16 CHAPMAN STREET, WERRINGTON

Precinct Subdivision
Noise Impact Assessment

Prepared for:

GLN Planning Pty Ltd
Level 10, 70 Pitt Street
SYDNEY NSW 2000

SLR

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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Grd Floor, 2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: +61 2 9427 8100
E: sydney@slrconsulting.com   www.slrconsulting.com

BASIS OF REPORT

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

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.18940-R01-v1.1	25 September 2019	Antony Williams	Mark Russell	Antony Williams
610.18940-R01-v1.0	9 August 2019	David O'Brien	Antony Williams	Antony Williams

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by GLN Planning to undertake a noise impact assessment in relation to the proposed subdivision of 16 Chapman Street, Werrington (the Precinct).

The proposal includes residential dwellings in the northern two-thirds of the site with the southern portion of the site being proposed to be subdivided into light industrial lots, as shown below in **Figure 1** and **Figure 2**.

1.1 Scope of this Report

This report identifies existing sources of noise at the site and the potentially affected sensitive receivers, and details the findings of environmental existing noise surveys completed in the area.

Where appropriate, design measures to control the potential noise impacts have been recommended.

At this early stage in the project specific details of the usage of the various residential and industrial areas are yet to be finalised. An aim of this noise assessment is therefore to inform the later design stages based on the predicted noise impacts

1.2 Noise Sources Potentially Impacting on the Precinct

Noise sources that have the potential to impact on the proposal include:

- **Rail noise** from the existing T1 Western Line. The T1 Western Line is located to the immediate north of the Precinct. Werrington Station is to the east of the Precinct and Kingswood Station is to the west. This existing line has both passenger and freight services during the daytime and night-time periods.
- **Road traffic** noise from the Great Western Highway. The Great Western Highway is the busiest road near the Precinct. It is, however, over 450 m to the south of the Precinct, meaning road traffic noise impacts are unlikely.
  - As part of the redevelopment of the Precent, a number of internal roads would be constructed as shown in **Figure 2**. These roads are, however, assumed to be local roads with low volumes of traffic and would not significantly affect nearby receivers.
- **Industrial noise** from new industrial areas within the Precinct. There is potential for noise from mechanical plant at the various residential areas of the Precinct (such as air conditioners).
  - At this early stage in the proposal, the industrial uses of the Precinct are not yet defined. Depending on the final use, there is potential for impacts from mechanical plant, car parking movements, truck deliveries, etc, on nearby receivers.

1.3 Terminology

This report uses specific acoustic terminology. A glossary is provided in **Appendix A**.

Figure 1 Proposed Subdivision

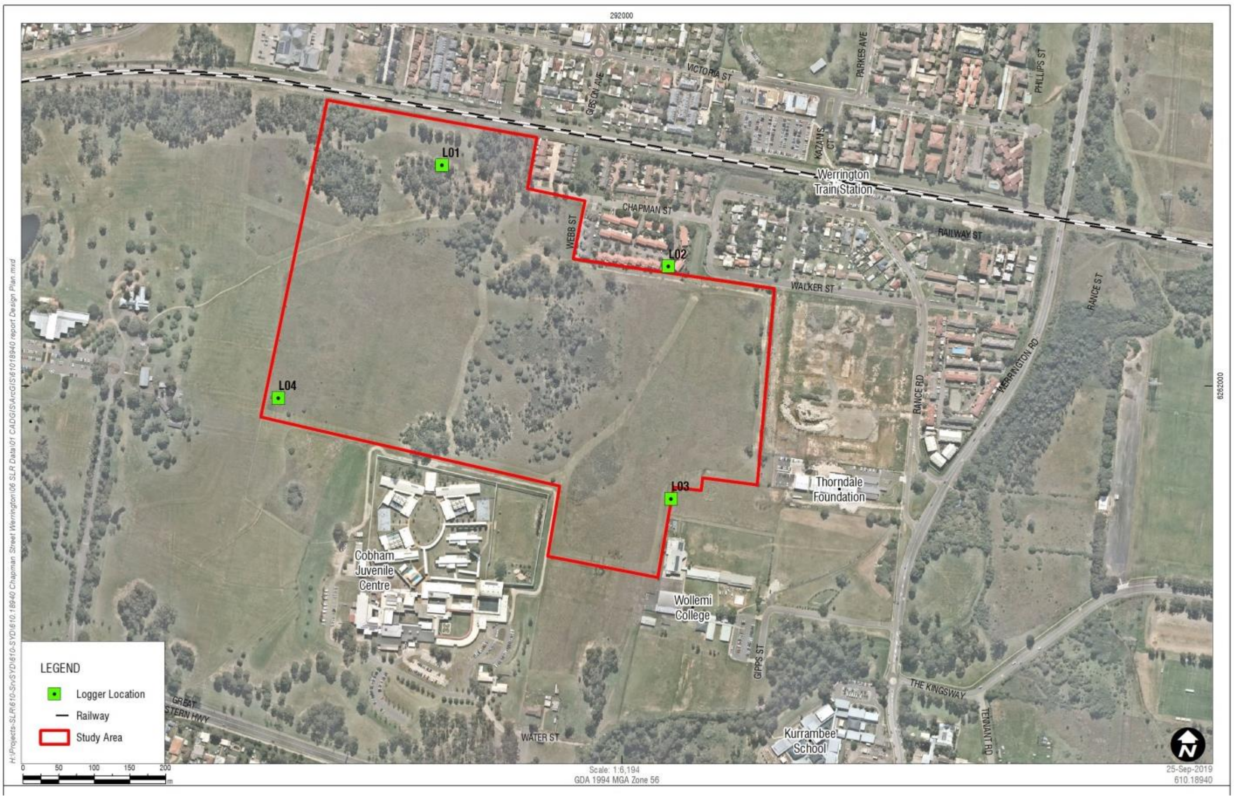


Figure 2 Proposed Site Layout

2 Existing Environment

The existing noise environment at the site is controlled by general environmental noise, train passbys in the northern portion of the site and distant road traffic noise from the surrounding road network. The nearest major road is the Great Western Highway, which is 450 m to the south of the Precinct.

The southern portion of the site is also affected to a lesser degree by noise from Wollemi College and Cobham Juvenile Centre, which includes occasional bells and PA announcements.

2.1 Unattended Ambient Noise Monitoring

Unattended noise monitoring was completed at the site in June and July 2019. The measured noise levels have been used to determine the existing noise environment and to set operational criteria for noise from the future industrial uses at the site.

The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time. All equipment carried current National Association of Testing Authorities (NATA) calibration certificates and the calibration was checked before and after each measurement.

The noise monitoring data has been processed to exclude noise from extraneous events and/or data affected by adverse weather conditions, such as strong wind or rain.

A summary of the ambient noise monitoring is provided in **Table 1** and the locations are shown in **Figure 1**.

Table 1 Summary of Existing Ambient Noise Levels

Location	Address	Measured Noise Levels (dBA)					
		Background Noise (RBL)			Average Noise (L_{Aeq})		
		Day	Evening	Night	Day	Evening	Night
L.01	16 Chapman Street, Werrington	39	43	36	55	56	54
L.02	15/4-12 Chapman Street, Werrington	37	44	37	57	48	46
L.03	16 Chapman Street, Werrington (Wollemi College)	38	46	39	51	50	48
L.04[1]	16 Chapman Street, Werrington	38	44	37	48	48	46

Note 1: Logger L.04 was observed to drift greater than 2 dB during the monitoring survey period. The logger data is presented, but has not been used in the assessment.

Details of each monitoring location together with graphs of the measured daily noise levels are in **Appendix B**.

2.2 Attended Noise Monitoring

Short-term attended noise monitoring was completed on Thursday 27 June 2019 and Monday 8 June 2019. The attended measurements allow the contributions of the various noise sources at each location to be determined. Detailed observations from the attended measurements are provided in **Appendix B**.

3 Operational Criteria

3.1 Airborne Road and Rail Noise

The NSW Government's State Environmental Planning Policy (Infrastructure) 2007 (the SEPP) was introduced to aid the delivery of infrastructure across the State.

In accordance with the SEPP, Table 3.1 of the NSW Department of Planning and Infrastructure's *Development near Rail Corridors and Busy Roads – Interim Guideline* (the DP&I Guideline), provides noise criteria for residential and non-residential buildings. These criteria are summarised in **Table 2**.

Table 2 DP&I Interim Guideline Noise Criteria

Residential Buildings		
Type of Occupancy	**Noise Level (dBA)**	**Applicable Time Period**
Sleeping areas (bedroom)	35	Night 10 pm to 7 am
Other habitable rooms (excl. garages, kitchens, bathrooms & hallways)	40	At any time
Non-Residential Buildings		
Type of Occupancy		**Recommended Max Noise Level (dBA)**
Educational Institutions including Child Care Centres		40
Places of Worship		40
Hospitals	Wards	35
	Other Noise Sensitive Areas	45

Note 1: Airborne noise is calculated as $L_{Aeq(15hour)}$ daytime and $L_{Aeq(9hour)}$ night-time.

If internal noise levels with windows or doors open exceed the above criteria by more than 10 dB, then a natural ventilation path from a non-noise affected facade or forced ventilation system for the habitable rooms may be necessary to allow residents to leave windows closed during noisy periods.

It is generally accepted that internal noise levels in a dwelling are 10 dB lower than external noise levels with the windows open, and 20 dB lower than external noise levels with the windows closed and standard glazing.

As the road traffic noise model predicts external noise levels, the internal noise goals have been adjusted by 10 dB for open windows and 20 dB for closed windows and standard glazing to provide external noise goals. The external noise goals applicable for the proposal are provided in **Table 3**.

Table 3 External Noise Goals Applicable to the Proposal

Type of Occupancy		External Noise Goals (dBA)[1,2]		Applicable Time Period
		Windows Open	Windows Closed	
Residential Buildings[3]				
Sleeping areas (bedrooms)		45	55	Night-time (10:00 pm to 7:00 am)
Other habitable rooms (excluding garages, kitchens, bathrooms and hallways)		50	60	At any time
Non-Residential Buildings				
Educational institutions including childcare centres		50	60	Whenever in use
Places of worship		50	60	Whenever in use
Hospitals	- Wards	45	55	Whenever in use
	- Other noise sensitive areas	55	65	Whenever in use

Note 1: Airborne noise is calculated as $L_{Aeq(15hour)}$ for the daytime and $L_{Aeq(9hour)}$ for the night-time.

Note 2: External noise goals are applicable 1 m from the external facade of a habitable room.

Note 3: These noise goals apply to all forms of residential buildings as well as aged care and nursing home facilities.

Where road/rail noise levels exceed the ‘windows open’ criteria, residential receivers will require windows and doors to be closed and alternative ventilation arrangements must therefore be provided.

Where road/rail noise levels exceed the ‘windows closed’ criteria, upgraded building/facade construction may be required, along with the alternative ventilation.

3.2 Industrial Noise Criteria

The *Noise Policy for Industry* (NPfI) was released in 2017 and sets out the NSW *Environment Protection Authority’s* (EPA’s) requirements for the assessment and management of noise from industry in NSW.

3.2.1 Trigger Levels

The NPfI describes ‘trigger levels’ which indicate the noise level at which feasible and reasonable noise management measures should be considered. Two forms of noise criteria are provided – one to account for ‘intrusive’ noise impacts and one to protect the ‘amenity’ of particular land uses.

- The **intrusiveness** of an industrial noise source is generally considered acceptable if the L_{Aeq} noise level of the source, measured over a period of 15 minutes, does not exceed the background noise level by more than 5 dB. Intrusive noise levels are only applied to residential receivers. For other receiver types, only the amenity levels apply.
- To limit continual increases in noise levels from the use of the intrusiveness level alone, the ambient noise level within an area from all industrial sources should remain below the recommended **amenity** levels specified in the NPfI for that particular land use.

For this assessment, the area surrounding the proposal is considered to be ‘suburban’.

3.2.2 Project Specific Criteria

The noise emission trigger levels for noise from the future industrial uses of the Precinct are provided in **Table 4** The project noise trigger level is the lowest value of the intrusiveness or amenity noise level for each period and these are shown below in bold.

Table 4 Project Specific Nosie Trigger Levels

Monitoring Location	Period	Representative Noise Logger	Recommended Amenity Noise Level $L_{Aeq(period)}$	Measured Noise Level (dBA)		Project Noise Trigger Levels $L_{Aeq(15minute)}$ (dBA)	
				RBL[1]	$L_{Aeq(period)}$	Intrusiveness	Amenity[2,3]
1	Daytime	L01	55	39	55	**44**	53
	Evening	L01	45	39 (43 actual)	56	**44**	44[4]
	Night-time	L01	40	36	54	**41**	42[4]
2	Daytime	L02	55	37	57	**42**	53
	Evening	L02	45	37 (44 actual)	48	**42**	43
	Night-time	L02	40	37	46	42	**38**
3	Daytime	L03	55	38	51	**43**	53
	Evening	L03	45	38 (46 actual)	50	**43**	43
	Night-time	L03	40	38 (39 actual)	48	43	**38**

Note 1: RBL = Rating Background Level.

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

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

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

4 Impact Assessment

A computer noise model was developed to predict road and rail noise levels across the proposed Precinct. SoundPLAN has been used and is a software package which allows noise predictions to be made in a 3D environment and includes a digitised ground map (containing ground contours and significant structures, where appropriate), the location and acoustic power levels of significant noise sources, and the location of noise-sensitive receivers.

At this early stage in the project information regarding the design of the residential dwellings in the Precinct are unknown and indicative building sizes have therefore been used in the model. All dwellings have been assumed to be single storey except the northern most lots which face the rail corridor in the north west portion, which are assumed to be double storey.

4.1 Rail Noise

Existing rail noise levels have been predicted in the subdivision during the daytime and night-time periods. The results of the predictions are provided in **Figure 3** as grid noise maps that represent the predicted existing noise level at 1.5 m above ground level.

The daytime noise predictions represent the period from 7 am to 10 pm and the night-time period is 10 pm to 7 am.

Figure 3 Existing Rail Noise – Daytime and Night-time Grid Noise Maps

The results show that existing rail traffic noise levels are generally limited to the northern area of the Precinct. The nearest buildings to the rail line are of residential use and are predicted to have noise levels in the region of 59 dBA during the daytime and 57 dBA during the night-time.

The highest noise levels are however limited to the residential lots in the north western portion of the subdivision, with noise levels in the rest of the site being considerably lower due to increased separation distance and intervening shielding provided by other buildings.

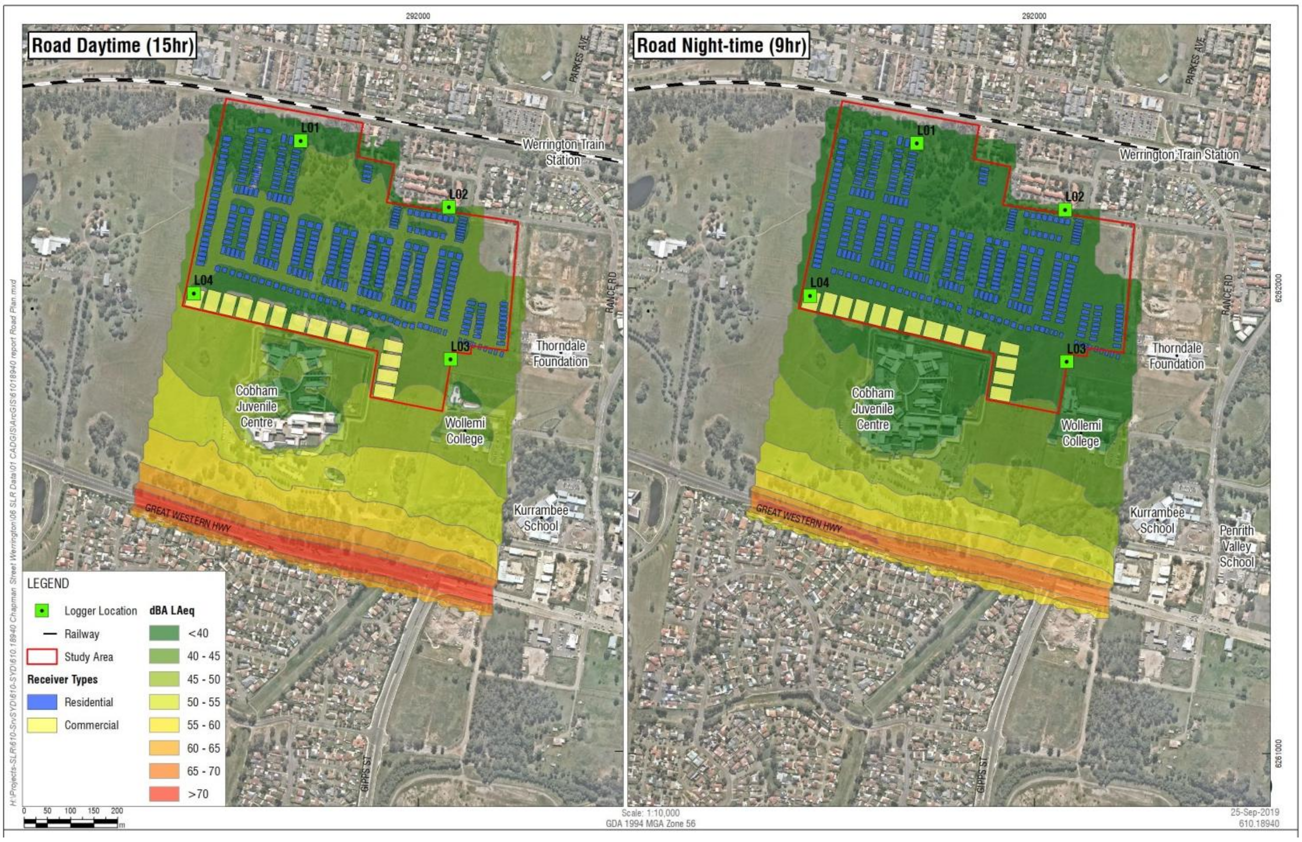
Residential buildings on the rows further back from the rail alignment are predicted to be subject to noise levels of around 50 to 55 dBA during the daytime and 45 to 50 dBA during the night-time, depending on angle of view to the rail.

4.2 Road Traffic Model

Road traffic noise levels have been predicted across the proposed subdivision during the daytime and night-time periods. The results are provided below in **Figure 4** as grid noise maps that represent the predicted existing road traffic noise levels at 1.5 m above ground level.

The daytime noise predictions represent the period from 7 am to 10 pm and the night-time period is 10 pm to 7 am.

Figure 4 Existing Road Traffic Noise – Daytime and Night-time Grid Noise Maps



The nearest residential lots in the Precinct are over 450 m from the Great Western Highway and are generally shielded by the industrial uses on the southern boundary. As a result, noise levels at the nearest residential receivers in the Precinct are predicted to be less than 50 dBA during the daytime and less than 45 dBA during the night-time.

4.3 Recommendations for Impacts

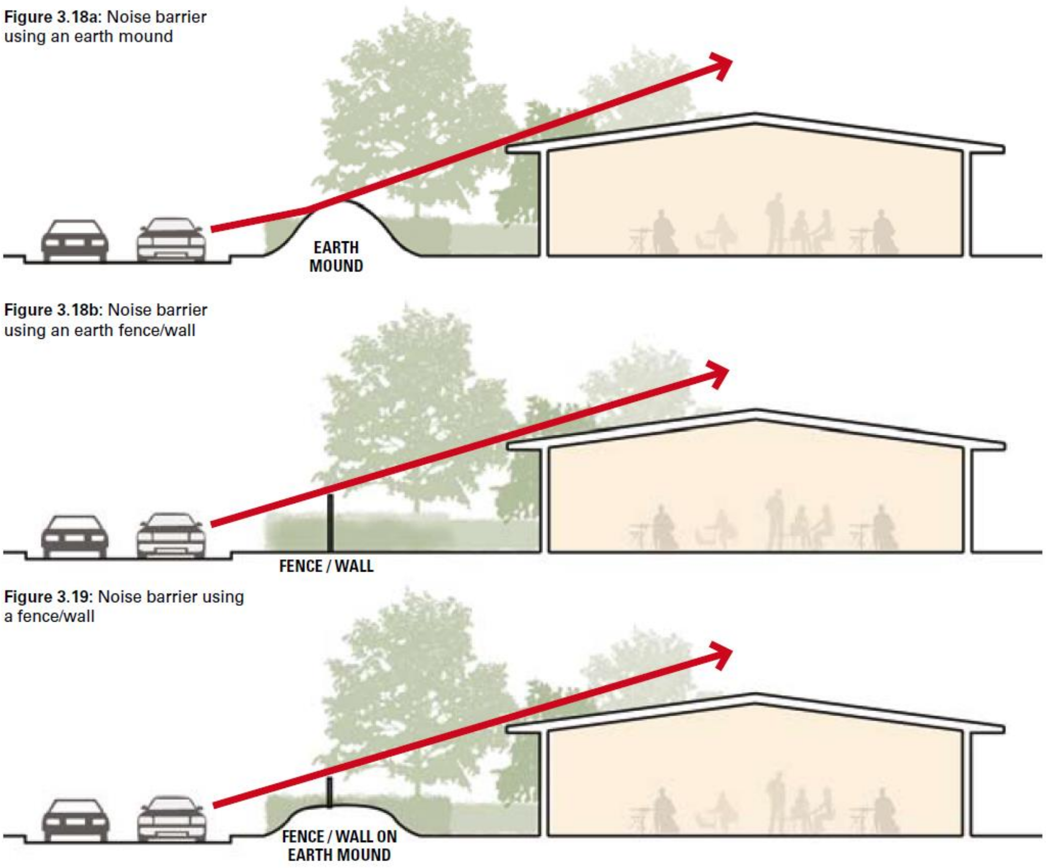
Sensitive receivers which are located close to sources of transportation noise will likely be affected by noise impacts and noise mitigation measures will need to be incorporated in to the design of the site.

The preferred mitigation strategy would be determined at a later stage in the project and would likely use a combination of the measures discussed below.

4.3.1 Noise Barriers/Mounds

Noise barriers can be an effective way to reduce road or rail noise impacts. Where space allows, raised earth mounds can also be used as noise barriers and can be enhanced by placing a low wall on top. These methods are shown below **Figure 5**.

Figure 5 Noise Barrier and Mounds



Note: Taken from DP&I *Development near Rail Corridors and Busy Roads – Interim Guideline*.

Whilst noise barriers can provide significant noise benefit they can also introduce a number of negative aspects, including access to property, aesthetic impacts, daylight access, overshadowing, drainage, graffiti, restriction of line-of-sight, maintenance access and safety concerns.

Noise barriers are generally only effective for ground and first floors of adjacent receivers, and typically provide no benefit to upper floors of multi-storey apartment blocks.

A noise barrier could potentially be considered in the north west portion of the Precinct, however it is noted that the rail line is on embankment in this area (and therefore elevated with respect to the surrounding ground), meaning a large height barrier would be required to effectively block line of sight. The length of the barrier would also be limited to the boundary of the Precinct and noise would still impact the site from the west.

For these reasons, a noise barrier in this location is unlikely to be considered appropriate.

4.3.2 Precinct Layout

The layout of the Precinct should be configured to locate less noise sensitive usages near to major source of noise, where possible. The current subdivision layout shows industrial uses in the south, which provides shielding from the Great Western Highway and the juvenile centre to the rest of the site. A buffer zone is also provided to the north of the industrial areas via the internal site road which provides a separation distance to the nearest residential dwellings. An internal site road is also used to provide separation from the nearest receivers to the rail corridor.

Larger, high density residential apartment buildings can also be used close to sources of transportation noise to act as noise barriers to shield lower density residential areas behind. Where structures are used to provide shielding to internal areas of the Precinct, the use of multi-storey buildings of at least two storeys provides the most benefit.

The effect of this principle is shown below in **Figure 6** and **Figure 7**. The first image illustrates how uninterrupted noise levels can propagate across a site, whereas the second image illustrates the effect of intervening structures. The comparison shows that significantly lower noise levels can be achieved if acoustic considerations are appropriately applied to the site layout early on in a project.

