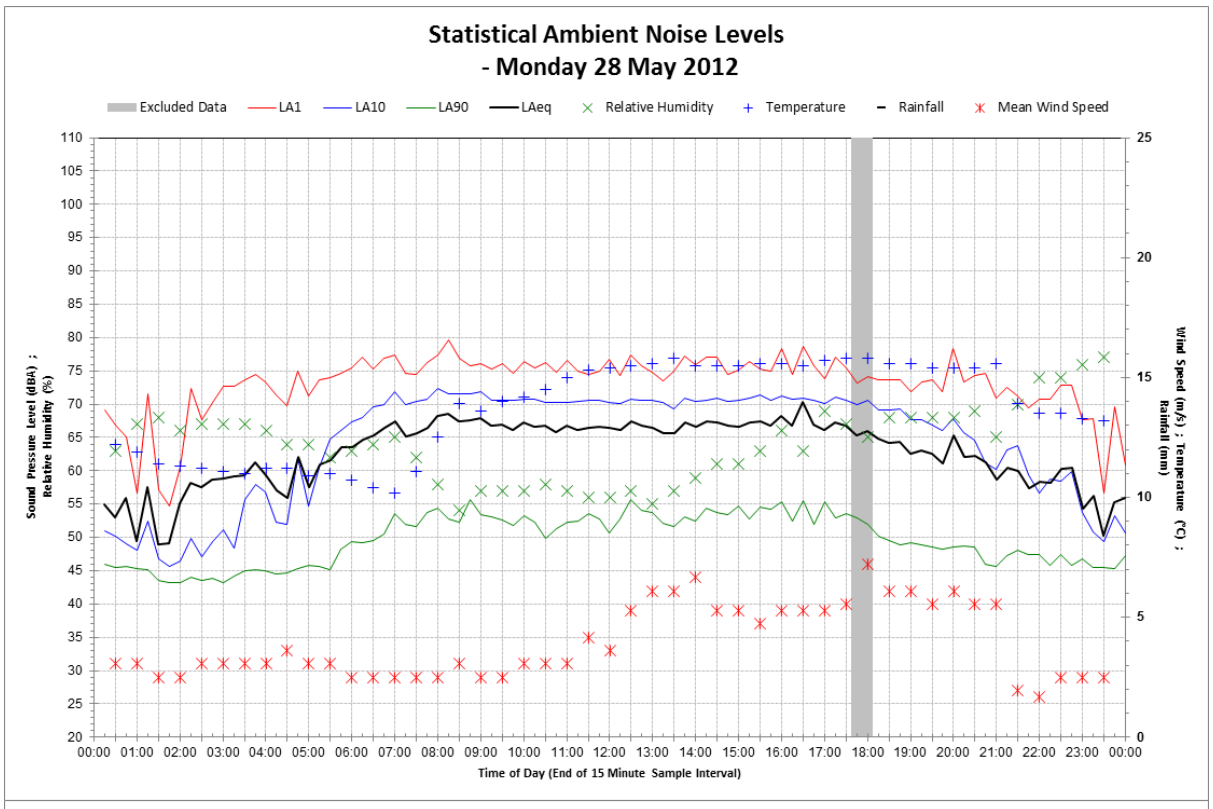
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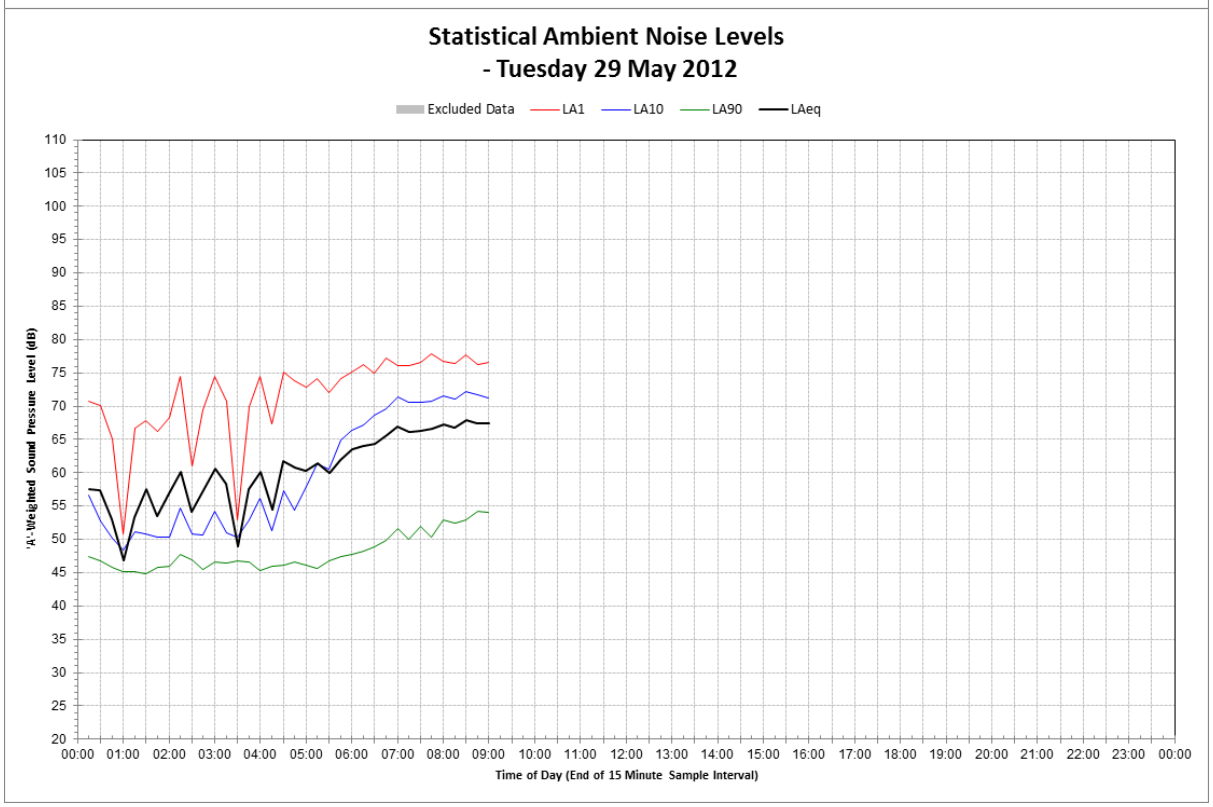
Time of Day (End of 15 Minute Sample