Figure 6 Cross Sectional Noise Map – Without Intervening Structures

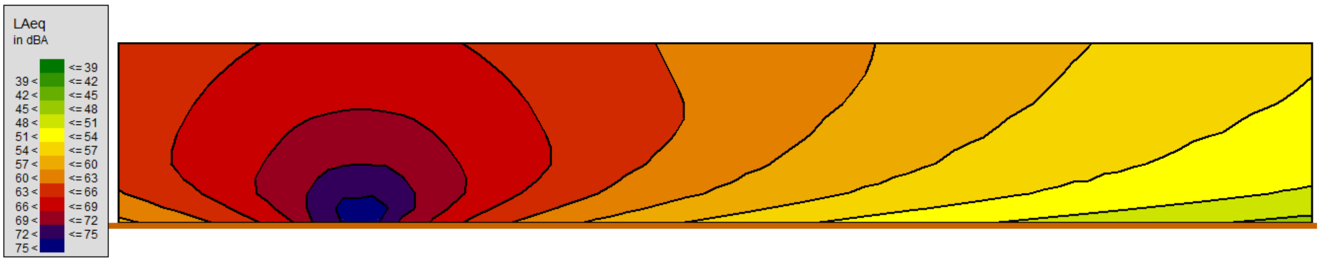
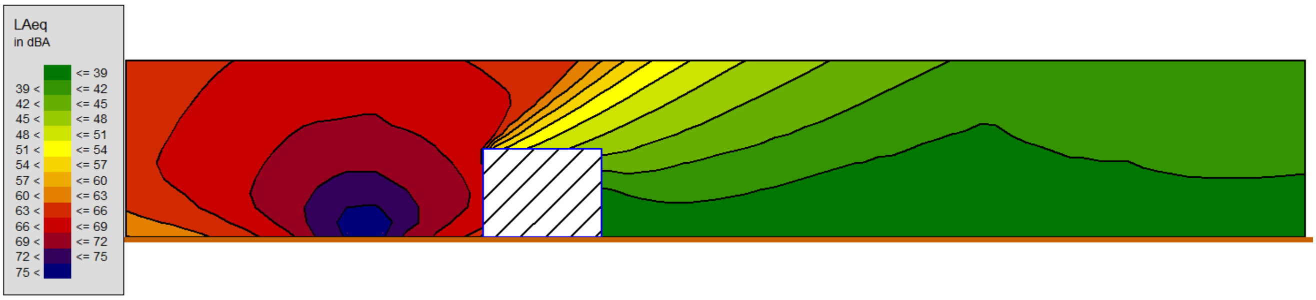


Figure 7 Cross Sectional Noise Map – With Intervening Structures



The current layout has double storey buildings in the north western portion of the site, which help to mitigate noise levels to the rest of the site.

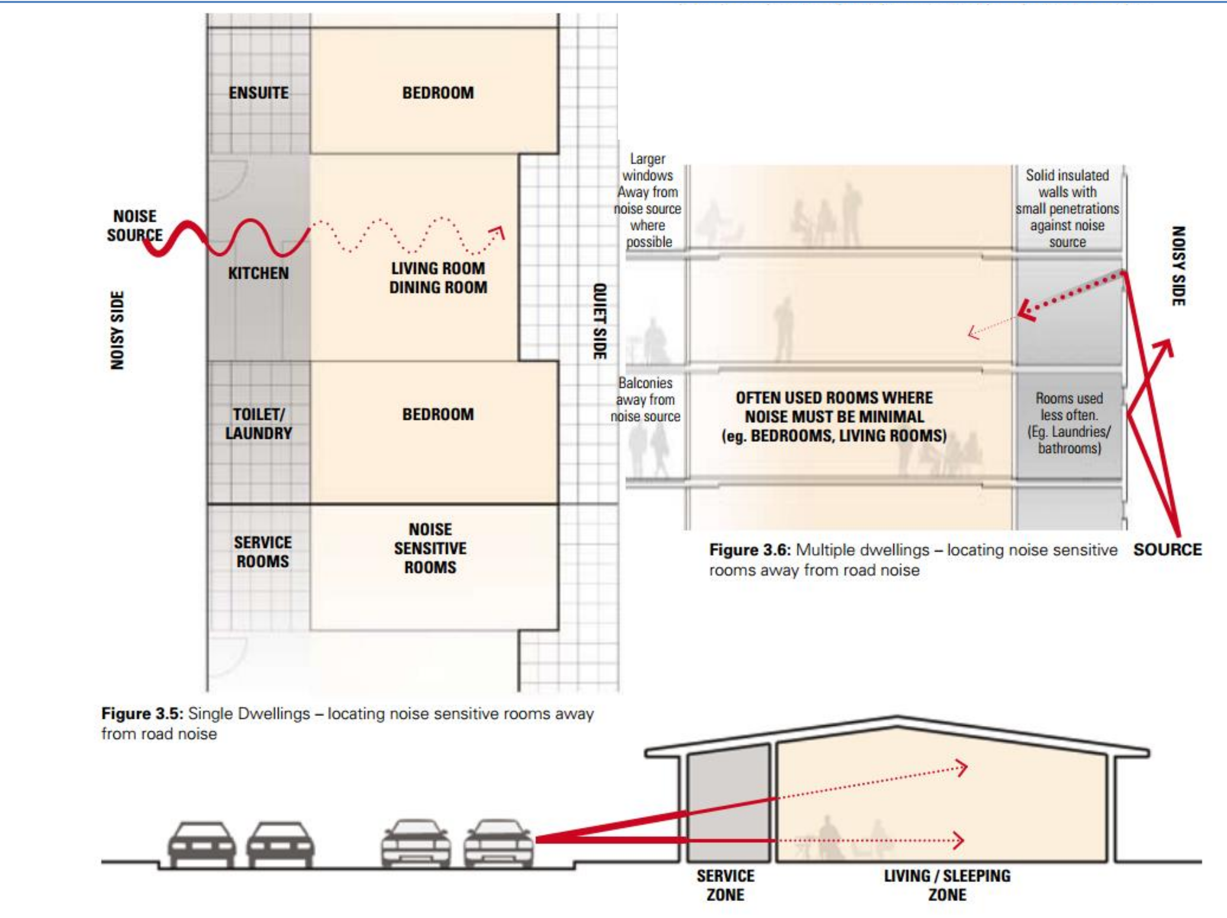
The facades of buildings used as barriers which face sources of noise should incorporate noise mitigation principles into their building design, such as locating less sensitive usages on the most noise exposed facades, to ensure appropriate internal noise conditions. This is further discussed in the following section

4.3.3 Internal Layout of Buildings

Where residential buildings are required to be located close to sources of transportation noise, the layout of the buildings can be optimised to minimise noise intrusion into sensitive areas. Buildings can be constructed so that noise insensitive areas such as kitchens, storage areas and laundries are located closer to the noise source.

An example of how residential buildings can be designed to shield sensitive sleeping and living areas is shown in **Figure 8**.

Figure 8 Examples of Design Orientation and Room Layout



Note: Taken from DP&I *Development near Rail Corridors and Busy Roads – Interim Guideline*.

4.3.4 Upgraded Facades and Mechanical Ventilation

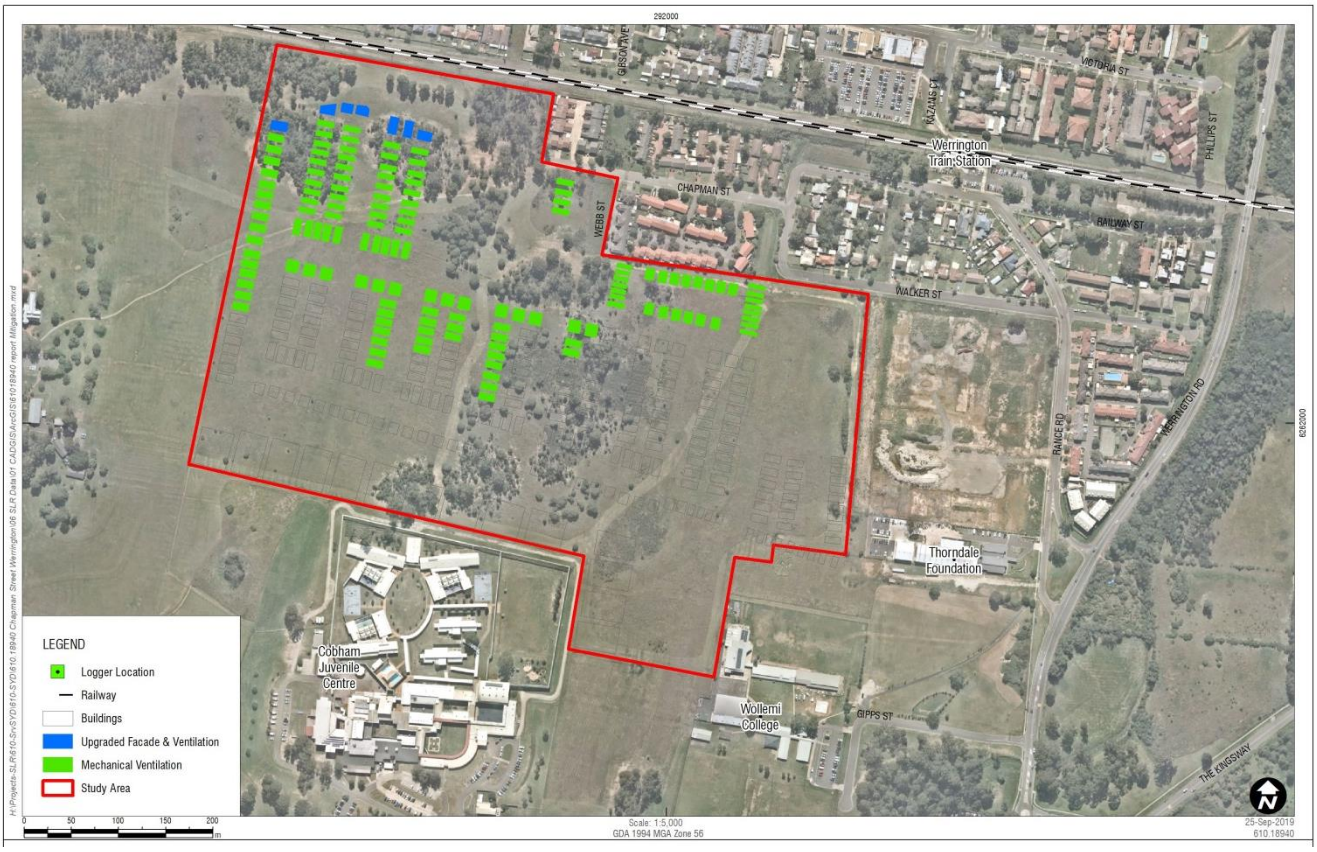
Where residual impacts remain after the optimisation of site layout and building design, the upgrading of facade elements of noise affected sensitive spaces can be used as a final mitigation approach to achieve appropriate internal noise levels.

Examples include using masonry external facades on the most exposed facades and reducing the number of windows to minimise noise intrusion into sensitive areas.

Where residential buildings are required to be located near to the existing rail line, it is likely that increased facade and/or glazing performance would be required due to relatively high external noise levels. Mechanical ventilation would also be required in certain locations so that residents are able to keep windows closed during noisy periods, whilst maintaining adequate air flow.

The indicative requirements for upgraded facades and mechanical ventilation due to existing rail noise are shown in **Figure 9**.

Figure 9 Indicative Locations for Upgraded Facades and Mechanical Ventilation – Existing Rail Noise



Noise ingress generally involves several pathways and is most common via the windows, doors, ventilation openings and roofs. The overall sound reduction of a building element is dependent upon the mass of the construction, the effective area and the extent of any gaps or openings. Glazing on facades exposed to transportation noise usually represents the weak acoustic link in the building construction.

For the proposed location of the northern most lots which face the rail corridor, the following typical noise reductions in **Table 5** are likely to be required, based on typical facade, window and room sizings.

It is noted that this information should be regarded as indicative and the extent of treatment will depend on the exact location of the lot, the individual dwelling facade sizes, the window area, room volume and orientation to the rail corridor. As such, these recommendations should be reviewed as the project progresses.

The necessary Weighted Noise Reduction (R_W) sound transmission loss performance of the various building facade elements are presented in **Table 6**. Deemed-to-comply construction details, as taken from the DP&I Guideline, are presented in **Figure 10**

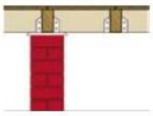
Table 5 Summary of Likely Facade Noise Reduction

Section	Noise Level, $L_{Aeq(9hour)}$ (dBA)		Required Facade Noise Reduction (dB)	Indicative Treatment Category
	Predicted	Applicable Criteria		
Northern most lots	59 57	40 – Non Sleeping Area 35 – Sleeping Area	19 22	2

Table 6 R_w of Building Elements

Category of Noise Control Treatment	R_w of Building Elements (minimum assumed)				
	Windows/Sliding Doors	Frontage Facade	Roof	Entry Door	Floor
Category 1	24	38	40	28	29
Category 2	27	45	43	30	29
Category 3	32	52	48	33	50
Category 4	35	55	52	33	50
Category 5	43	55	55	40	50

Figure 10 Deemed-to-Comply Construction Details – Category 2

Category No.	Building Element	Standard Constructions	sample
2	Windows/Sliding Doors	Openable with minimum 6mm monolithic glass and full perimeter acoustic seals	
	Frontage Facade	**Timber Frame or Cladding Construction:** 6mm fibre cement sheeting or weatherboards or plank cladding externally, 90mm deep timber stud or 92mm metal stud, 13mm standard plasterboard internally with R2 insulation in wall cavity.	
		Brick Veneer Construction: 110mm brick, 90mm timber stud frame or 92mm metal stud, minimum 50mm clearance between masonry and stud frame, 10mm standard plasterboard internally.	
		Double Brick Cavity Construction: 2 leaves of 110mm brickwork separated by 50mm gap	
	Roof	Pitched concrete or terracotta tile or metal sheet roof with sarking, 10mm plasterboard ceiling fixed to ceiling joists, R2 insulation batts in roof cavity.	
	Entry Door	40mm solid core timber door fitted with full perimeter acoustic seals	
	Floor	1 layer of 19mm structural floor boards, timber joist on piers	
		Concrete slab floor on ground	

4.4 Industrial Noise

Noise from industrial development in the Precinct would be required to be assessed against the noise goals in **Table 4**, noting that the criteria relate to total noise from the cumulative impact of all industrial sources in the area.

At this stage of the development the industrial uses are yet to be finalised. The southern boundary is currently designated as light industrial and impacts from industrial noise may be apparent at receivers situated nearby, depending of the final use.

Although not an industrial noise source, the noise emissions from domestic air-conditioners that may be installed on properties as part of the future residential development within the Precinct would also be required to be assessed.

It is recommended that once the various land uses are finalised, a detailed acoustic assessment of noise impacts to all sensitive land uses within the Precinct and existing sensitive land uses surrounding the Precinct should be undertaken. Where exceedances are predicted, the following strategies could be used by planners and projects proponents:

- Maximise the separation distance between noisy activities and sensitive areas
- Take advantage of any natural topographical features that can be used to screen noise impacts when planning land use in an area
- Optimise the subdivision layout to maximise the area shielded from noise
- Using intervening structures such as less noise sensitive multi-storey buildings to act as barriers. Buildings used as barriers should incorporate noise mitigation principles into their design to ensure appropriate internal noise conditions.

5 Conclusion

This report provides an assessment of the potential noise impacts at the proposed subdivision of 16 Chapman Street, Werrington, on the basis on noise monitoring completed at the site.

The impact of existing road and rail noise on the subdivision varies across the site with the most affected locations being situated adjacent T1 Western Line.

Mitigation strategies have been recommended which include acoustically optimising the site layout, using intervening multistorey buildings to provide shielding to the rest of site and designing building layouts to place less noise sensitive usages near to source of noise.

Where residual impacts exist, noise mitigation through building design may be required for a number of buildings which are close to sources of rail noise. This could be achieved through the use of upgraded facade elements, such as windows and doors. The requirement for noise mitigation for each building would be identified during the later design stages.

Rooms on exposed facades would likely also need mechanical ventilation to enable windows to be kept closed as a noise mitigation measure.

The preferred mitigation strategy for the proposal would be determined at a later stage in the project.

Based on the assessment of the potential impacts and the requirement for mitigation, the proposed development is considered feasible and supported from a noise standpoint.

APPENDIX A

Acoustic Terminology

1. Sound Level or Noise Level

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

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

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

2. 'A' Weighted Sound Pressure Level

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

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

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

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

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

3. Sound Power Level

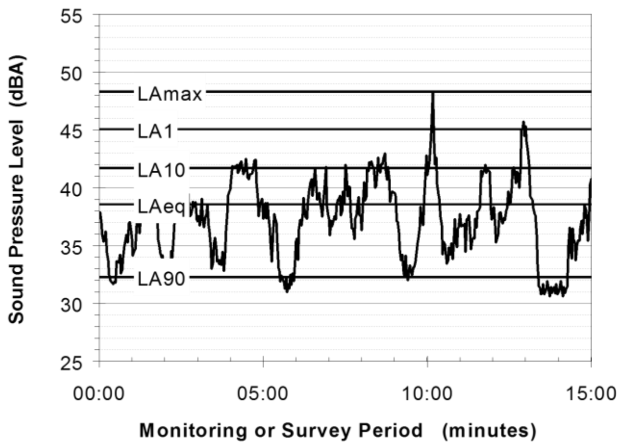
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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

4. Statistical Noise Levels

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

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



Of particular relevance, are:

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

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

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

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

5. Frequency Analysis

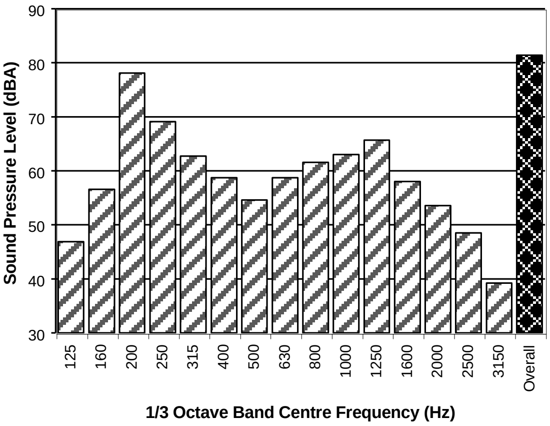
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

Frequency analysis can be in:

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

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



6. Annoying Noise (Special Audible Characteristics)

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

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

7. Vibration

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

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

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

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

8. Human Perception of Vibration

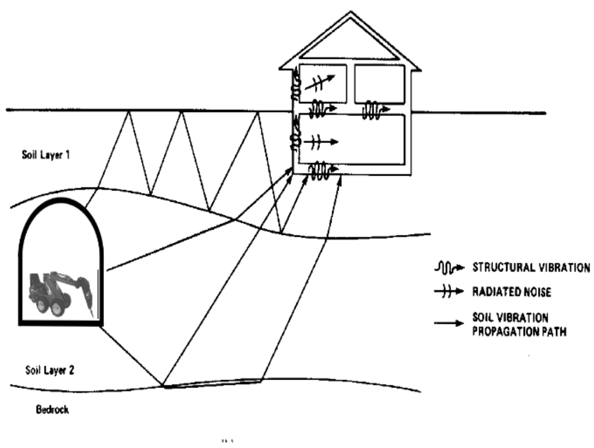
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience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

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

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

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

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



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

APPENDIX B

Noise Logging Graphs

Noise Monitoring Location	L.01
Noise Monitoring Address	**16 Chapman Street, Werrington**

Logger Device Type: Svantek 957, Logger Serial No: 20677

Ambient noise logger deployed within existing public open land, extended to approximately 2.5 – 3 m above ground level.
Logger located with view of the T1 rail line to the north. The purpose of this logger was to establish existing rail noise and calibration of rail noise model.

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	39	55	50	67
Evening	43	56	51	68
Night-time	36	54	46	65

Ambient Noise Logging Results – RNP Defined Time Periods

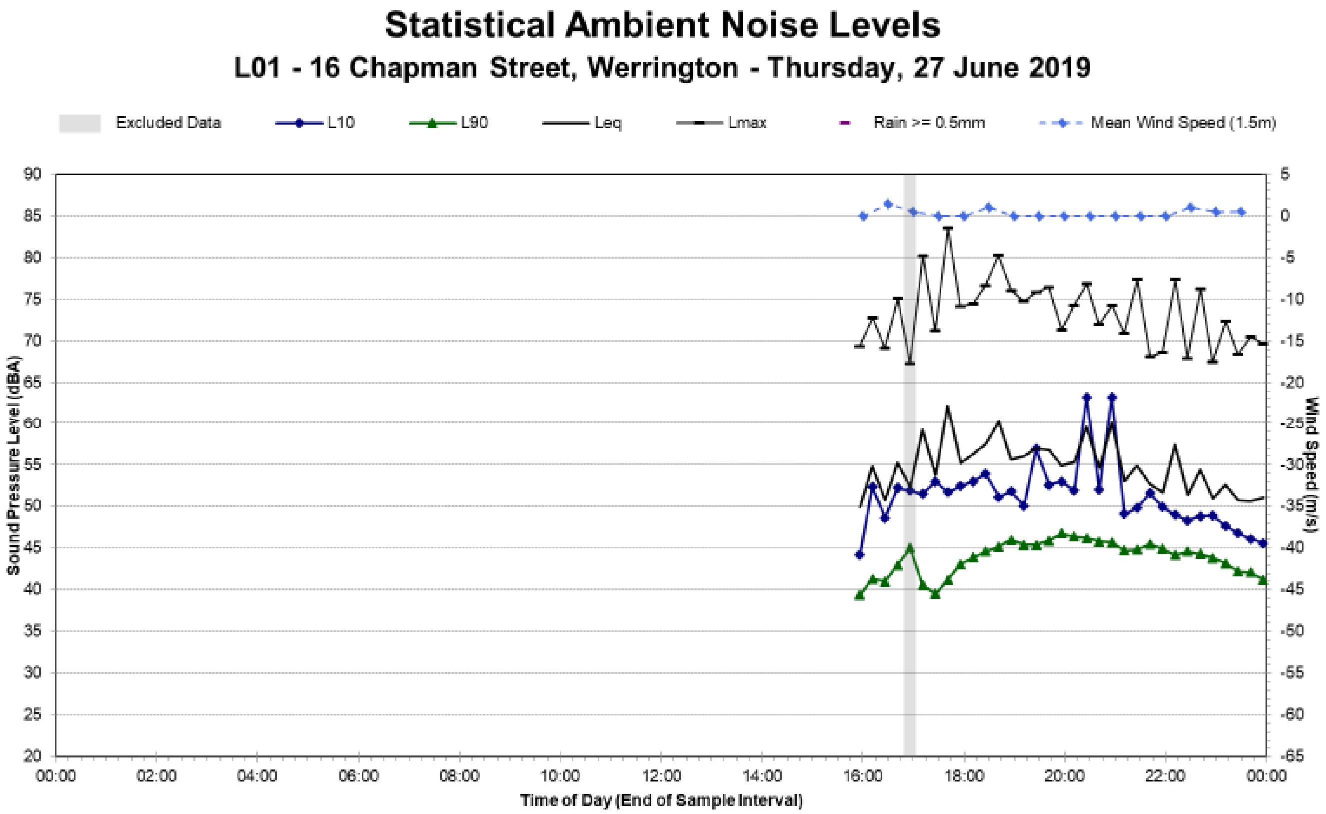
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	56	58
Night-time (10pm-7am)	54	58

Attended Noise Measurement Results

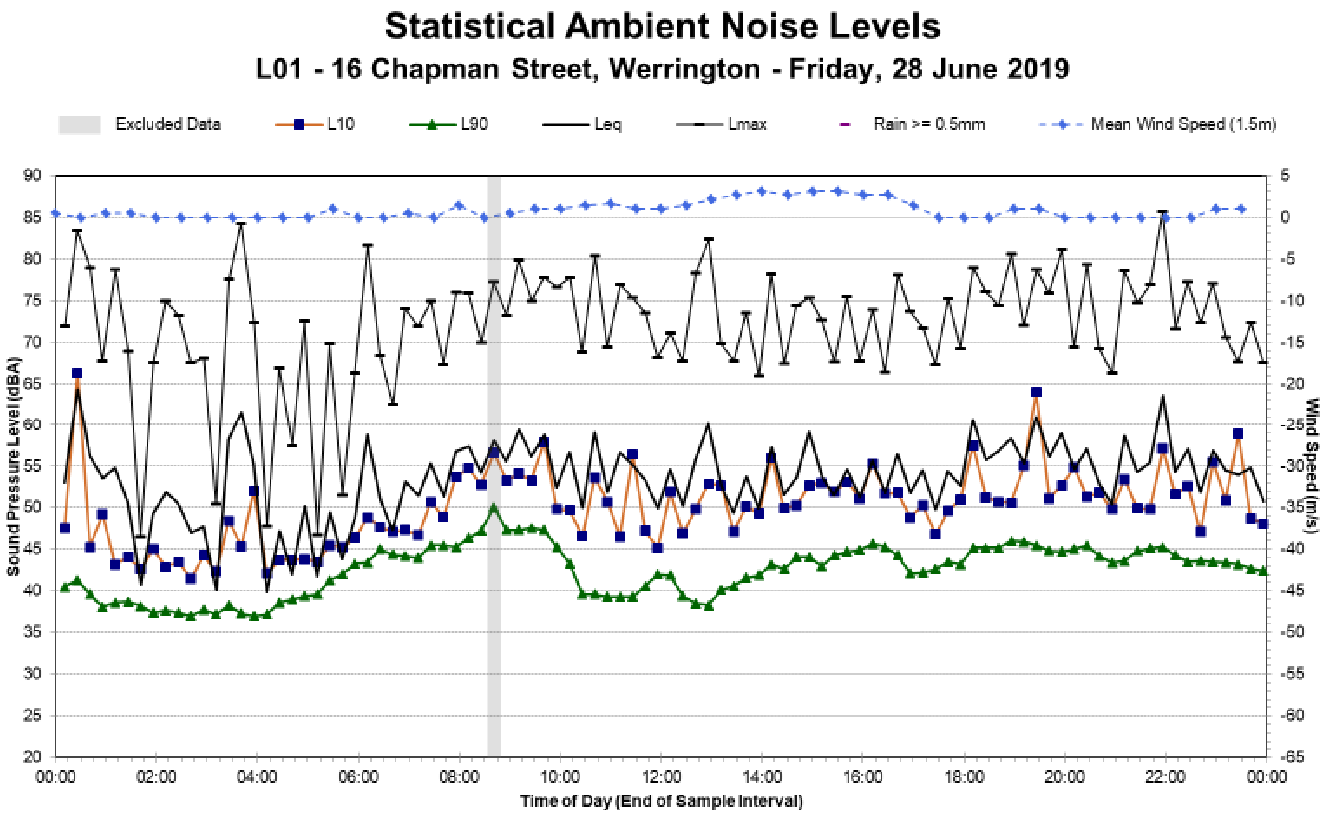
Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax

Photo of Noise Monitoring Location

Note1: 8 July excluded from data



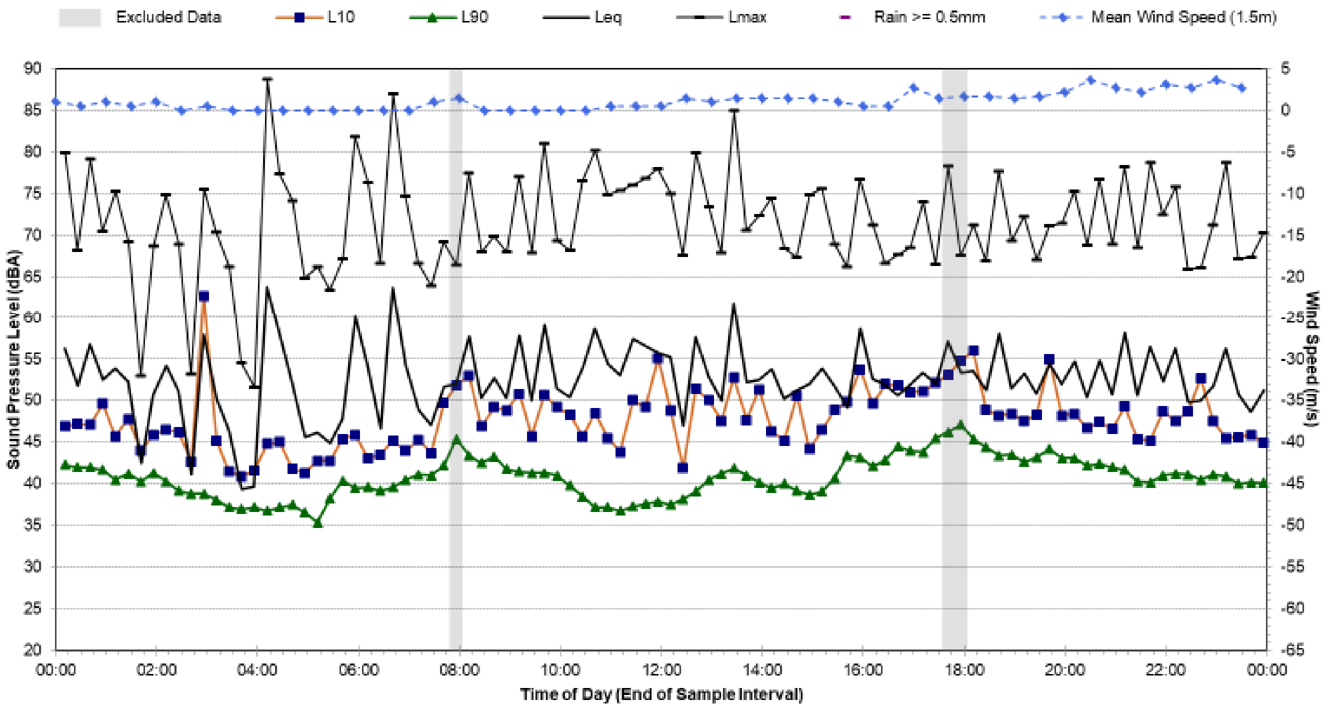
Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Thursday, 27 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Friday, 28 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

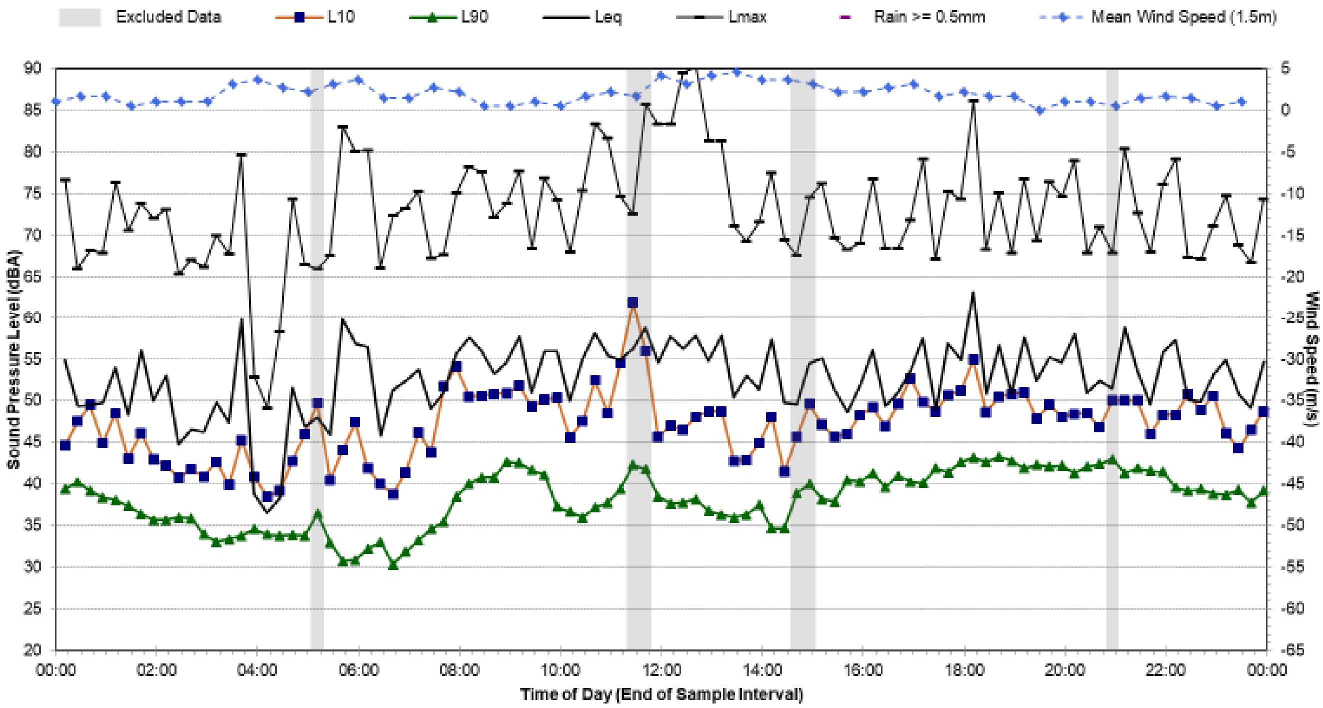
Statistical Ambient Noise Levels

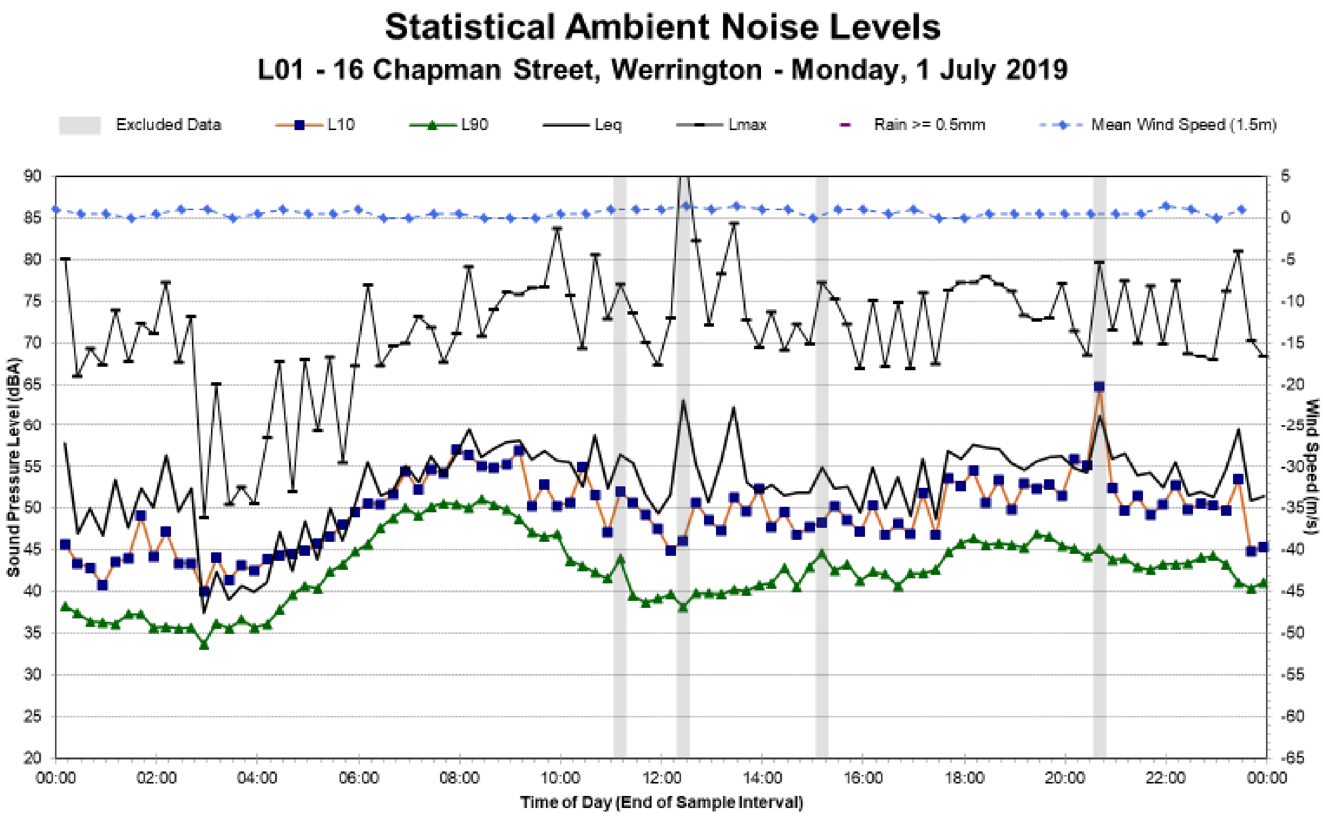
L01 - 16 Chapman Street, Werrington - Saturday, 29 June 2019

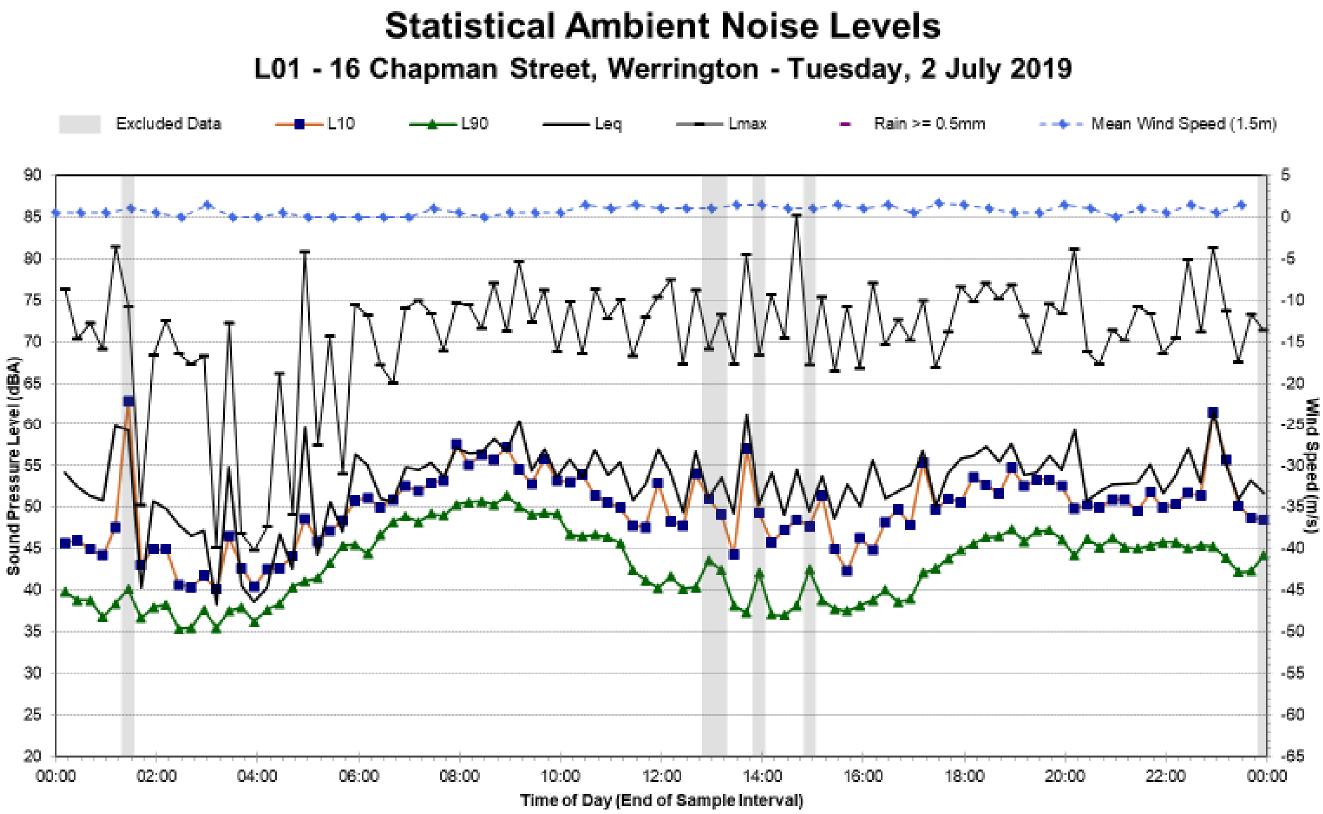


Statistical Ambient Noise Levels

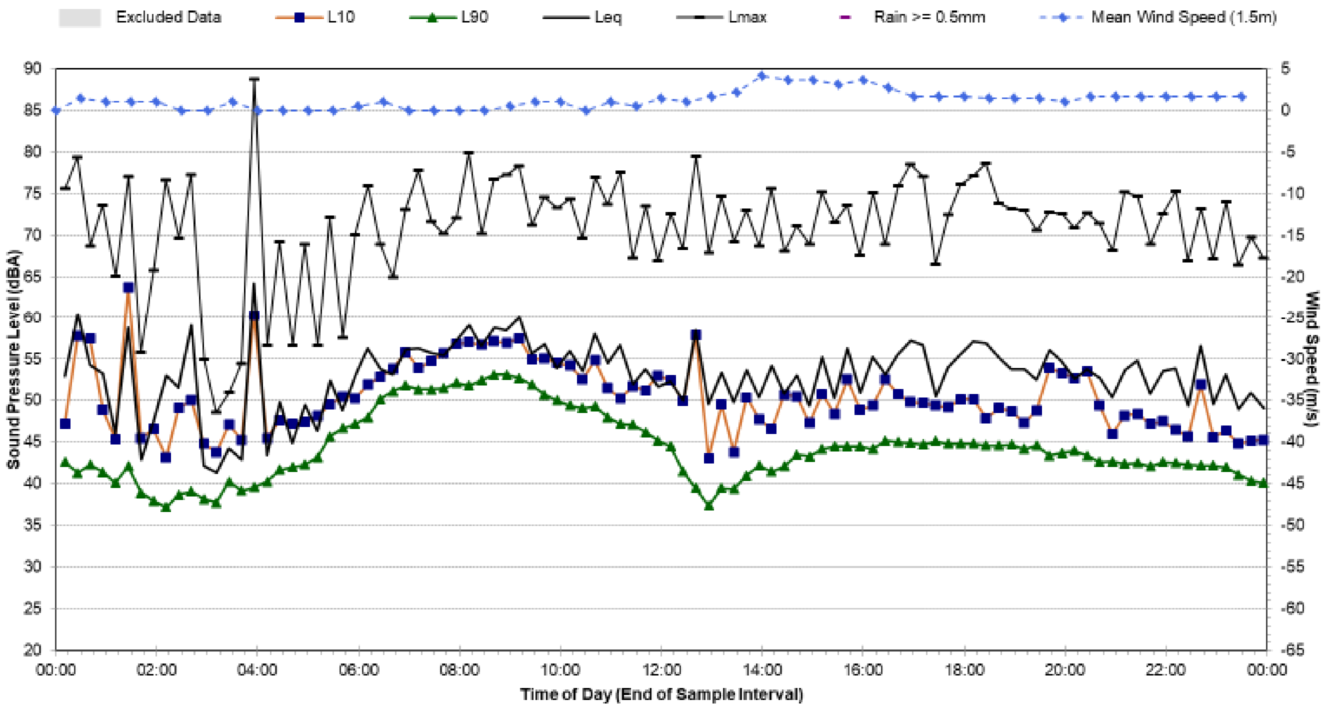
L01 - 16 Chapman Street, Werrington - Sunday, 30 June 2019



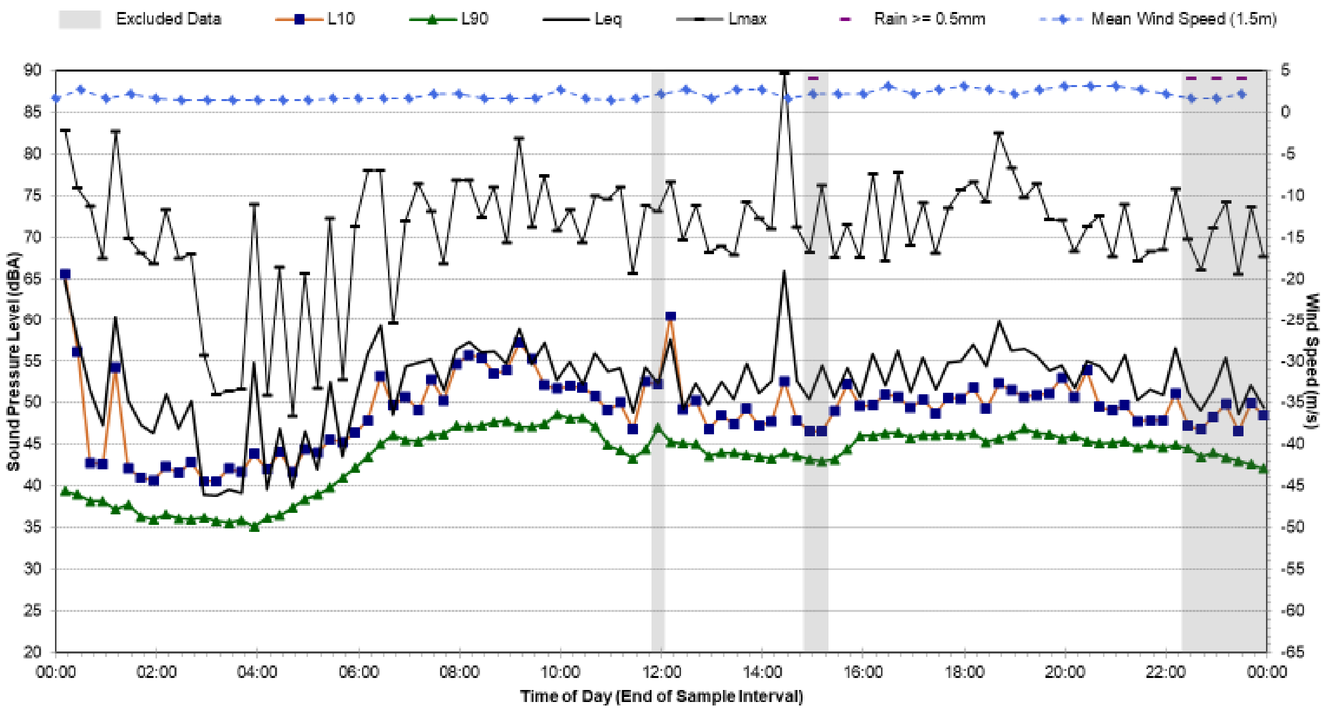

Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Monday, 1 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