Interval)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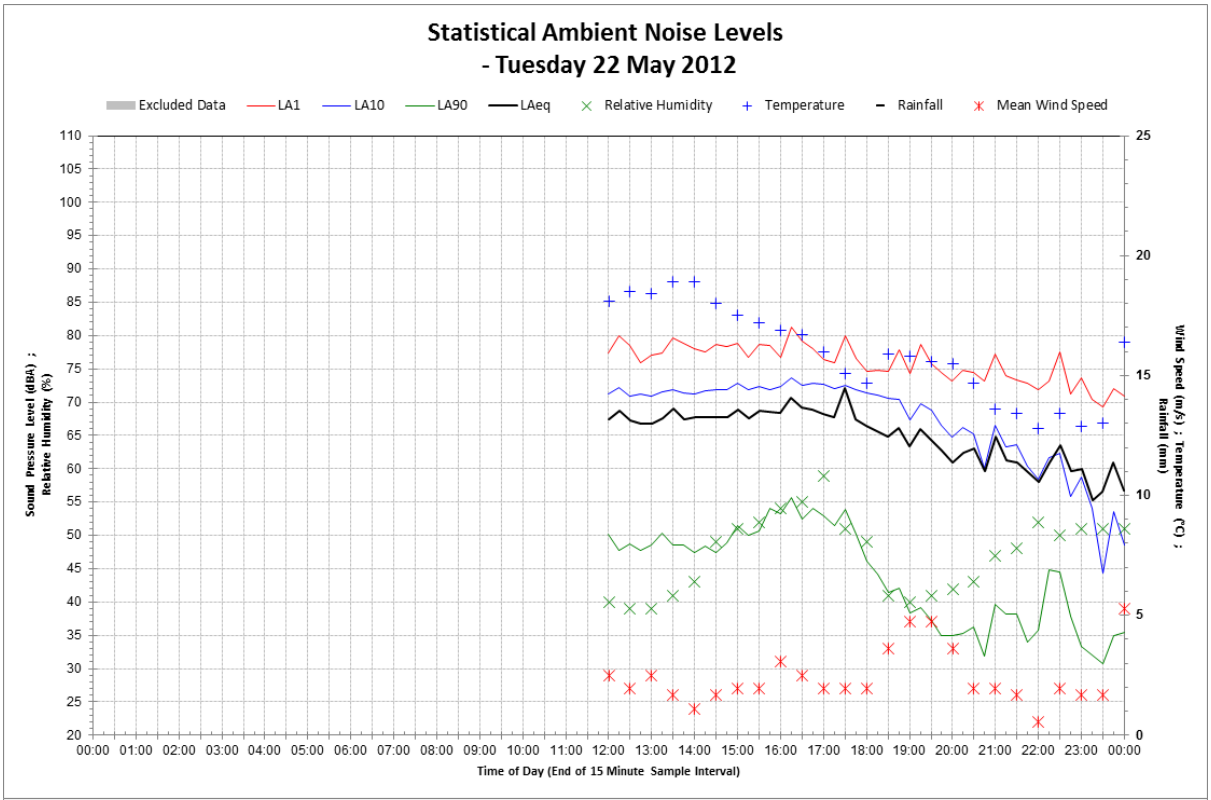
Time of Day (End of 15 Minute Sample Interval)

Appendix B

Noise Monitoring Charts

Location 2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