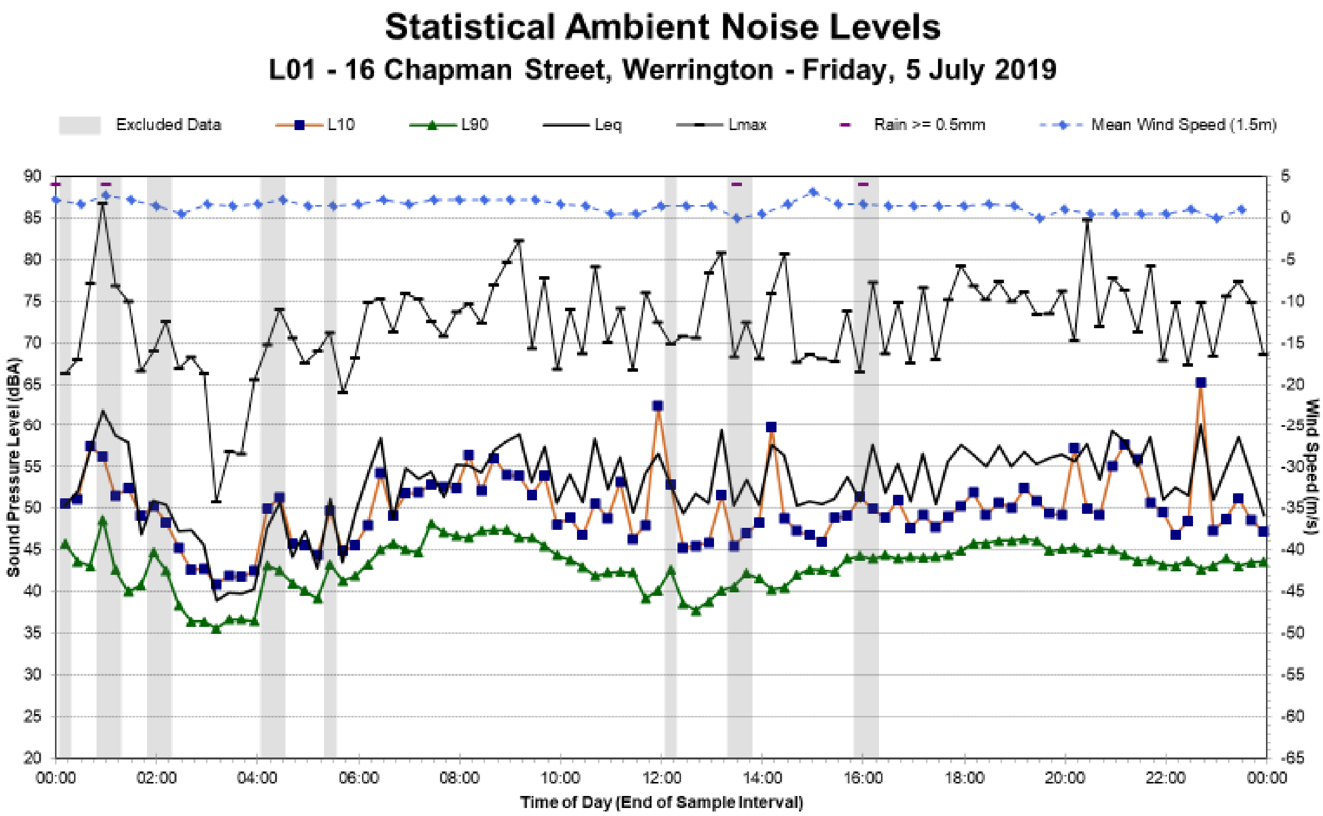

Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Tuesday, 2 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Wednesday, 3 July 2019

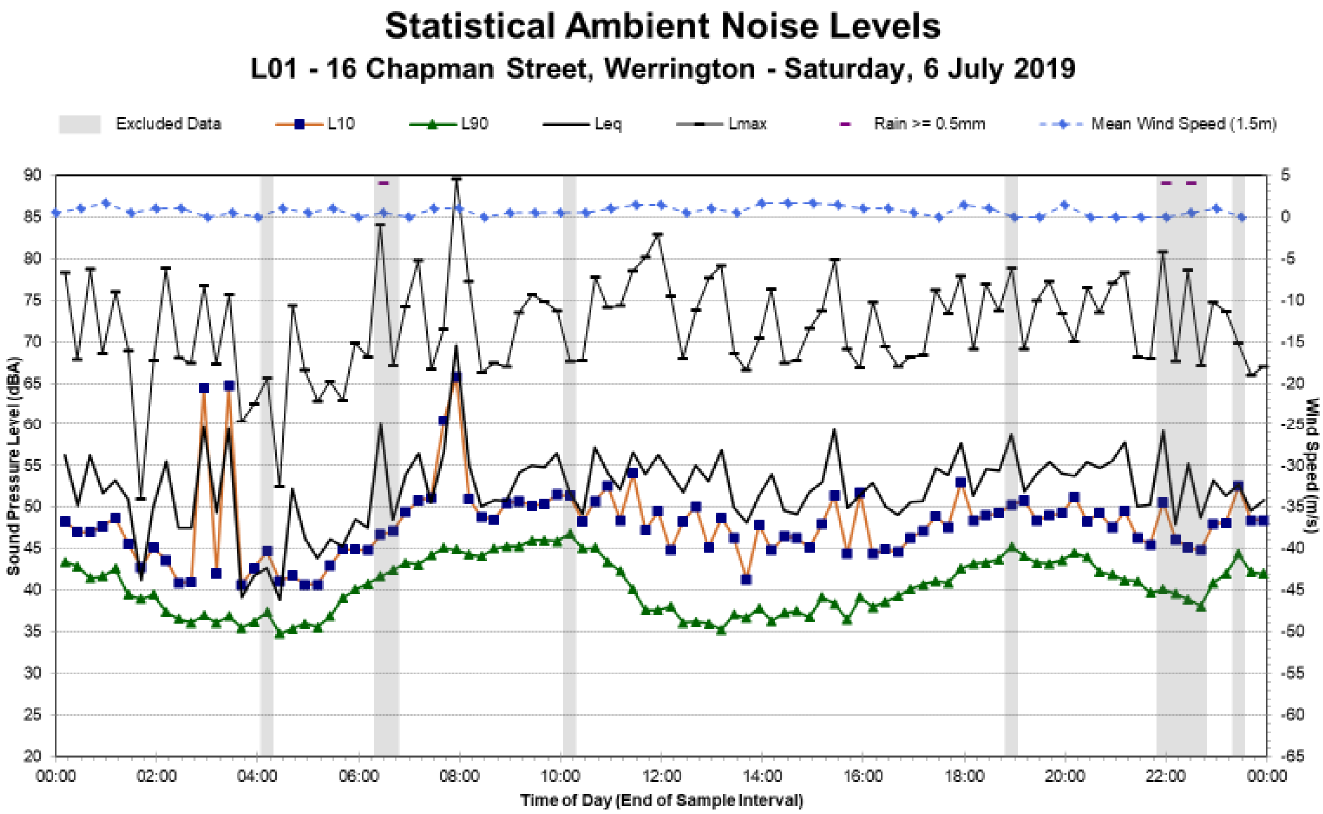


Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Thursday, 4 July 2019





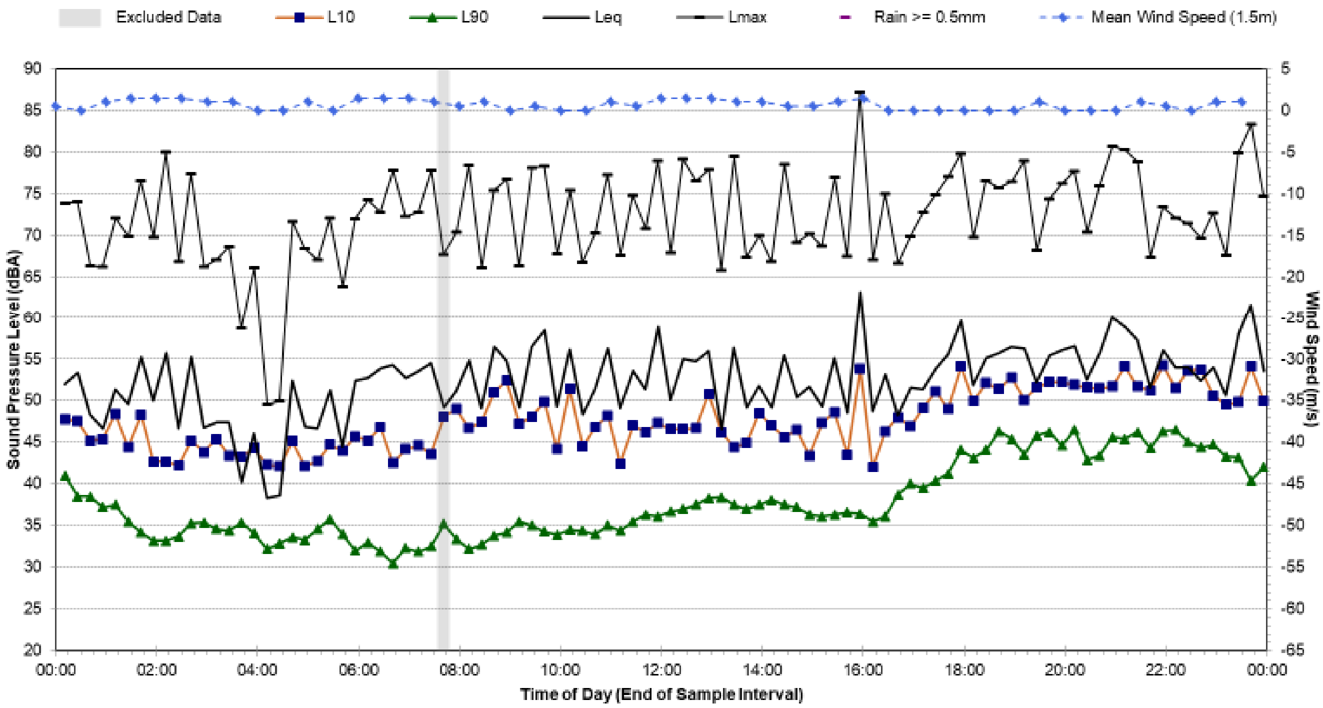
Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Friday, 5 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



Statistical Ambient Noise Levels
L01 - 16 Chapman Street, Werrington - Saturday, 6 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

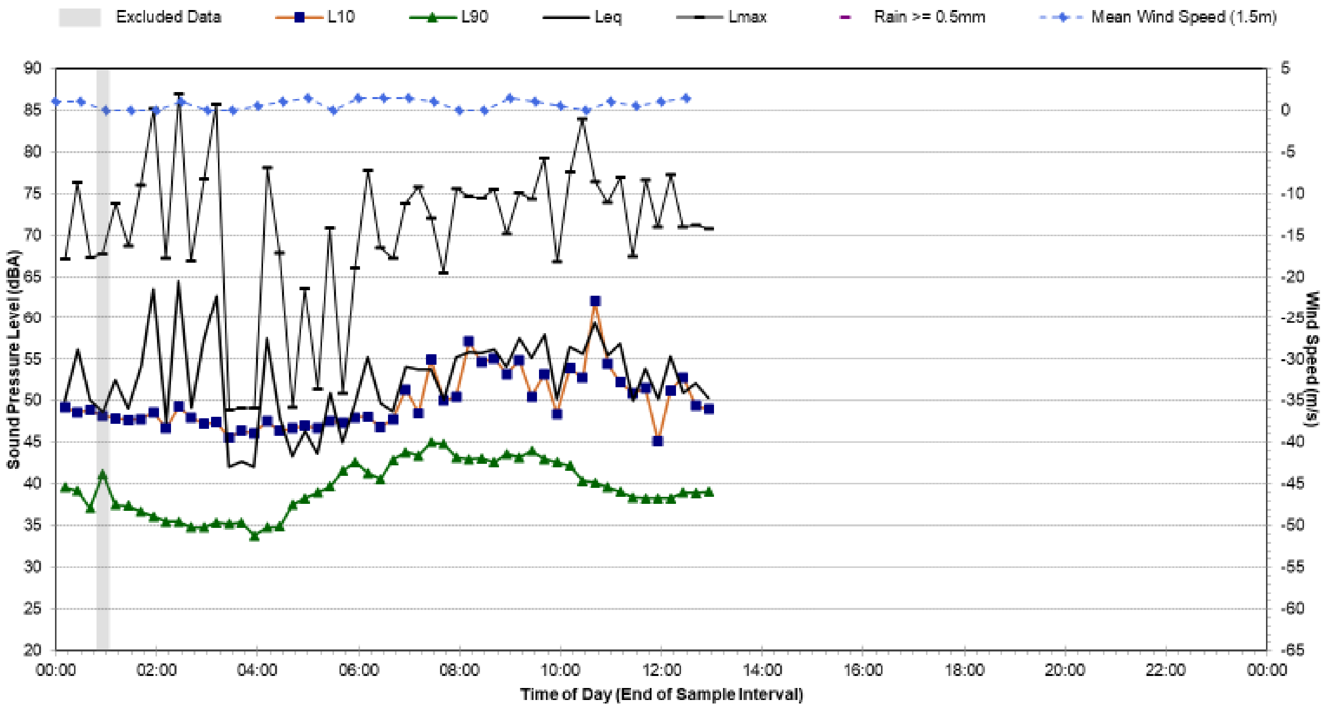
Statistical Ambient Noise Levels

L01 - 16 Chapman Street, Werrington - Sunday, 7 July 2019



Statistical Ambient Noise Levels

L01 - 16 Chapman Street, Werrington - Monday, 8 July 2019



Noise Monitoring Location	L.02
Noise Monitoring Address	15/4-12 Chapman Street, Werrington

Logger Device Type: Svantek 957, Logger Serial No: 20674
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3008204

Ambient noise logger deployed at residential address 15/4-12 Chapman Street, Werrington. Logger located within cluster of units adjacent to precinct proposed location.

Attended noise measurements indicate the ambient noise environment at this location is dominated by overhead aircraft, natural fauna and birdsong, trains along the T1 line and some local traffic along Chapman Street.

Recorded Noise Levels (LAmax):
8/07/2019: Birdsong 43 – 50, Rail 45 – 48, Aircraft 40 – 53, Trucks 50.

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	37	57	51	60
Evening	44	48	49	54
Night-time	37	46	45	50

Ambient Noise Logging Results – RNP Defined Time Periods

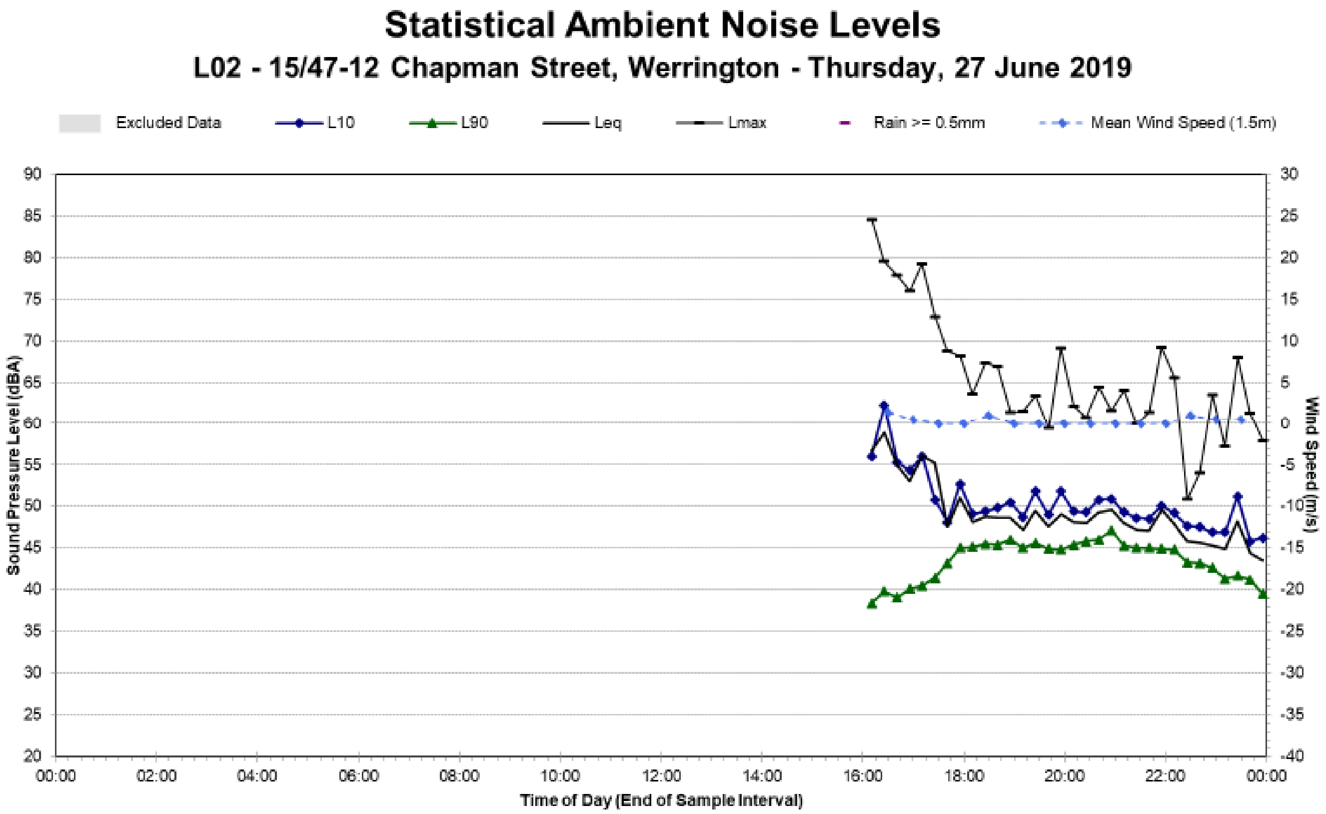
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	55	50
Night-time (10pm-7am)	46	60

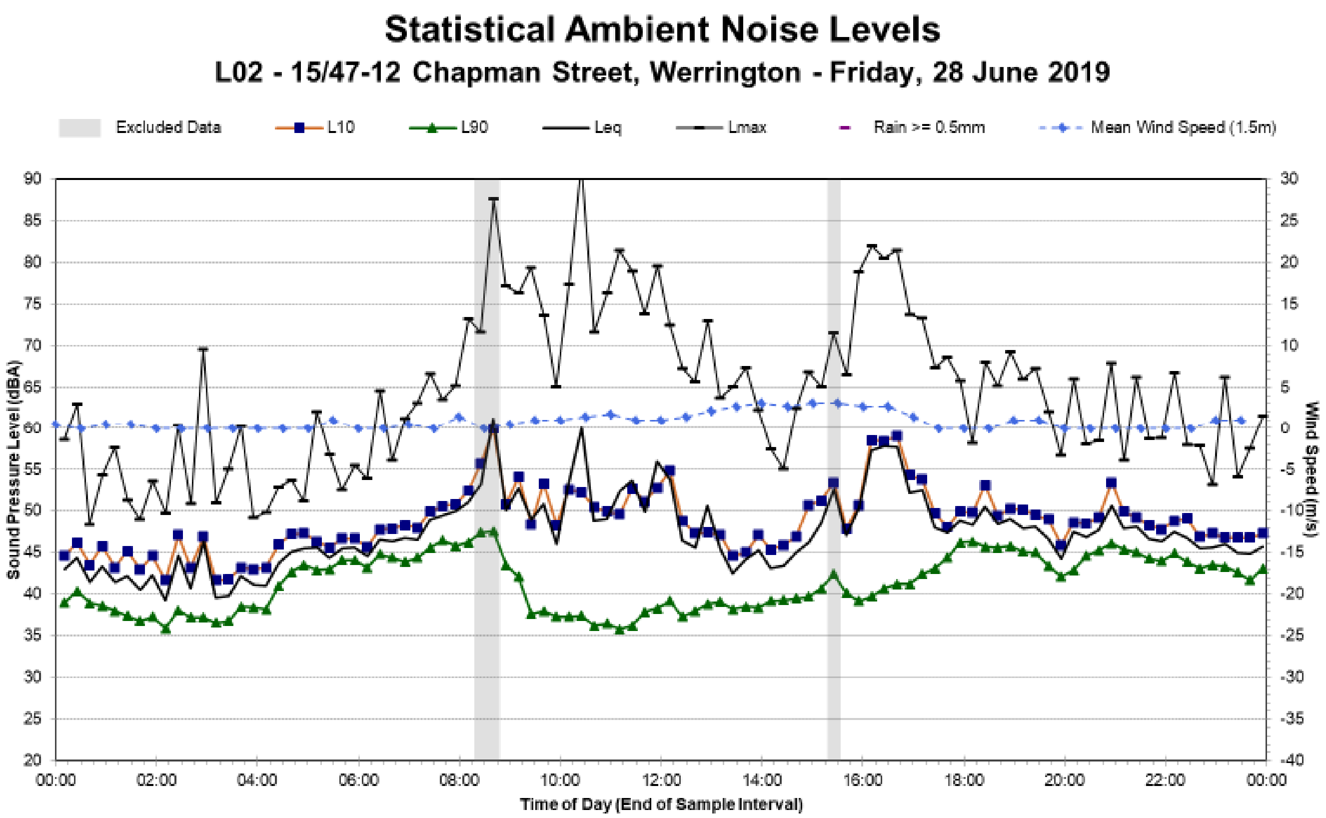
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
8/07/2019	11:40	35	45	73

Note 1: 8 July excluded from data

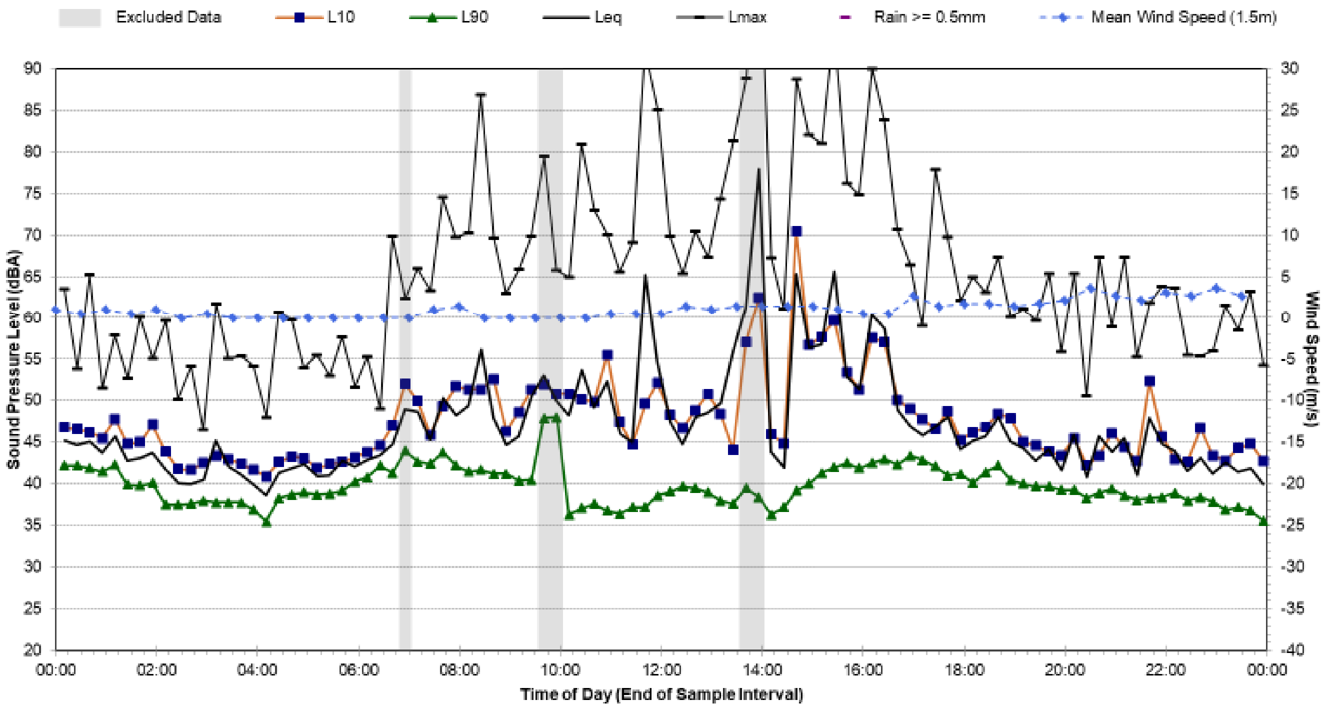
Photo of Noise Monitoring Location


Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Thursday, 27 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Friday, 28 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

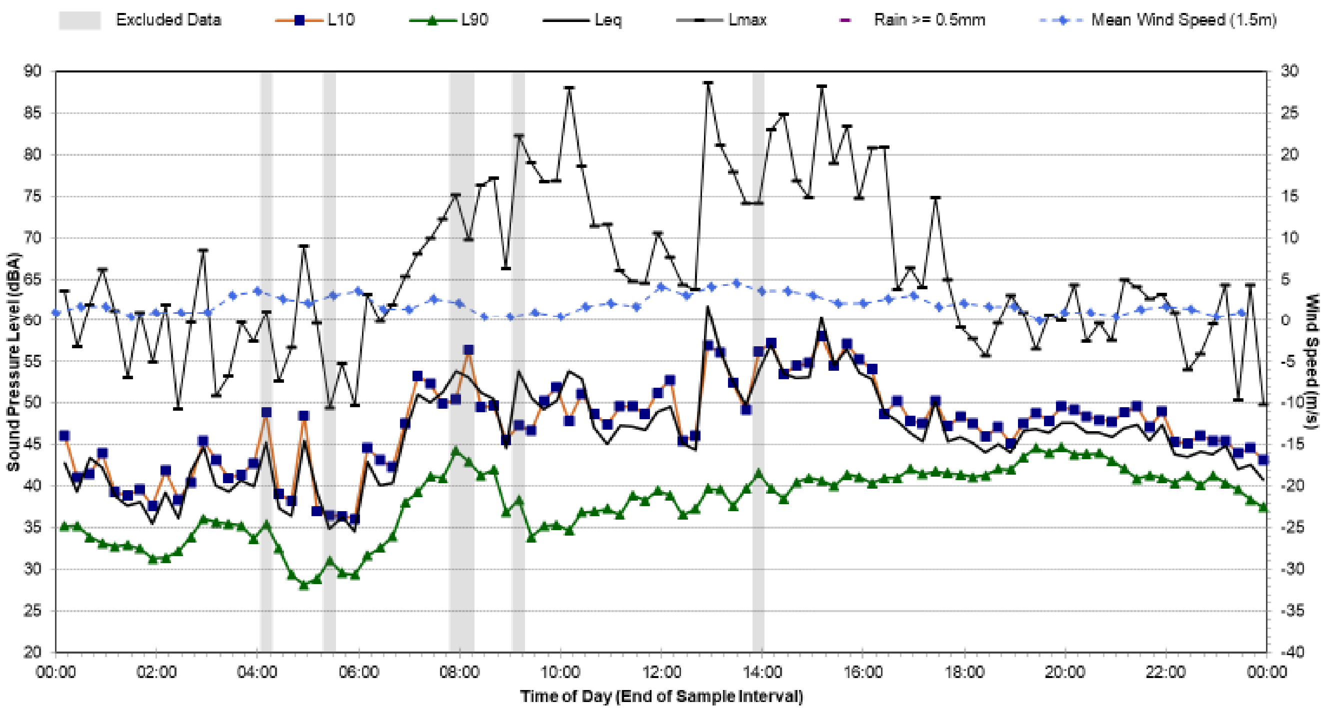
Statistical Ambient Noise Levels

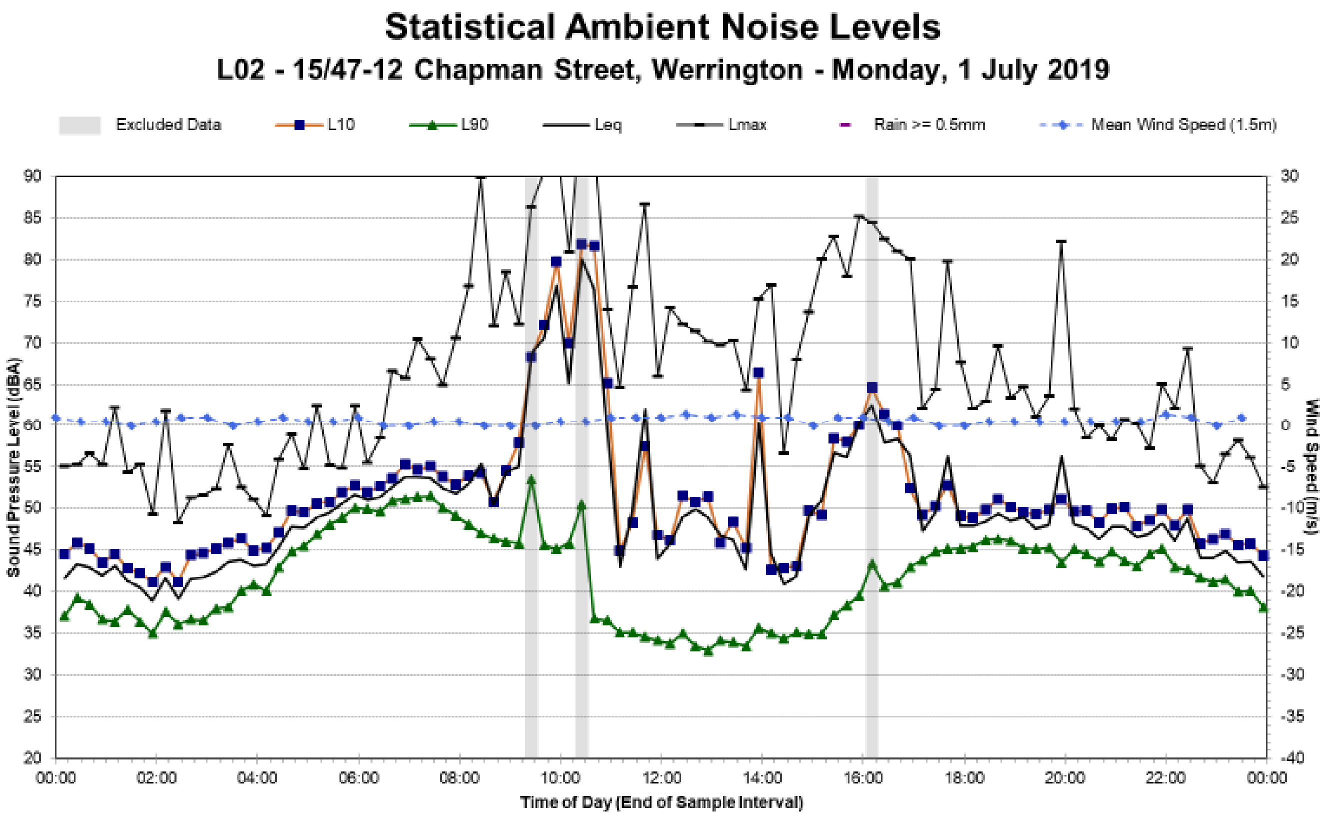
L02 - 15/47-12 Chapman Street, Werrington - Saturday, 29 June 2019

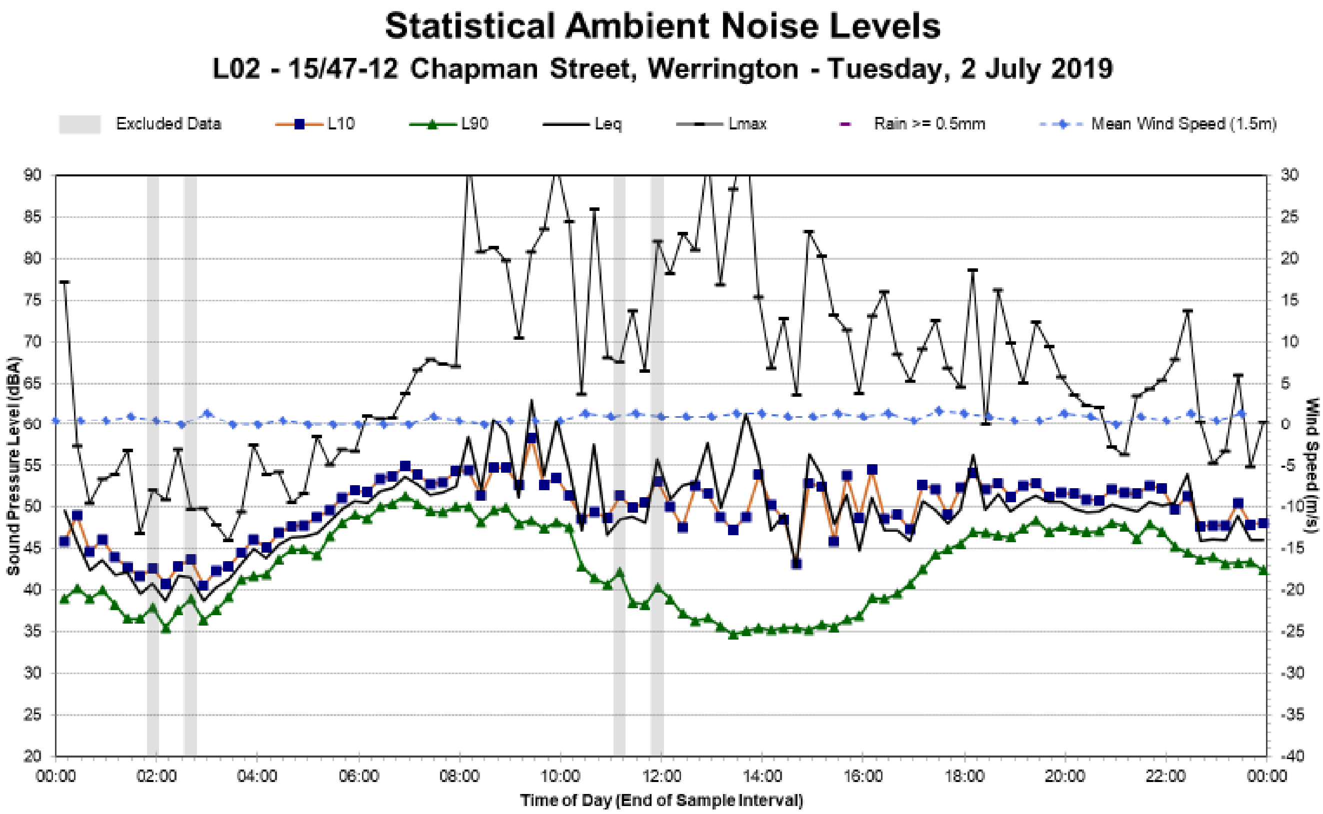


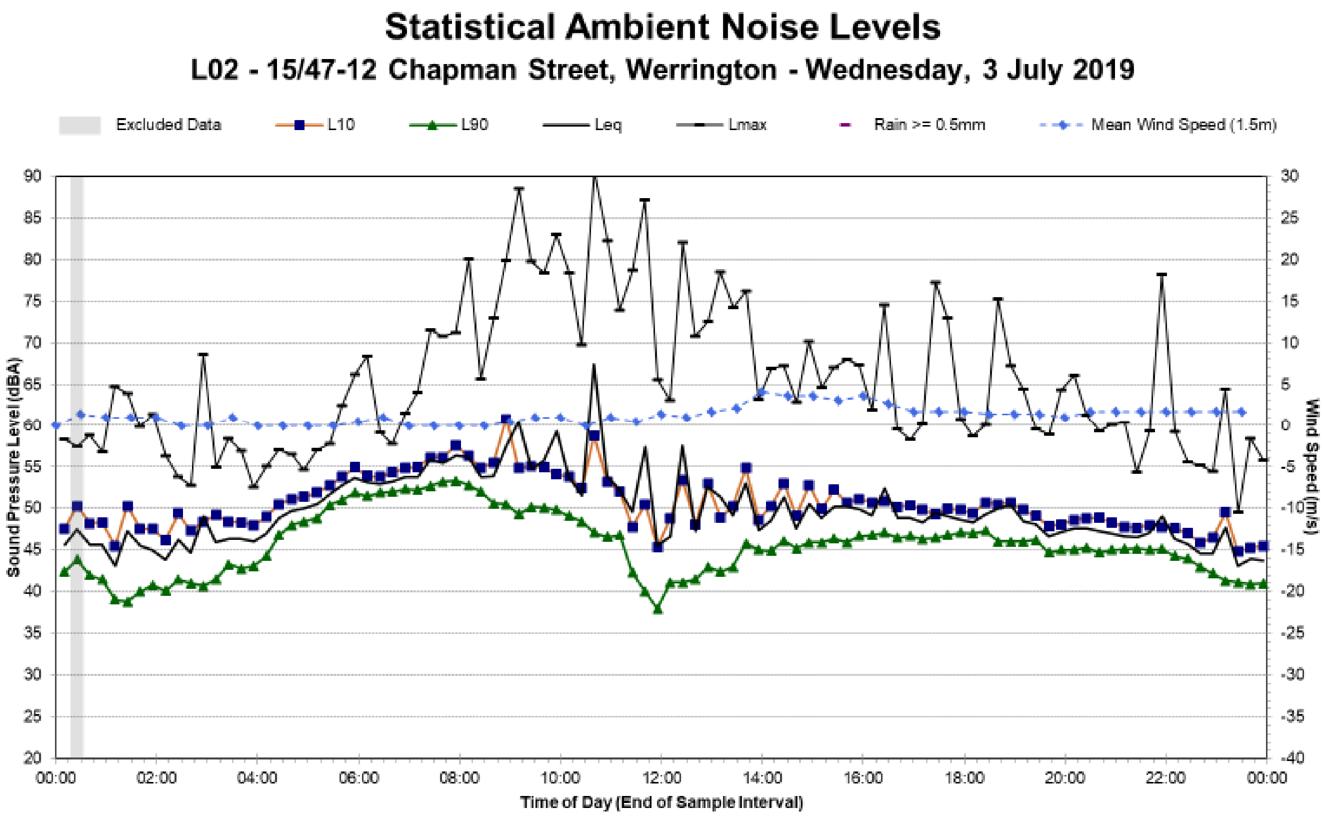
Statistical Ambient Noise Levels

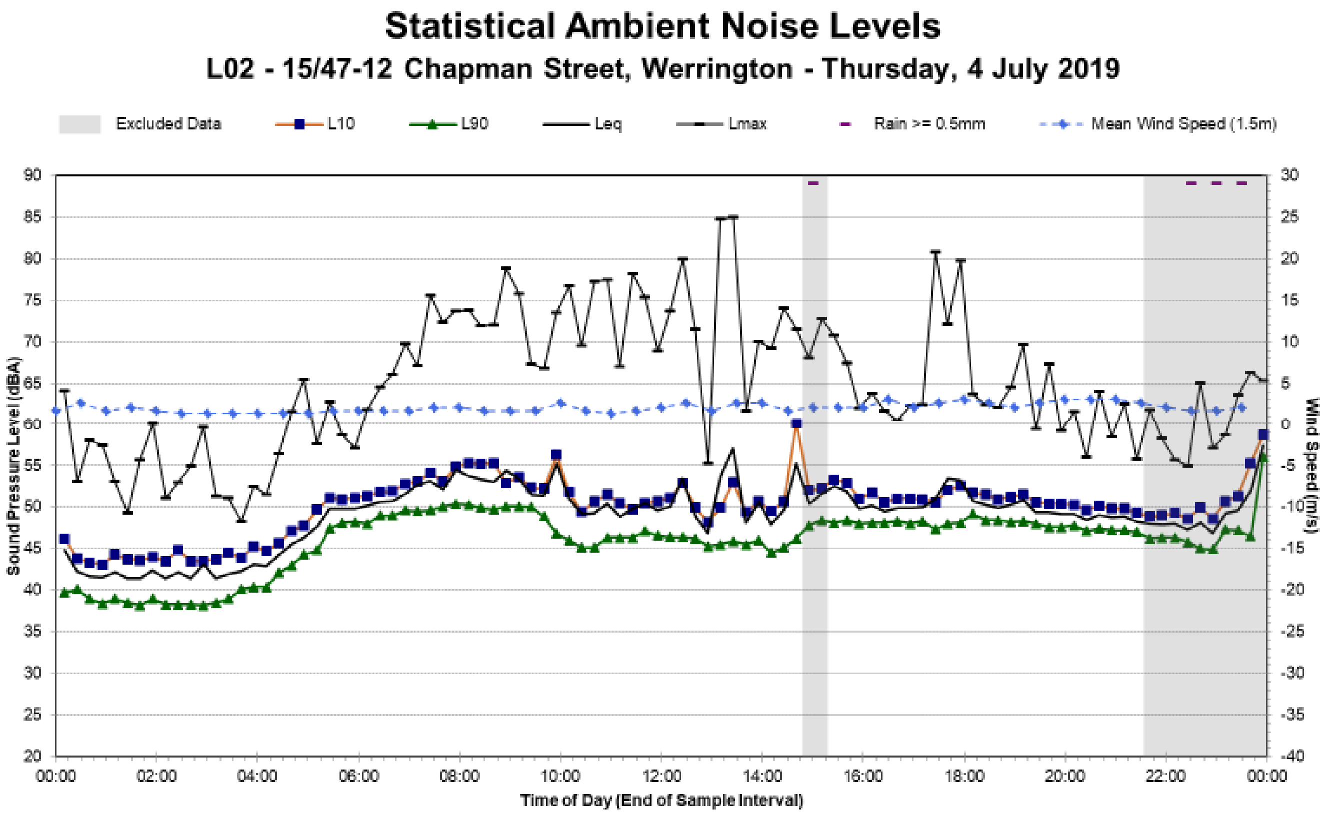
L02 - 15/47-12 Chapman Street, Werrington - Sunday, 30 June 2019

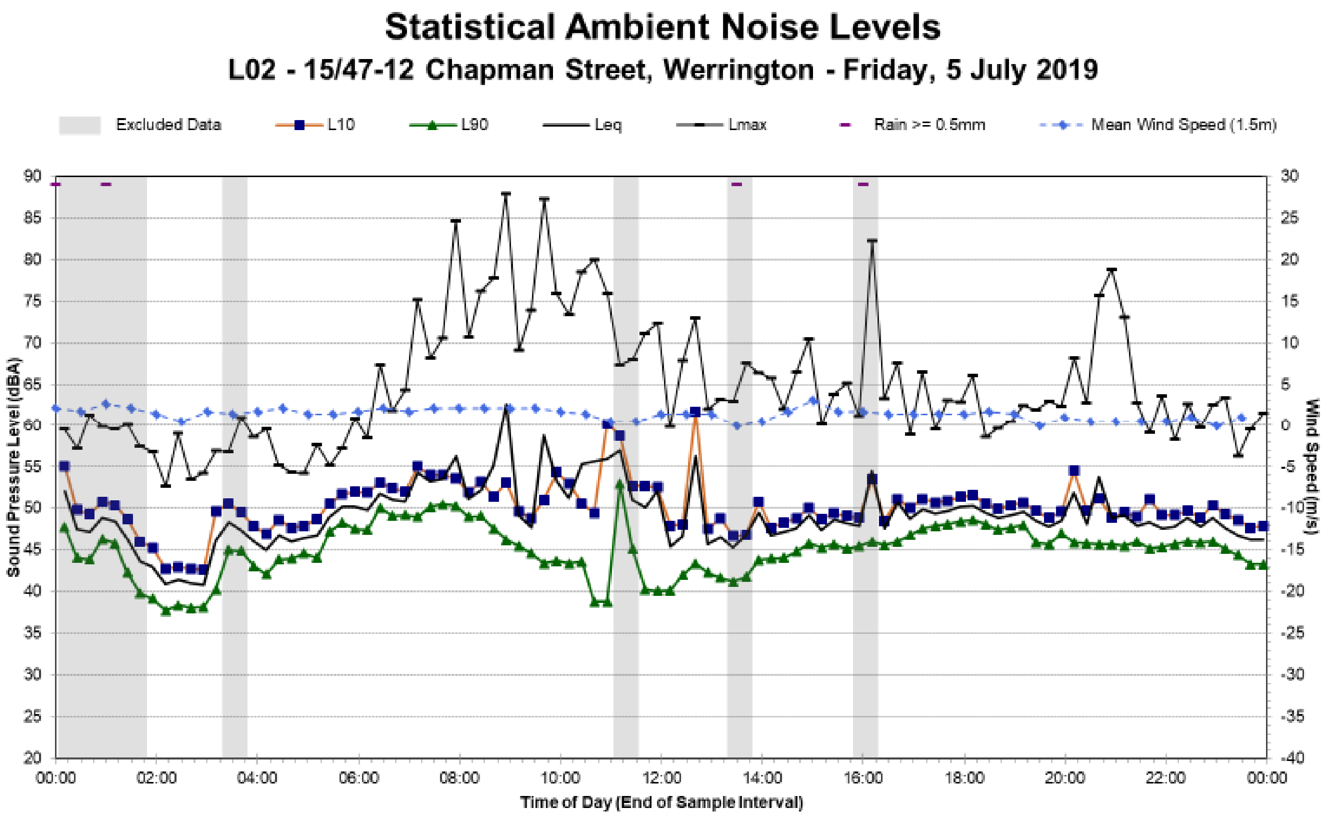



Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Monday, 1 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

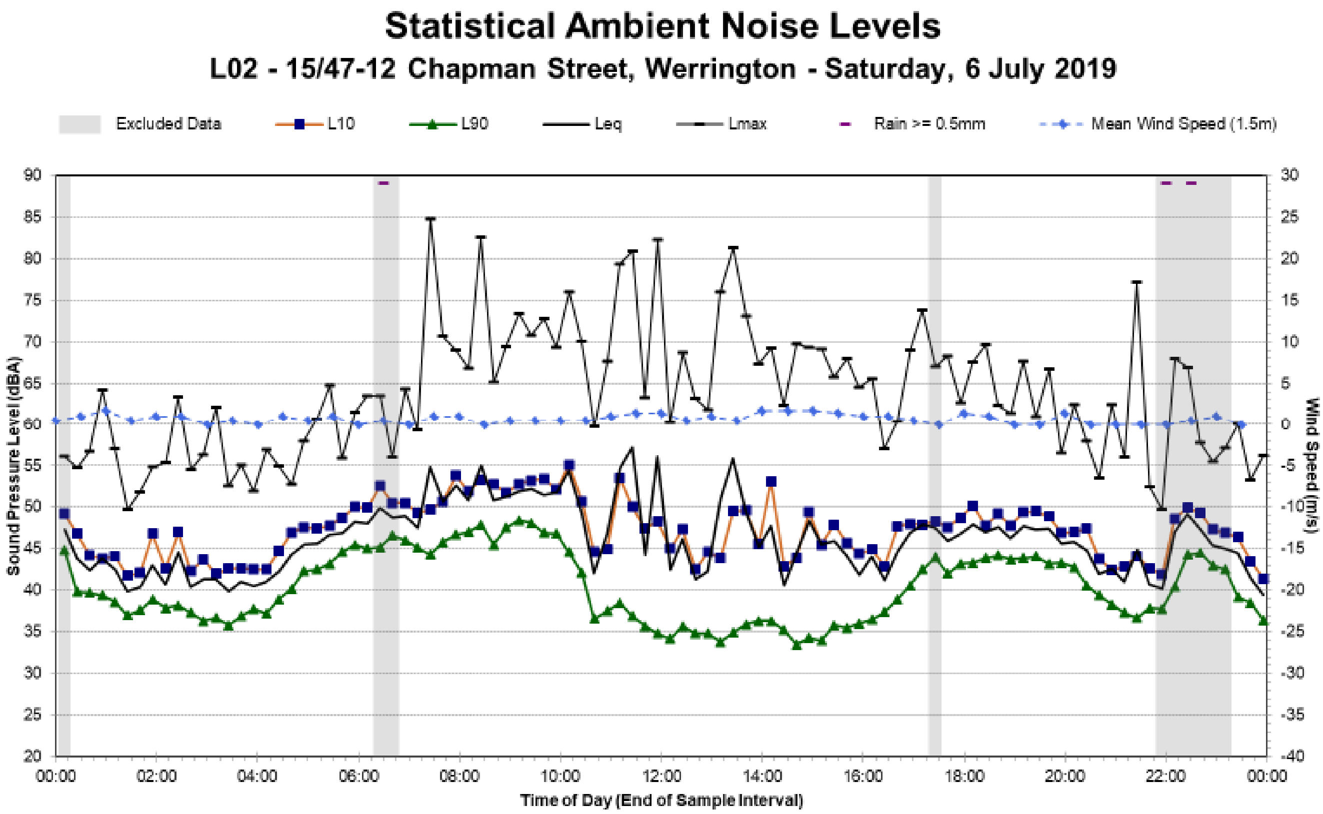

Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Tuesday, 2 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Wednesday, 3 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