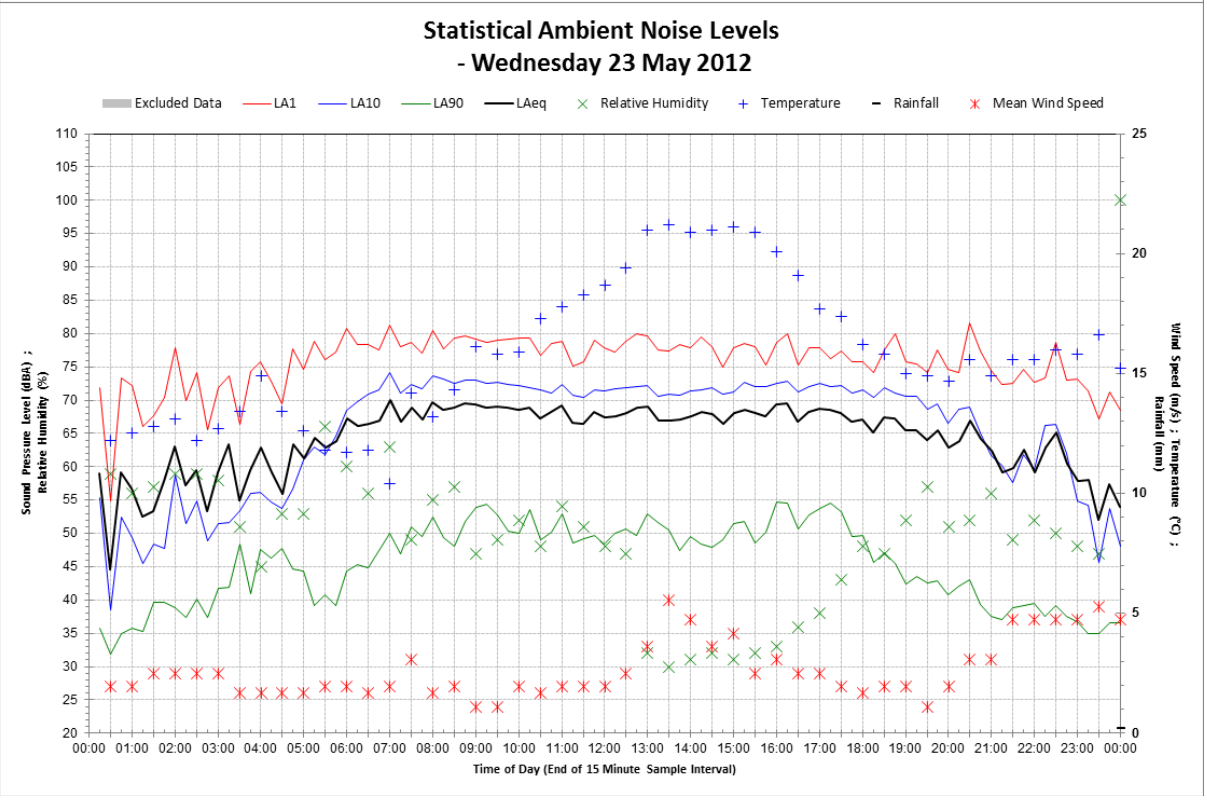
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)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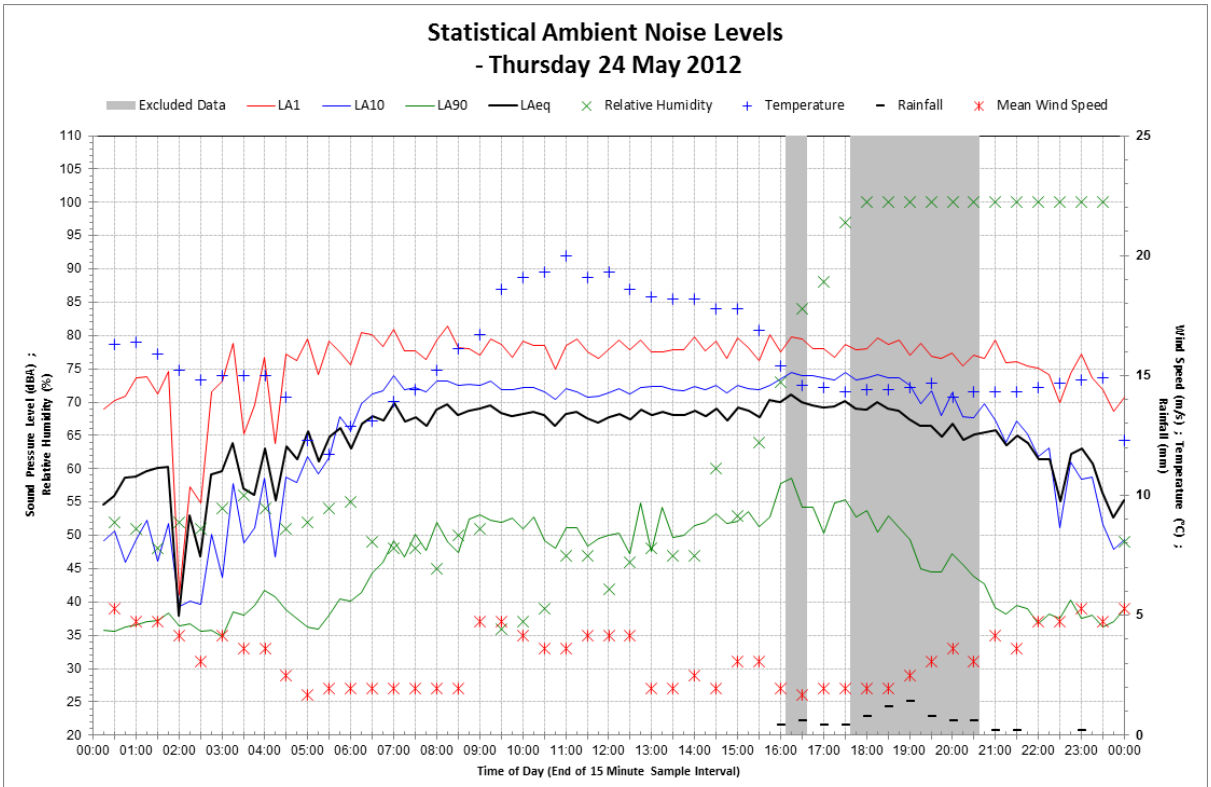