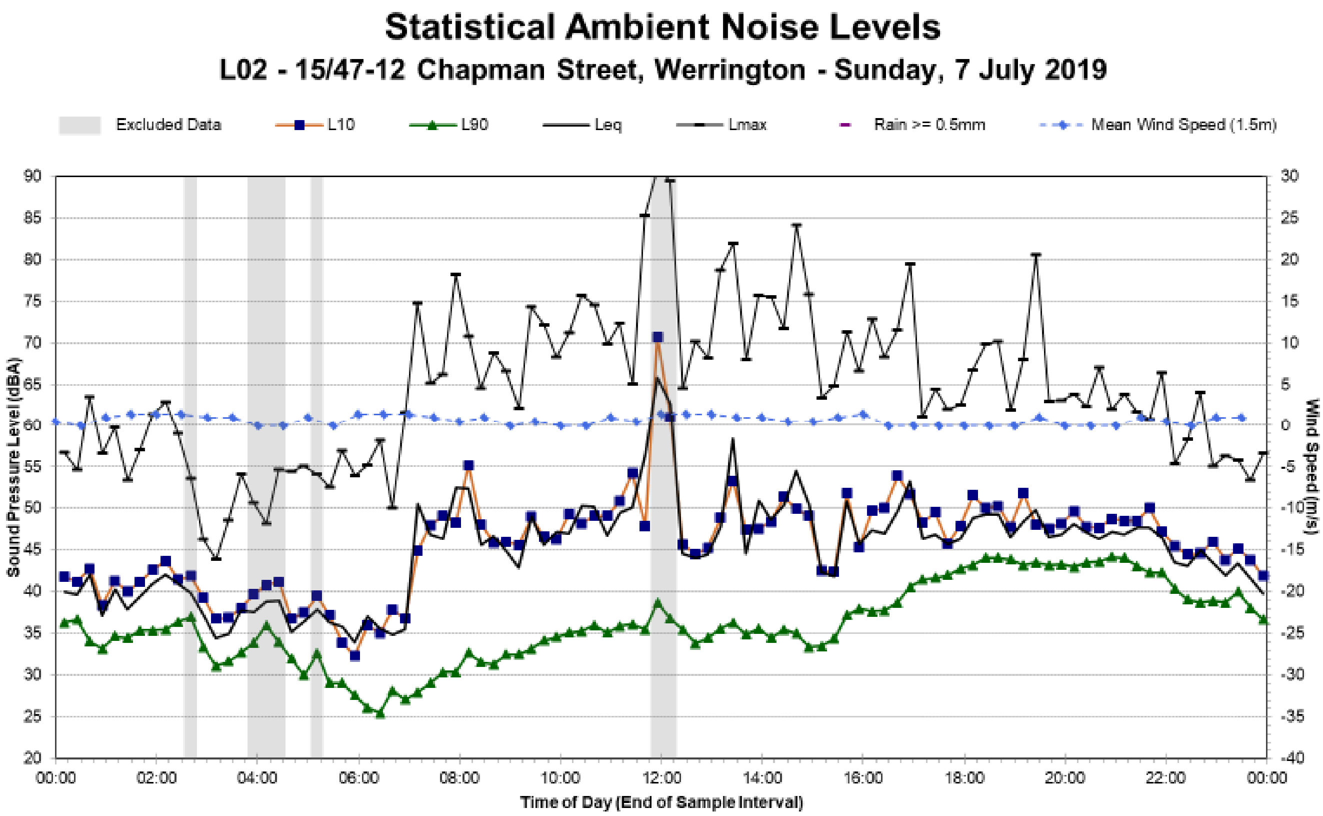

Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Thursday, 4 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

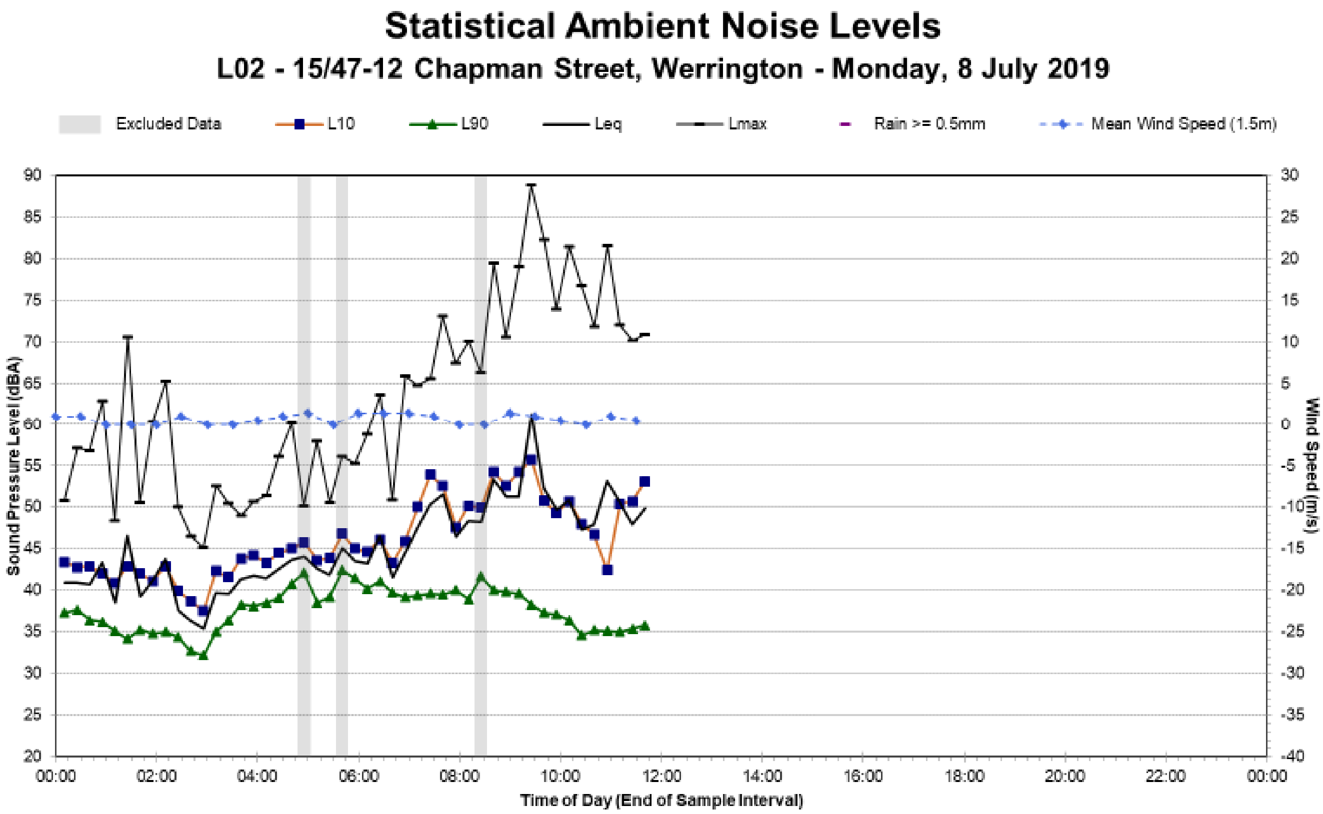


Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Friday, 5 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Saturday, 6 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Sunday, 7 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 15/47-12 Chapman Street, Werrington - Monday, 8 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

Noise Monitoring Location	L.03
Noise Monitoring Address	**16 Chapman Street, Werrington**

Logger Device Type: Brüel and Kjær 2250L, Logger Serial No: 3004636
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3008204

Ambient noise logger deployed at residential address 50 m north of the Wollemi College within the 16 Chapman Street Precinct proposed location.
Attended noise measurements indicate the ambient noise environment at this location is dominated by natural fauna and bird song, distant trains along the T1 line, overhead aircraft, and distant traffic along the Great Western Highway.

Recorded Noise Levels (LAmax):
27/06/2019: Birdsong 45 – 50, Rail horn 50, Motorbike along GWH 50, Aircraft 46 – 58, PA from Juvenile Centre 46.

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	38	51	48	56
Evening	46	50	51	54
Night-time	39	48	48	52

Ambient Noise Logging Results – RNP Defined Time Periods

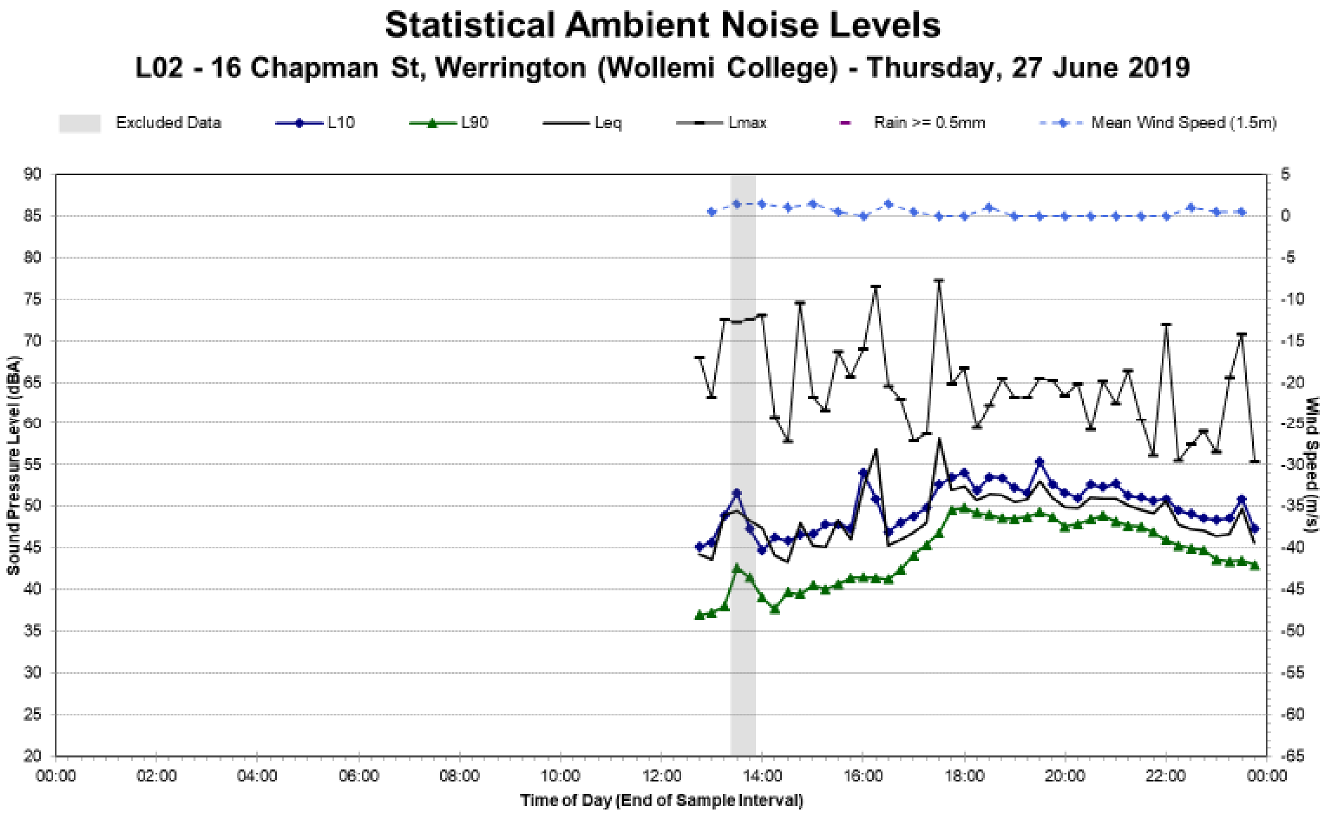
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	50	56
Night-time (10pm-7am)	48	54

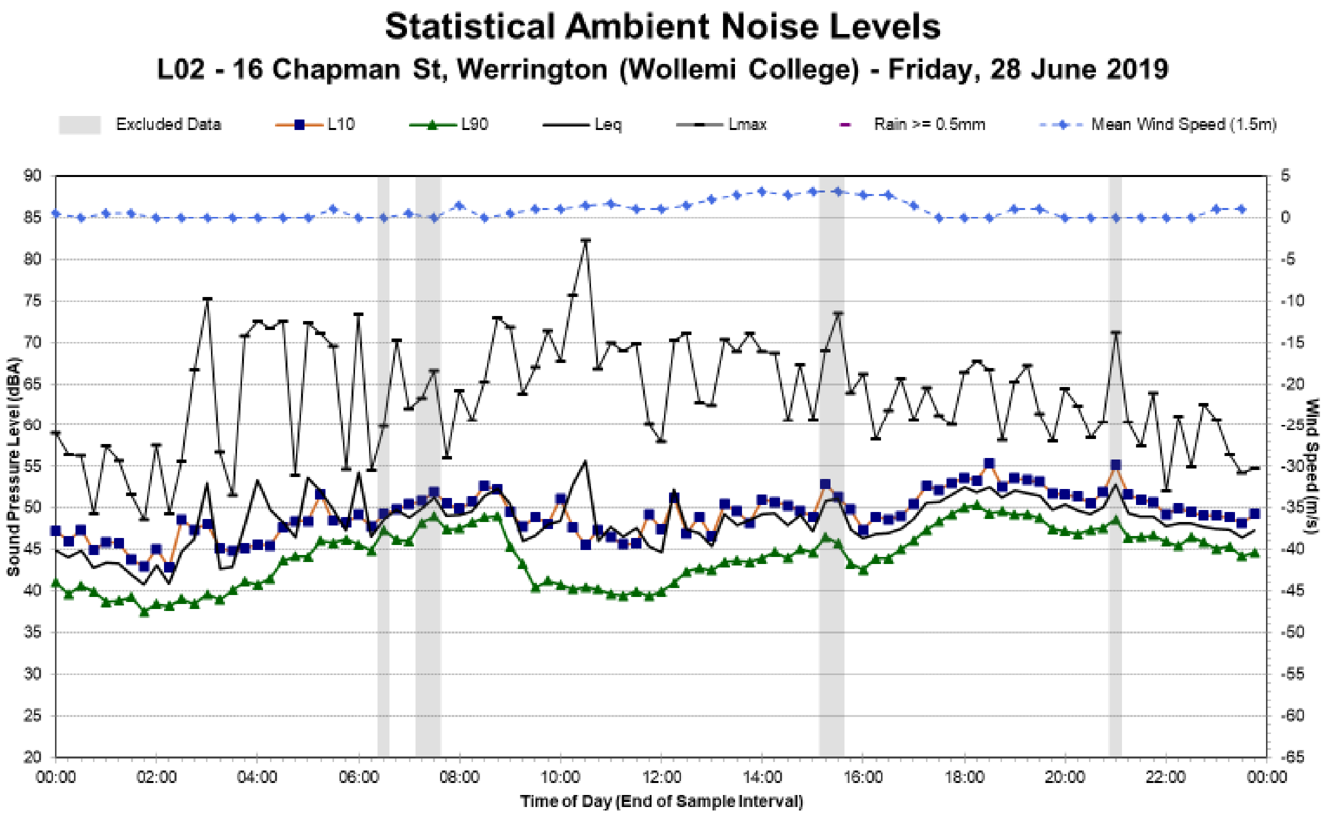
Attended Noise Measurement Results

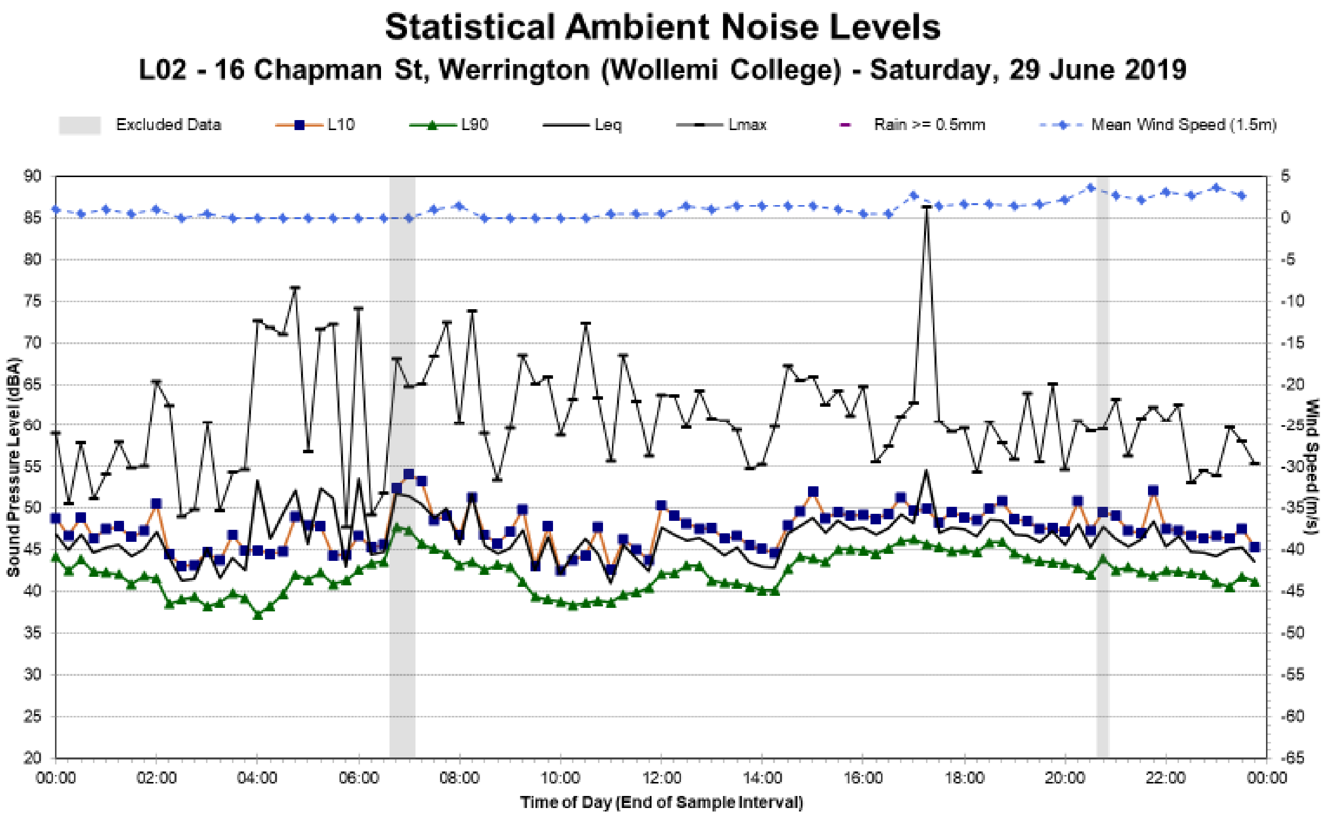
Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
27/06/2019	12:35	37	42	59

Photo of Noise Monitoring Location

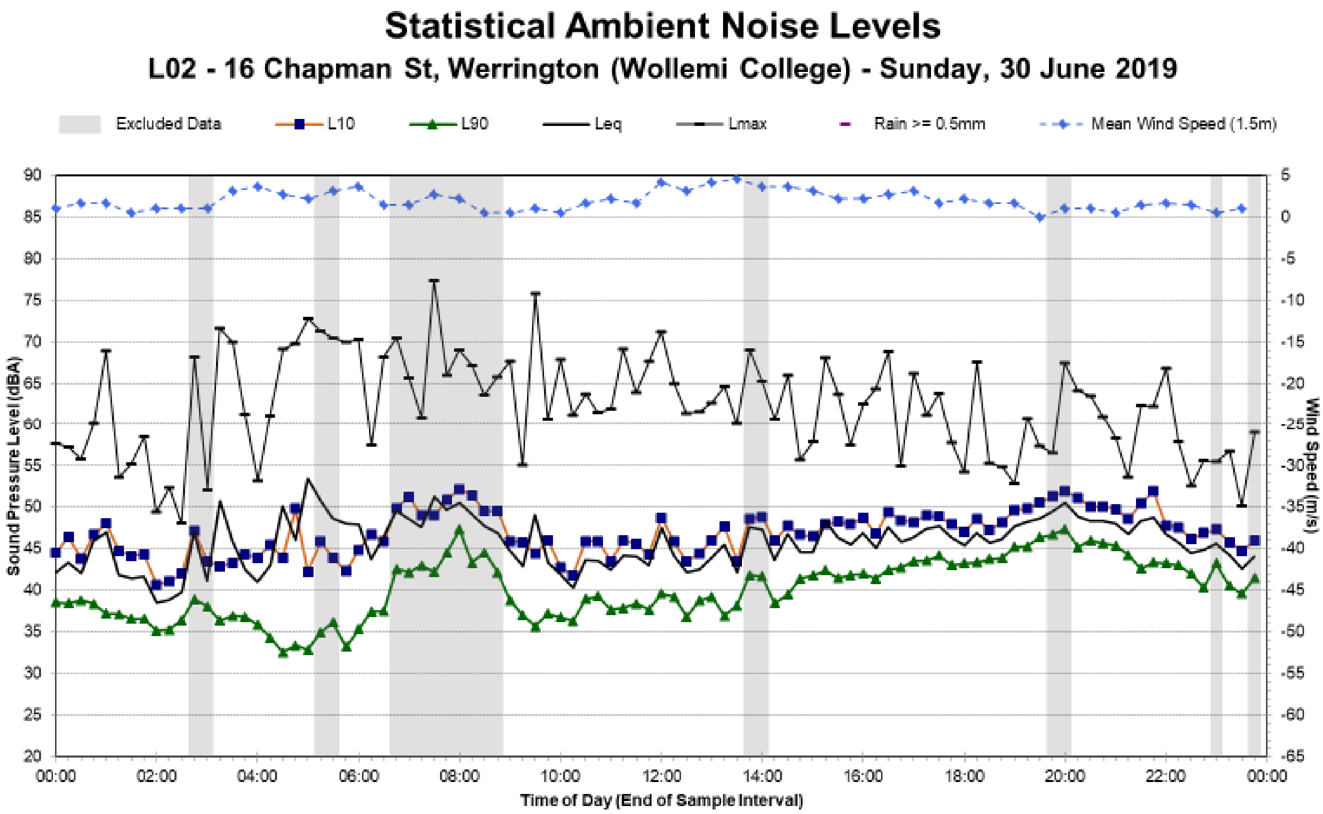
Note 1: 8 July excluded from data


Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Thursday, 27 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

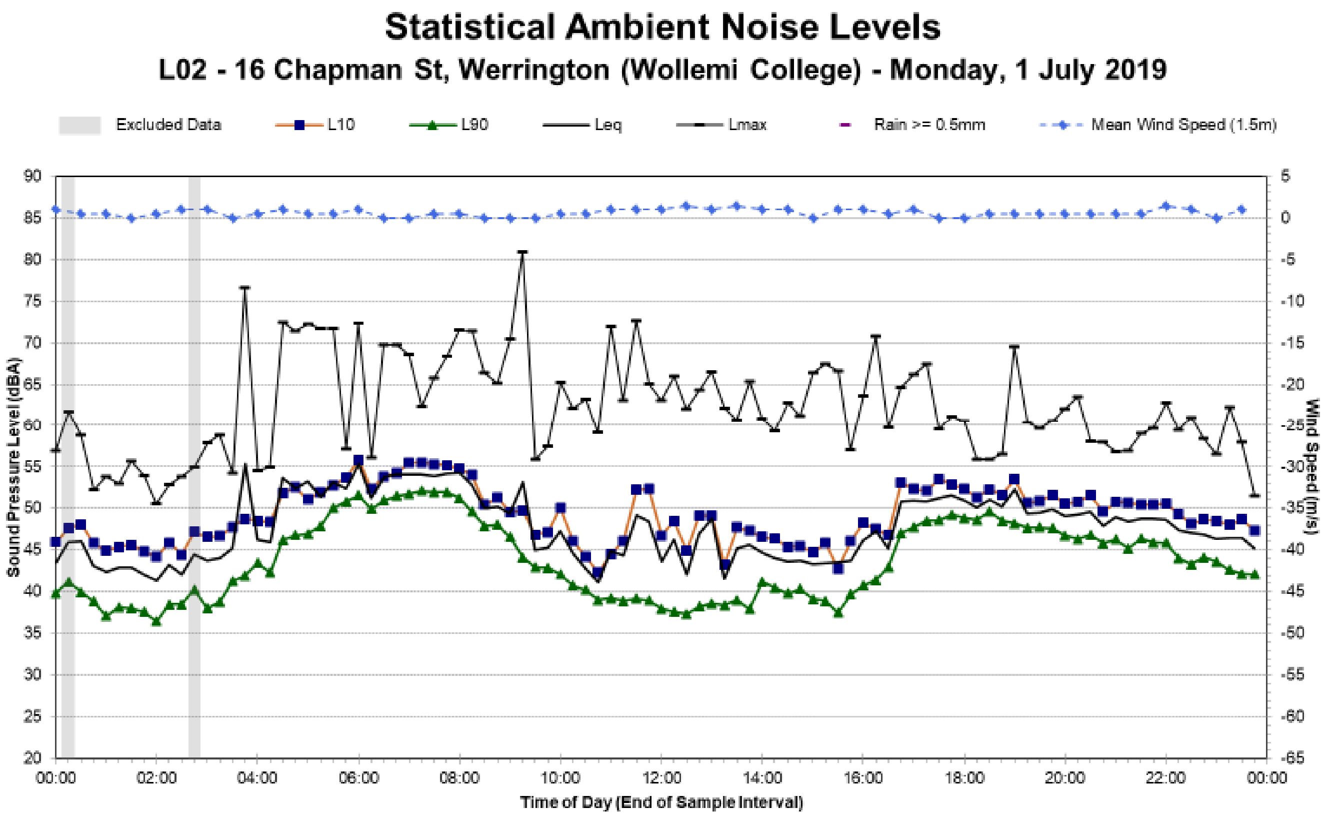

Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Friday, 28 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

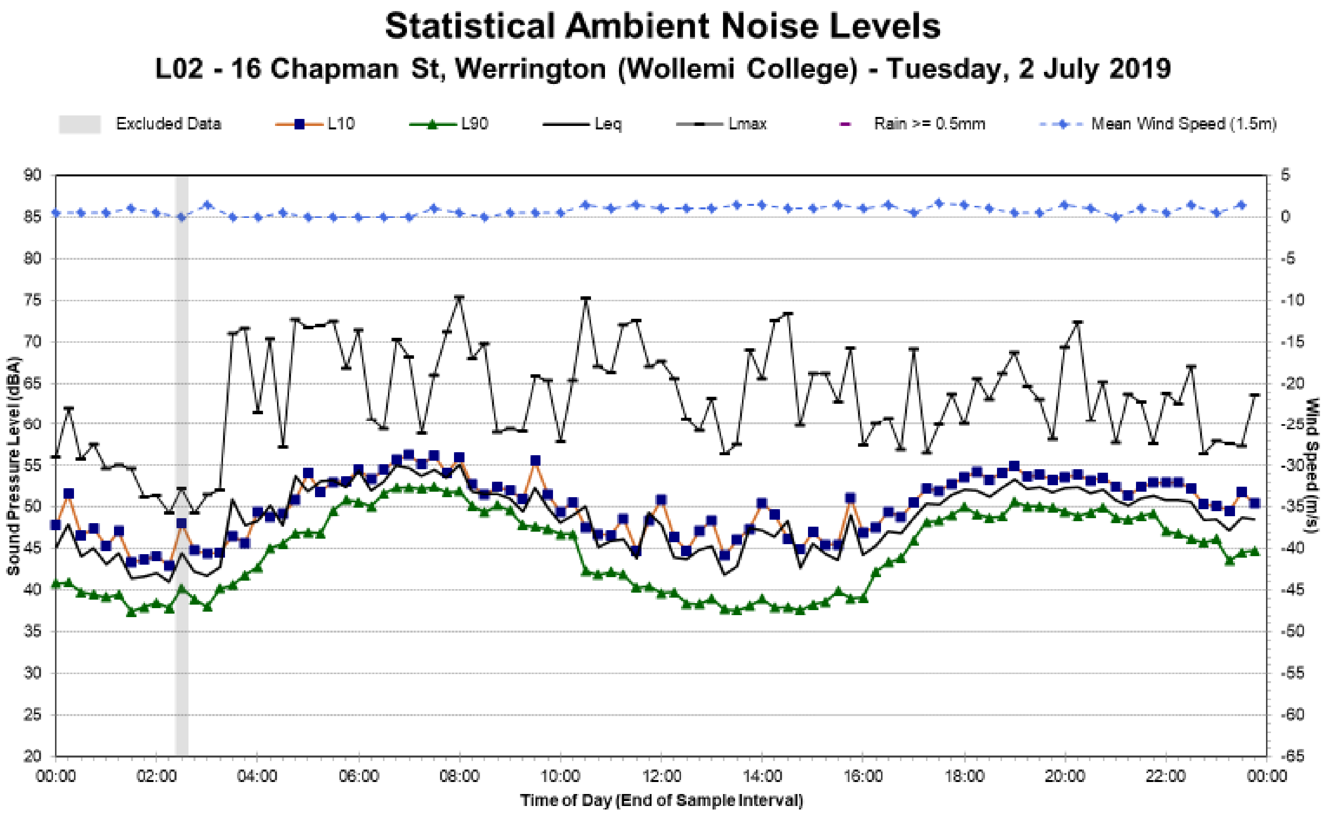


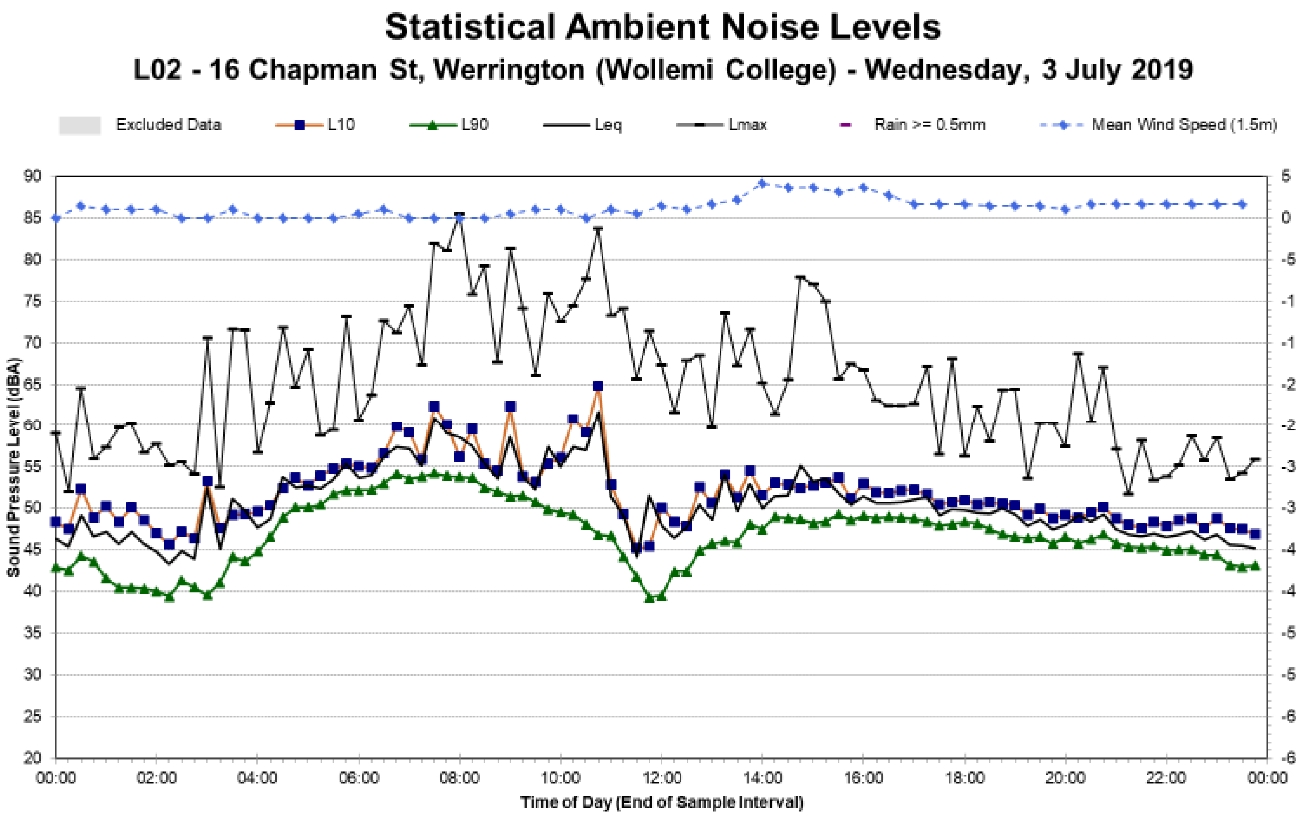
Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Saturday, 29 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



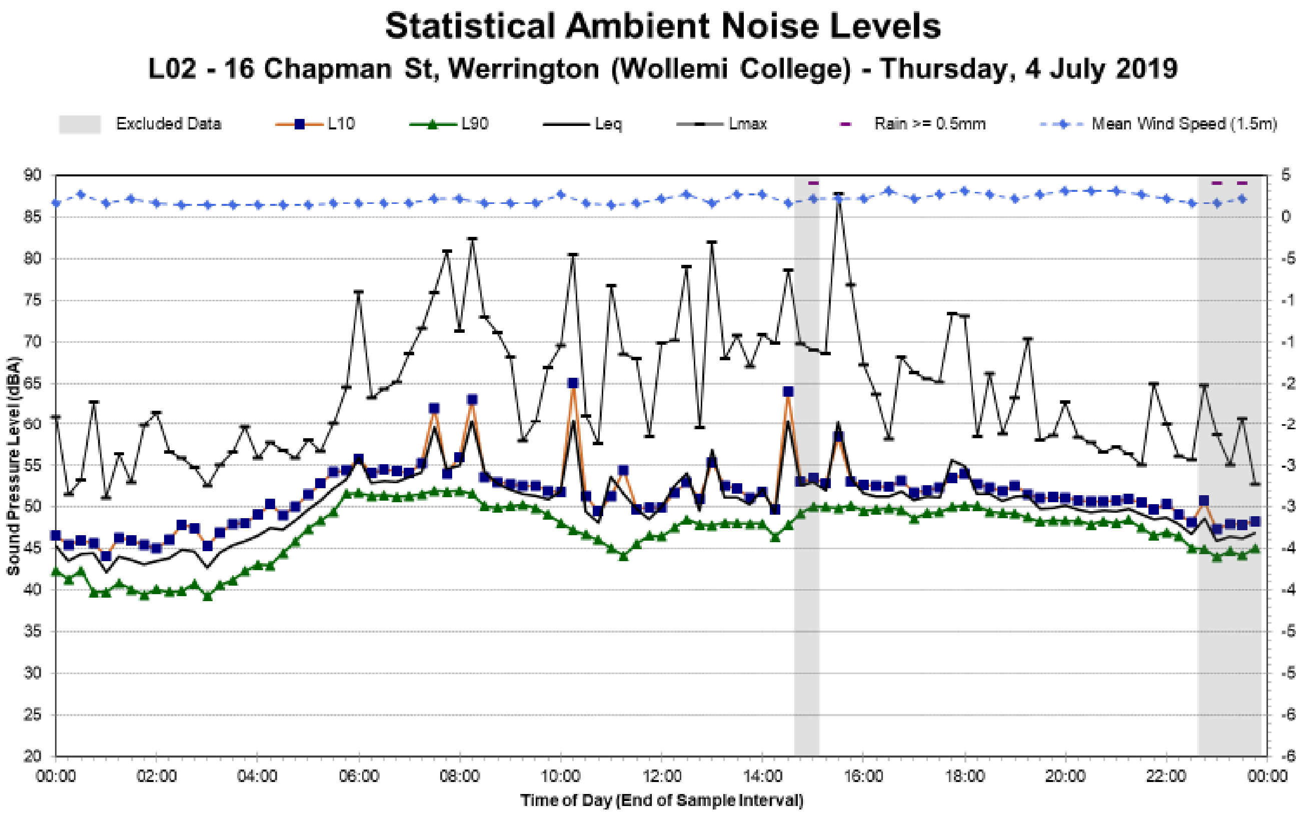
Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Sunday, 30 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Monday, 1 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Tuesday, 2 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



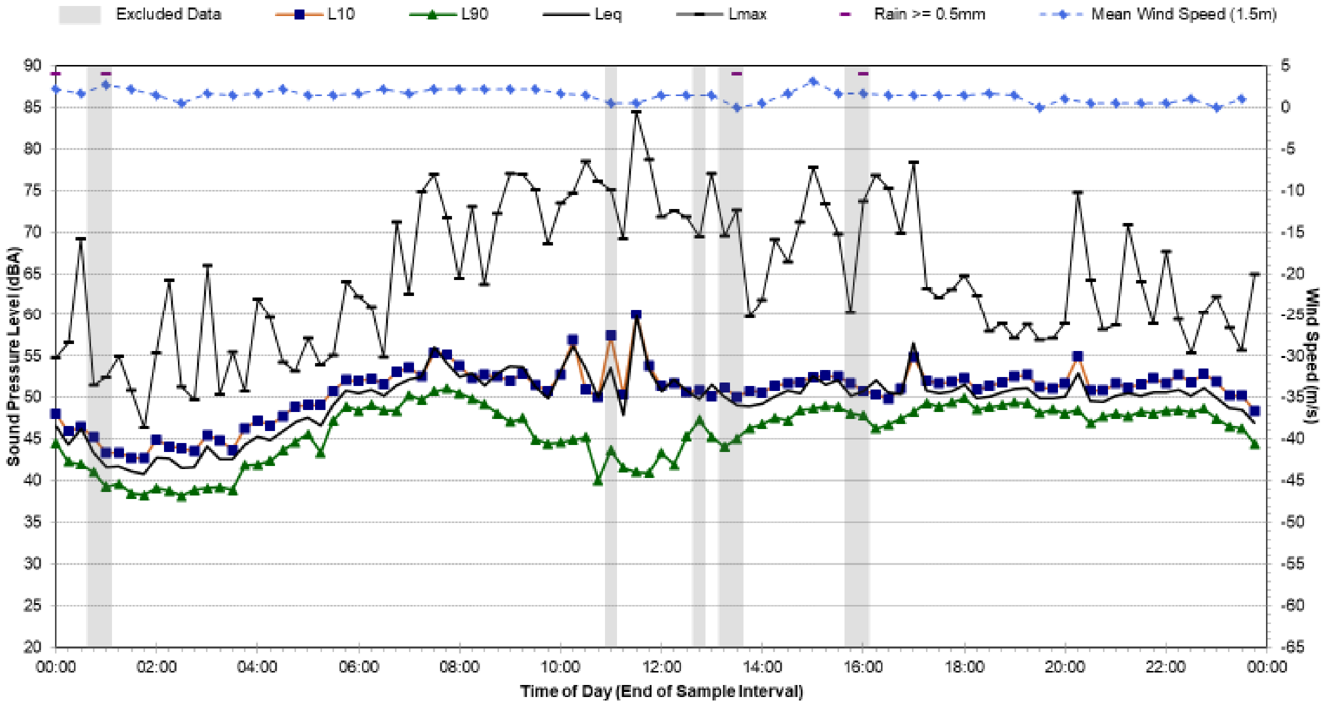
Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Wednesday, 3 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)



Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Thursday, 4 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

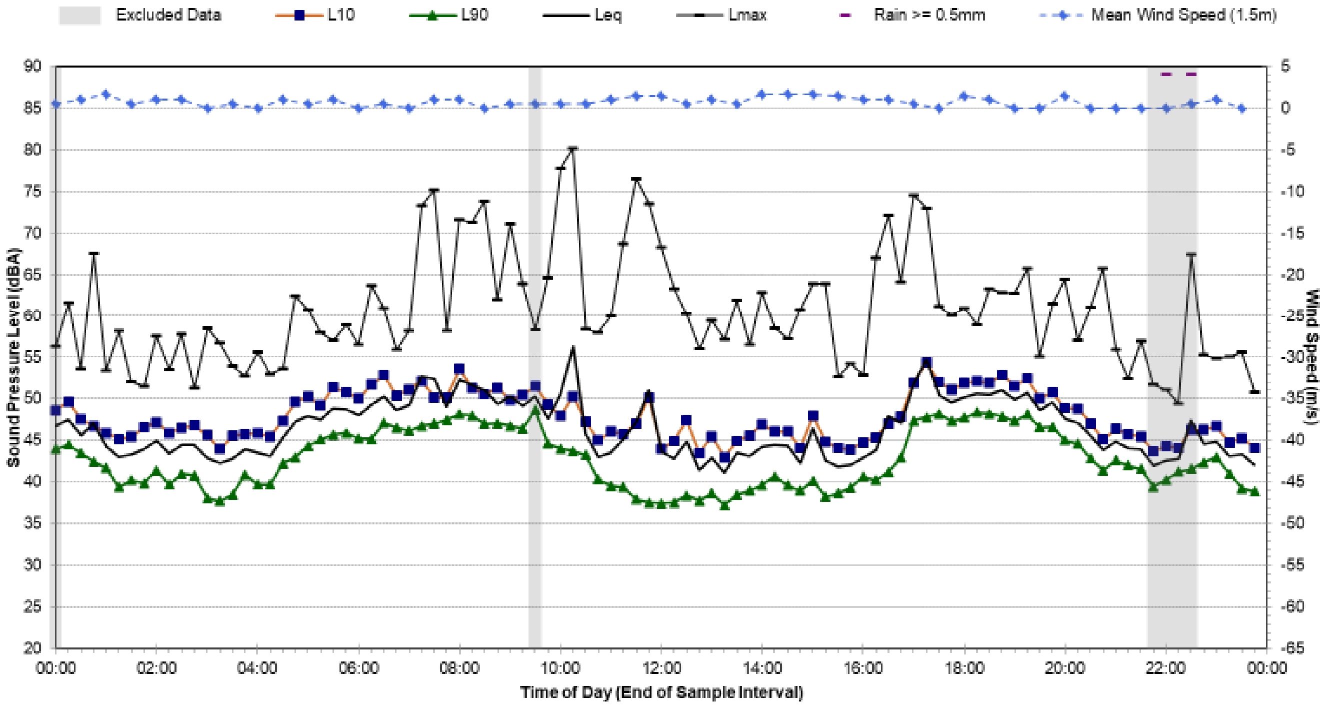
Statistical Ambient Noise Levels

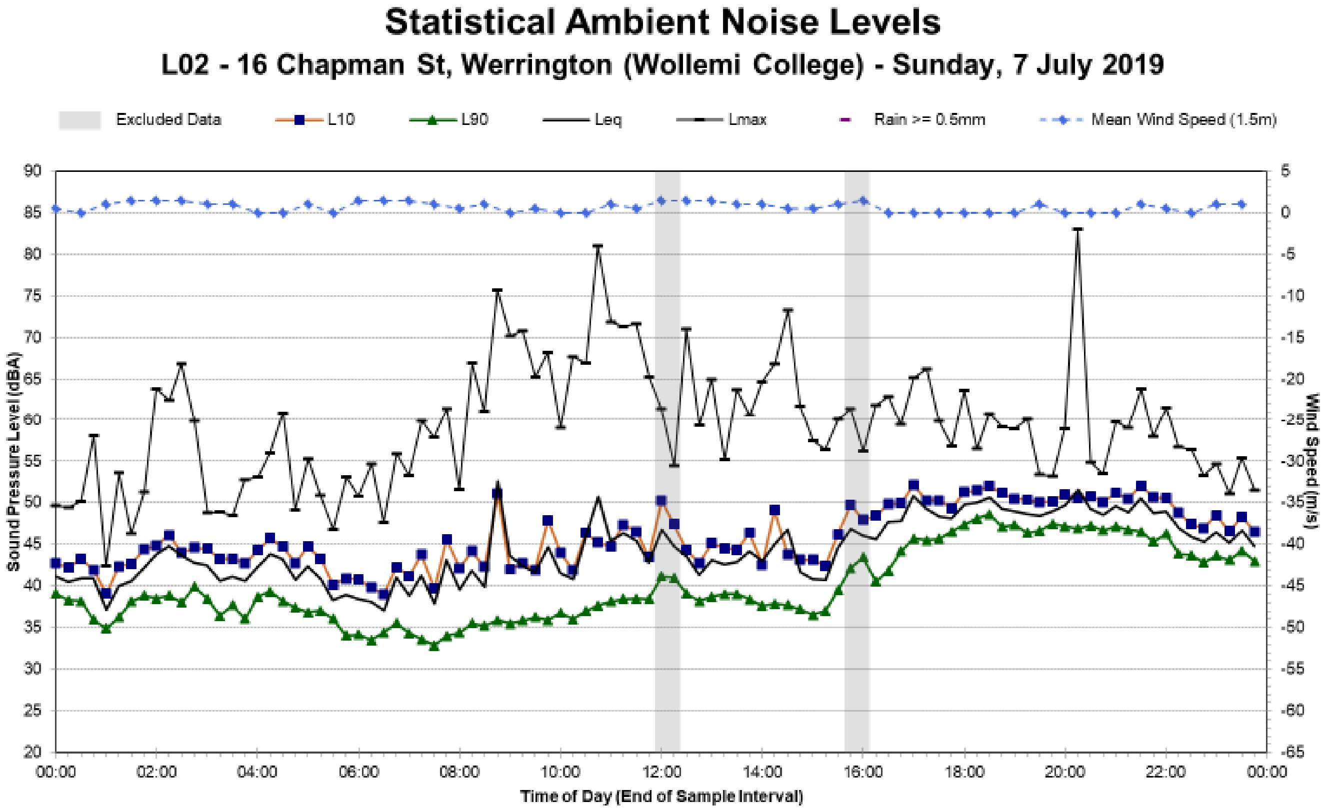
L02 - 16 Chapman St, Werrington (Wollemi College) - Friday, 5 July 2019

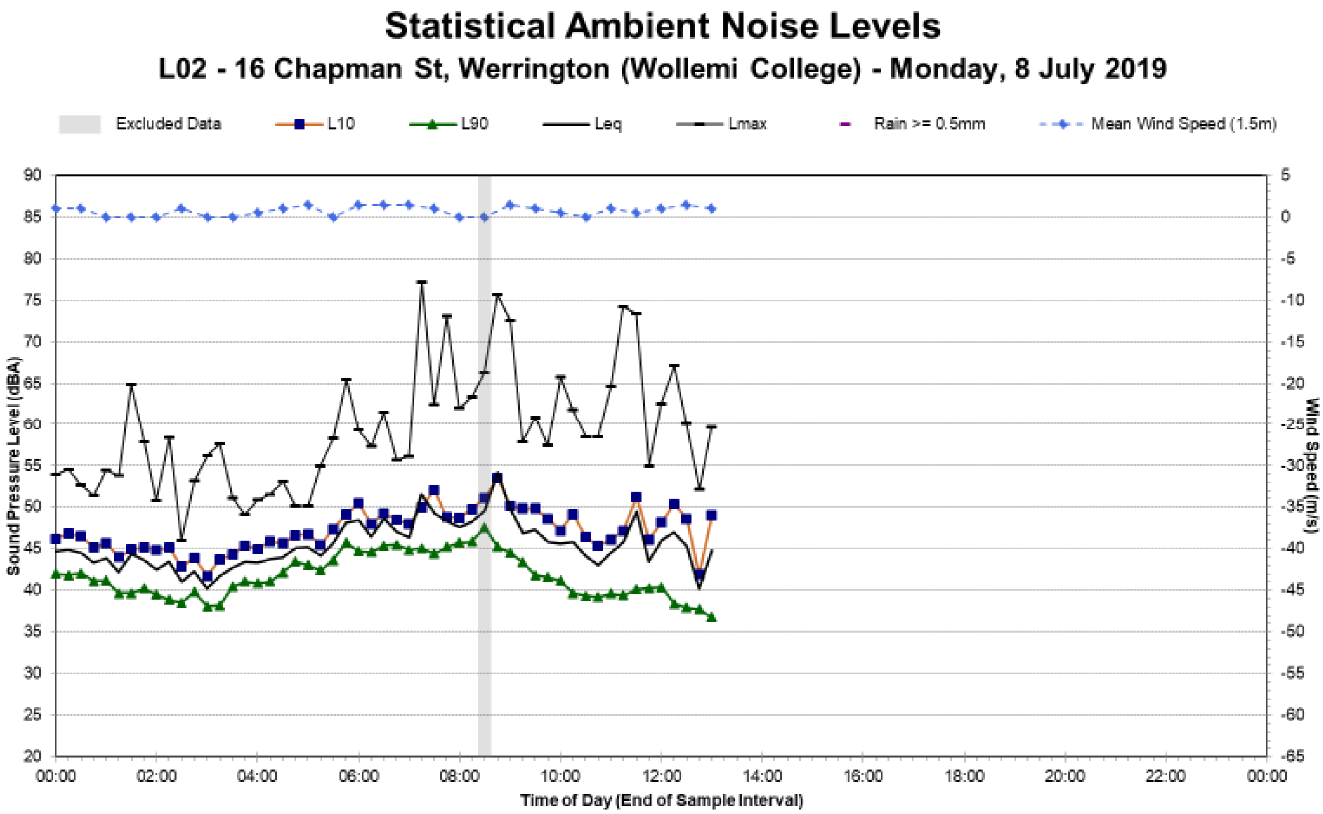


Statistical Ambient Noise Levels

L02 - 16 Chapman St, Werrington (Wollemi College) - Saturday, 6 July 2019




Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Sunday, 7 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 16 Chapman St, Werrington (Wollemi College) - Monday, 8 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

Noise Monitoring Location	L.04
Noise Monitoring Address	16 Chapman Street, Werrington

Logger Device Type: Svantek 957, Logger Serial No: 21423
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3008204

Ambient noise logger deployed at with the 16 Chapman Street Precinct Development proposal, approximately 160 m west north-west of the Cobham Juvenile Centre.