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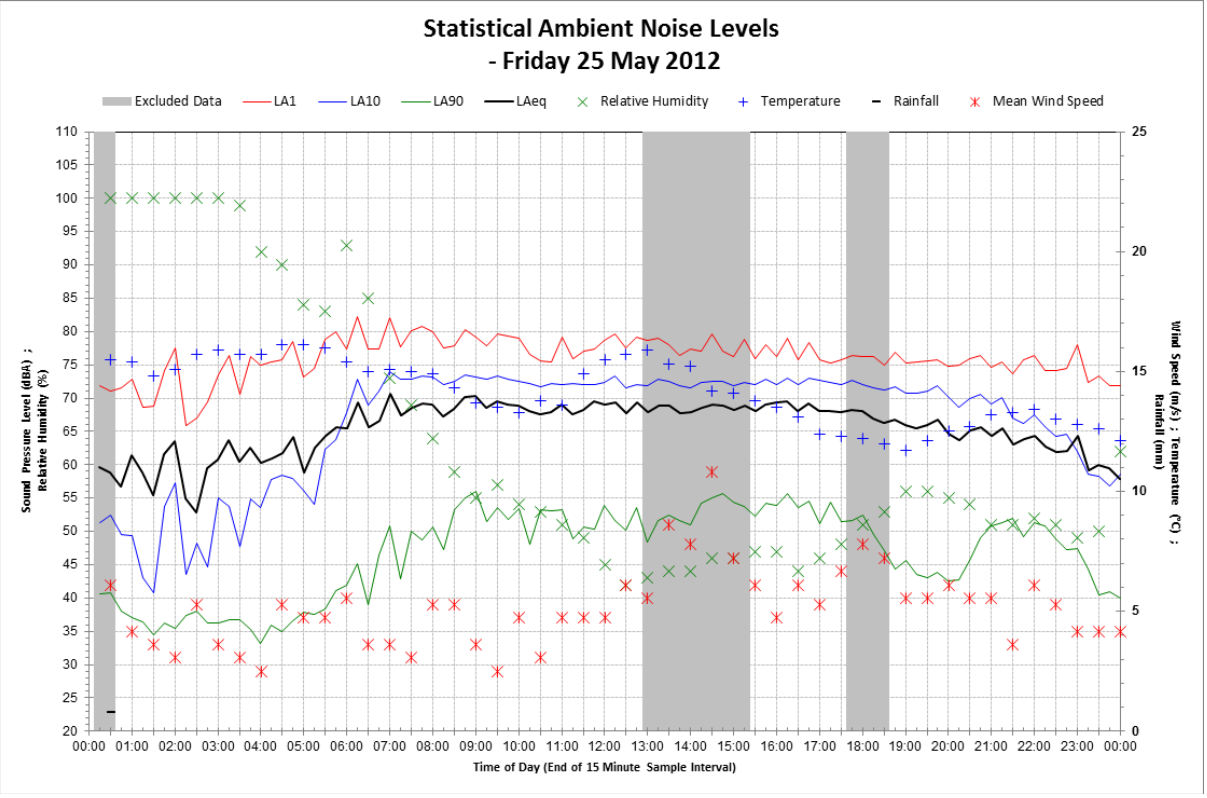
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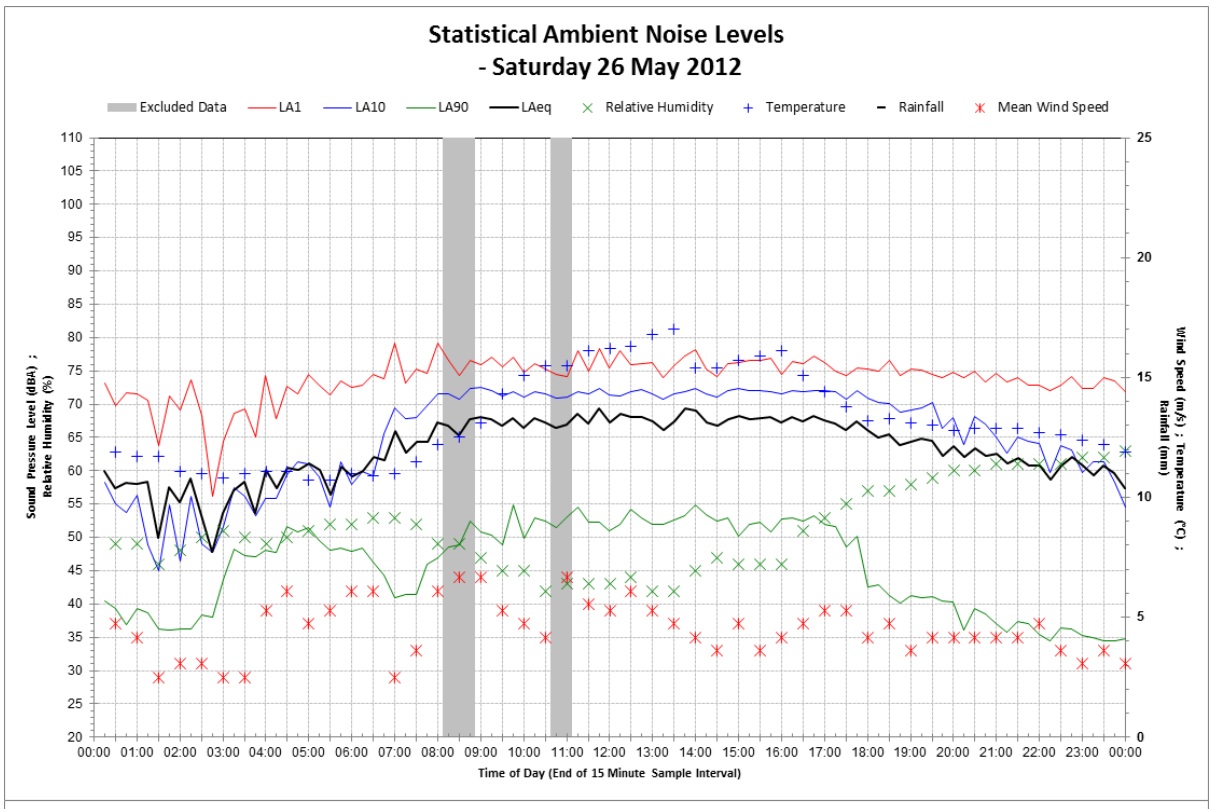
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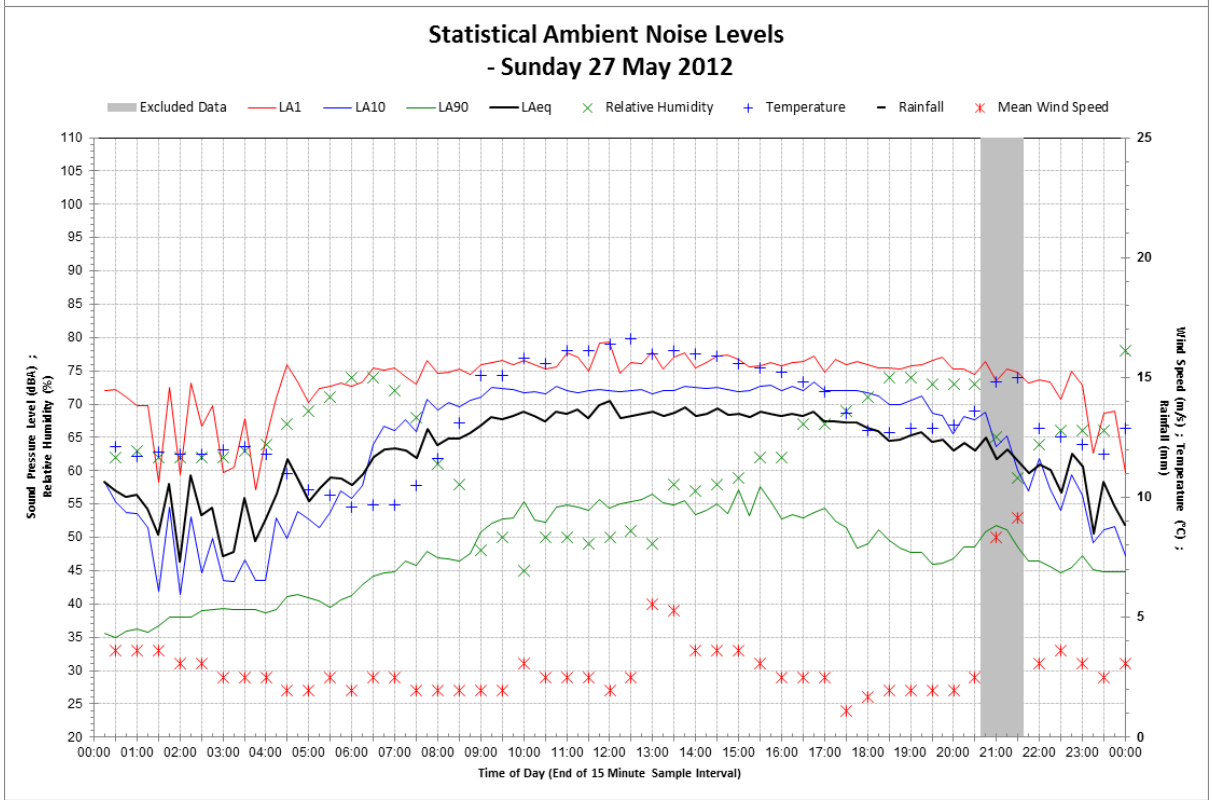
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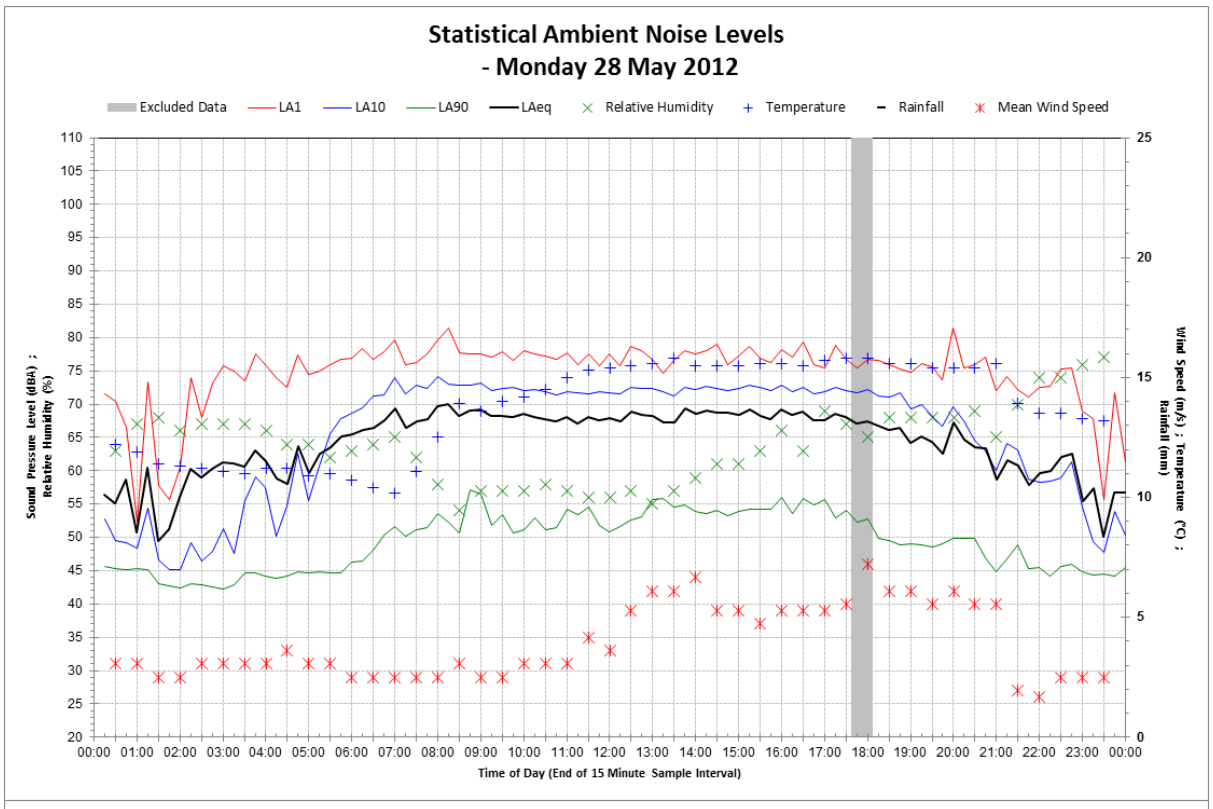
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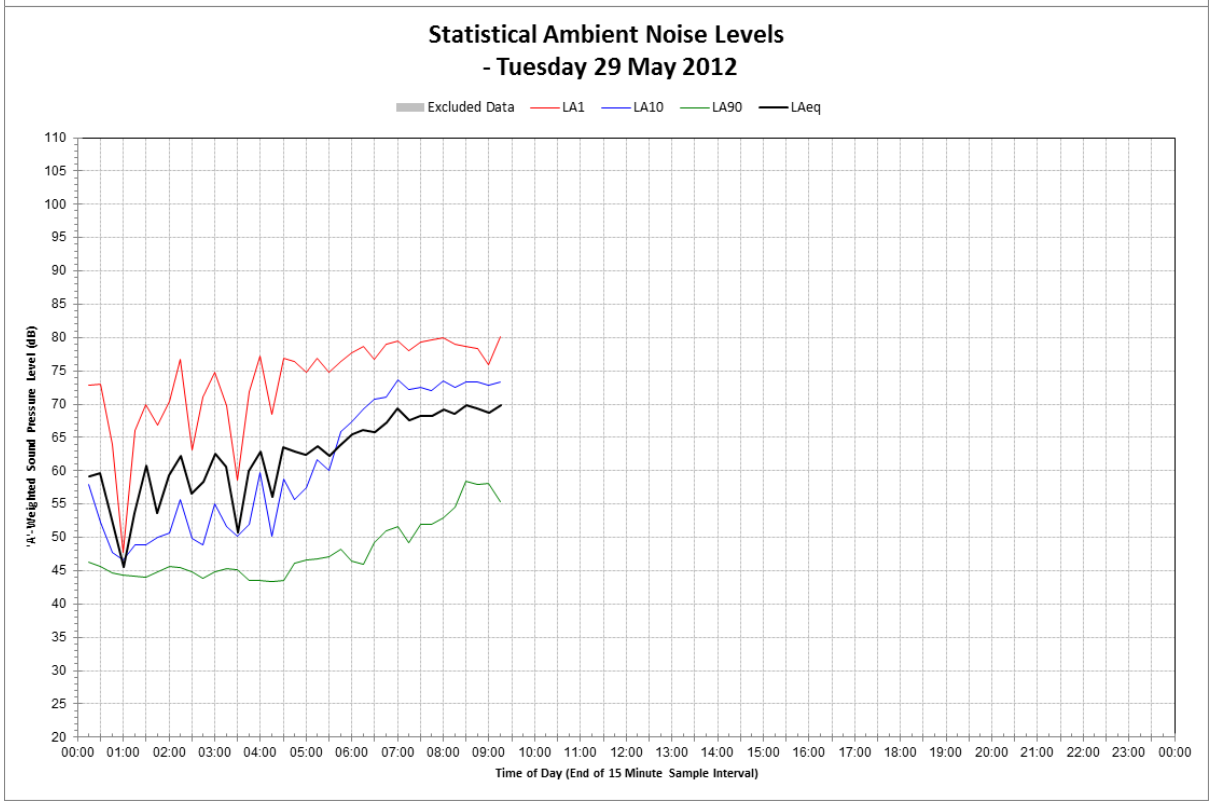
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Time of Day (End of 15 Minute Sample Interval)

GHD

Level 3 GHD Tower 24 Honeysuckle Drive Newcastle NSW 2300
PO Box 5403 Hunter Region Mail Centre NSW 2310
T: (02) 4979 9999 F: (02) 4979 9988 E: ntlmail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	J.Tjia/ S.Ritchie	V Chavand	*V Chavand*	V Chavand	*V Chavand*	18/06/2012
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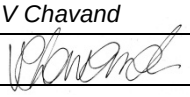
2	L Basutu	S Ritchie		V Chavand		23/11/2012