Attended noise measurements indicate the ambient noise environment at this location is dominated by natural fauna and birdsong, distant traffic along the Great Western Highway, overhead aircraft and trains along the T1 line.

Recorded Noise Levels (LAmax):
27/06/2019: Birdsong 40 – 56, Distant bikes along GWH 44 – 48, Aircraft 50, Rail movements 42 – 52, Distant truck brakes 46 – 48.

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	38	48	46	53
Evening	44	48	49	53
Night-time	37	46	46	51

Ambient Noise Logging Results – RNP Defined Time Periods

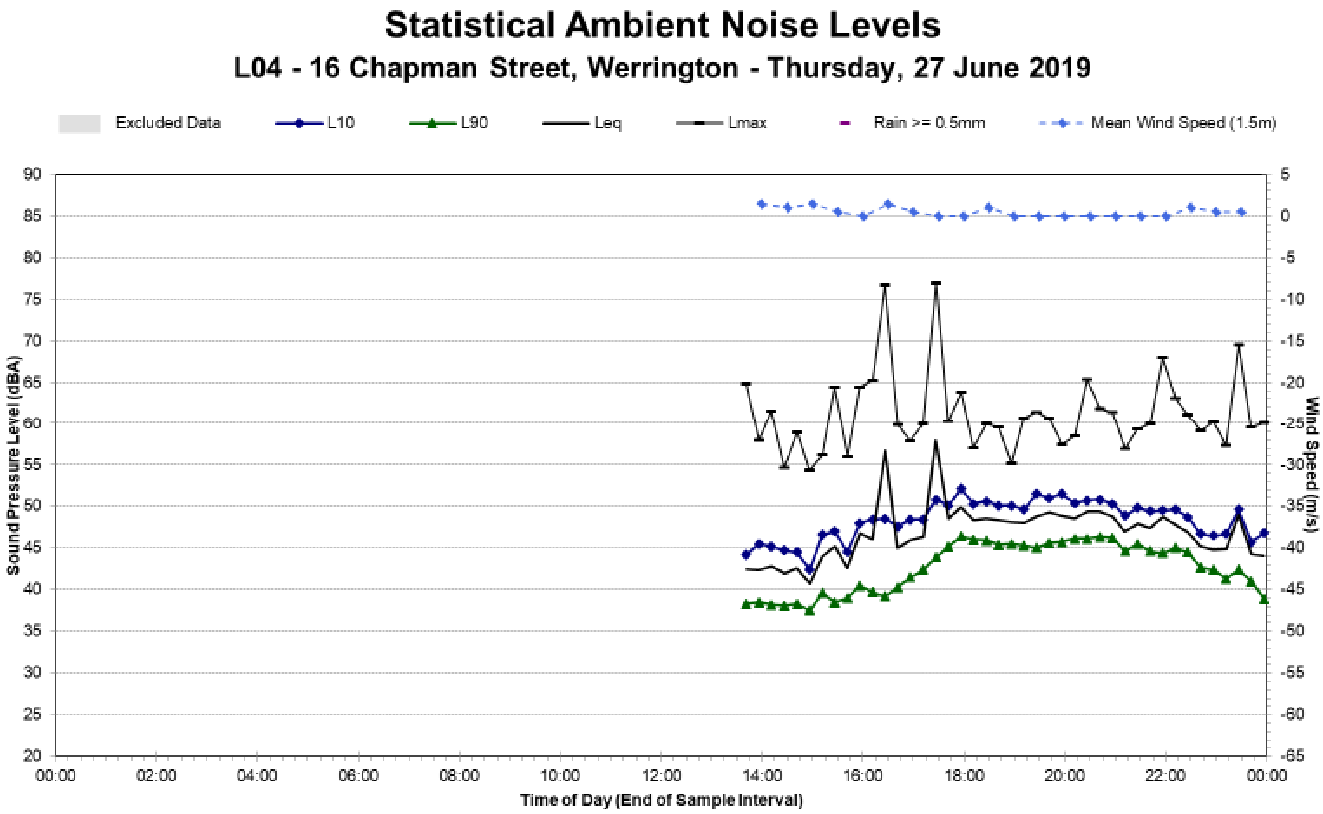
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	48	52
Night-time (10pm-7am)	46	52

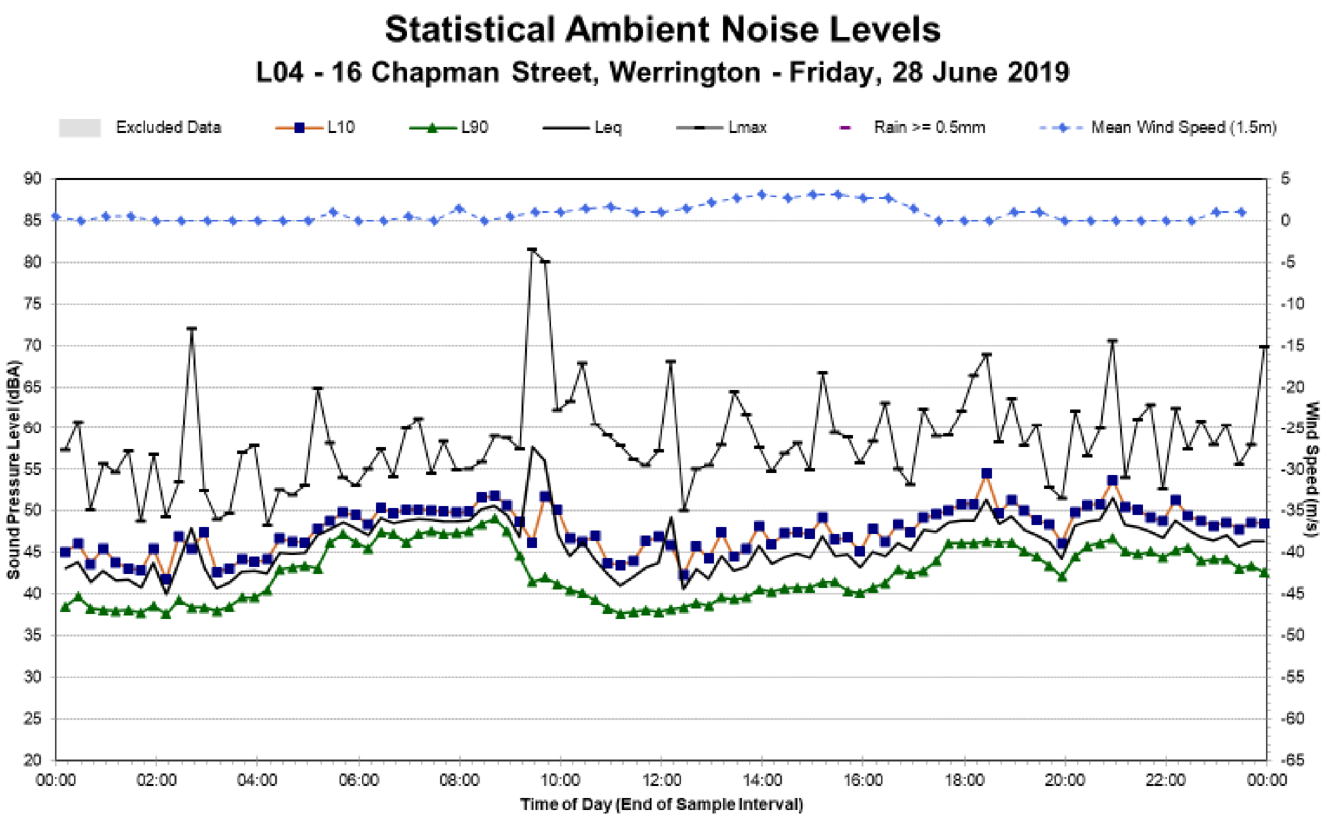
Attended Noise Measurement Results

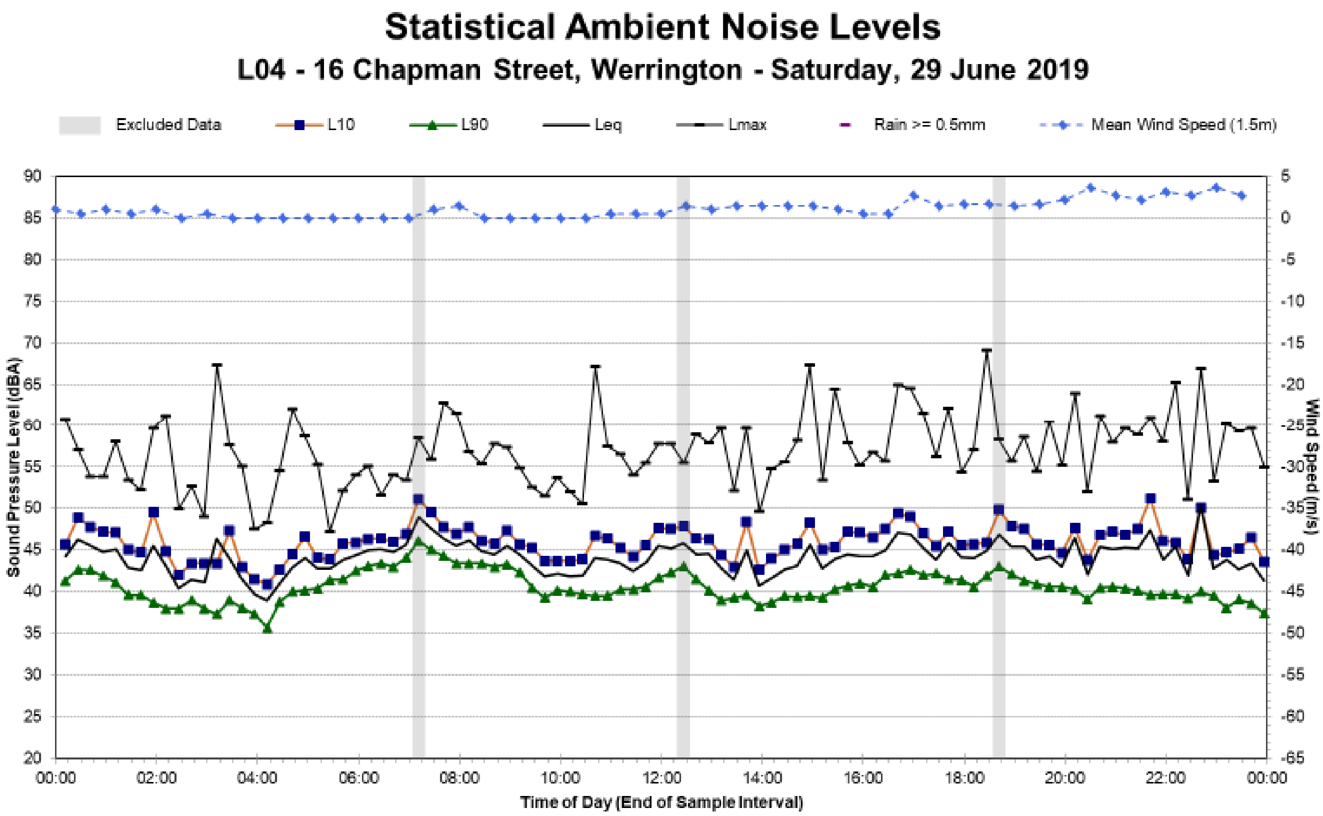
Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
27/06/2019	13:20	40	43	64

Photo of Noise Monitoring Location

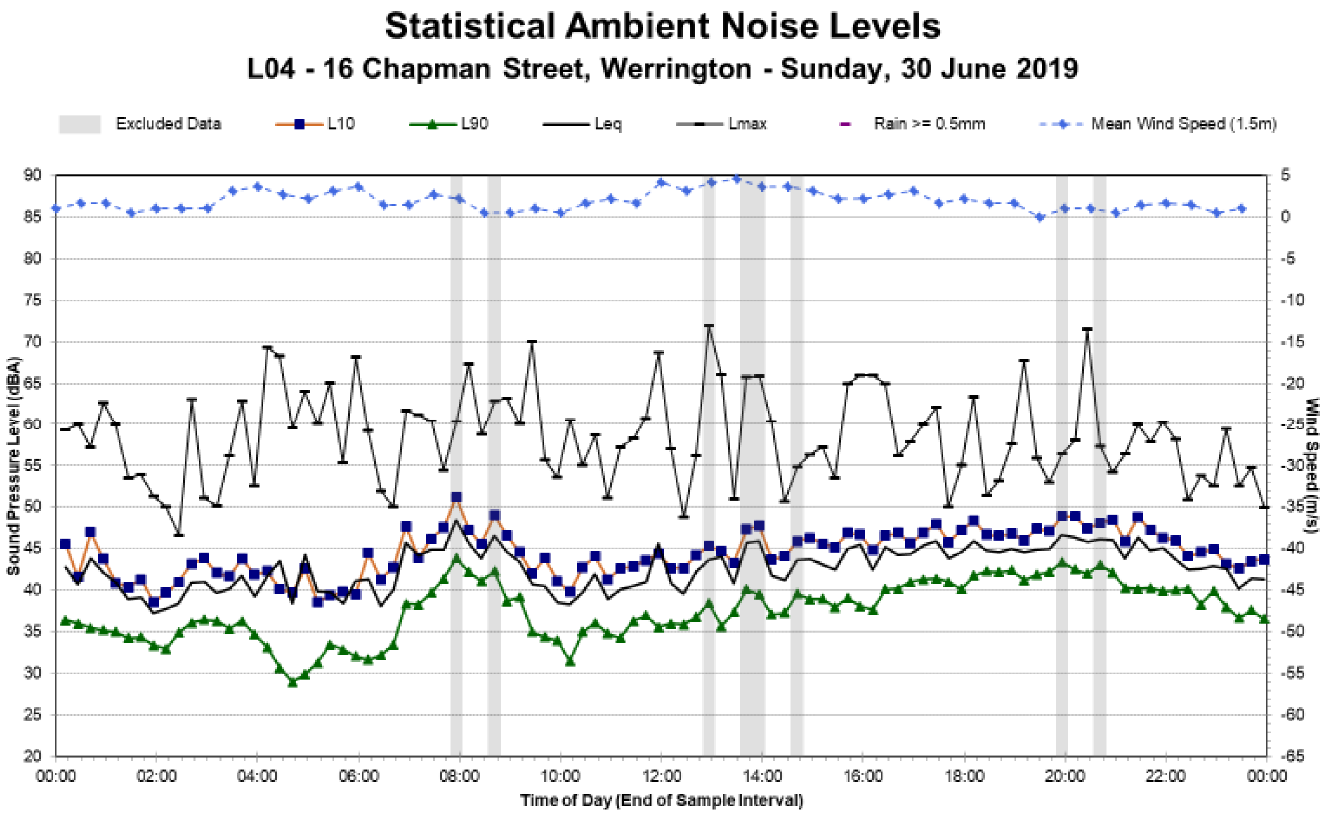
Note 1: Calibration drift of 2 dB was observed. 8 July removed from data


Statistical Ambient Noise Levels
L04 - 16 Chapman Street, Werrington - Thursday, 27 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

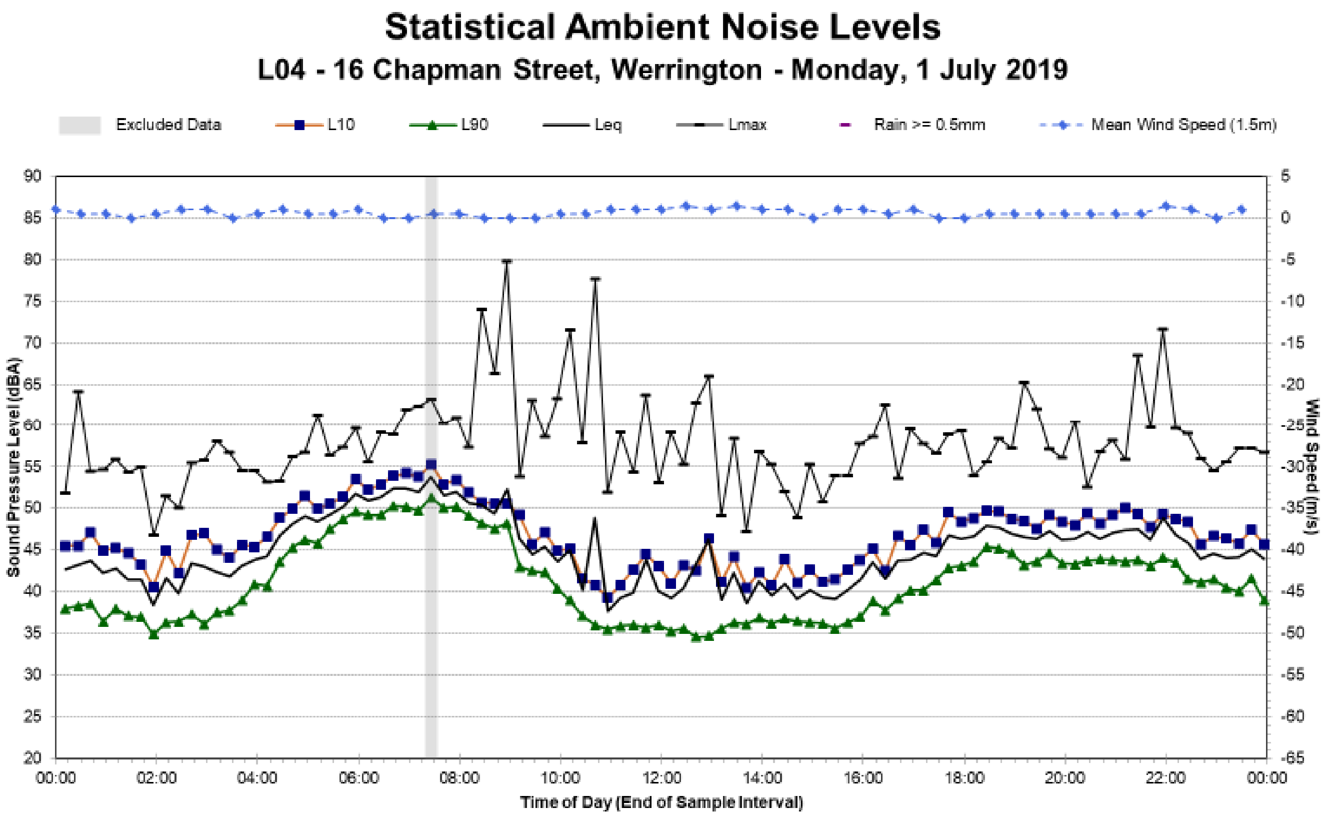

Statistical Ambient Noise Levels
L04 - 16 Chapman Street, Werrington - Friday, 28 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

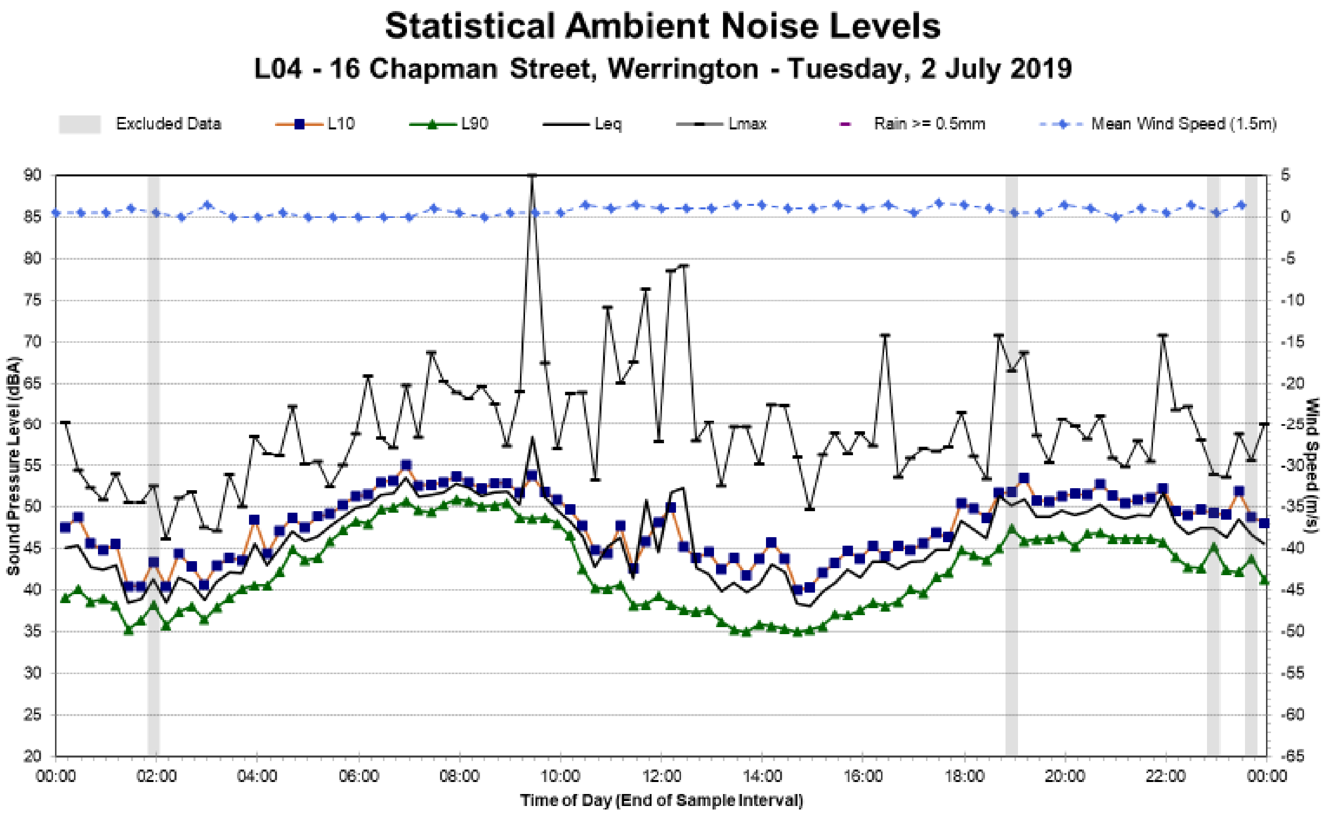


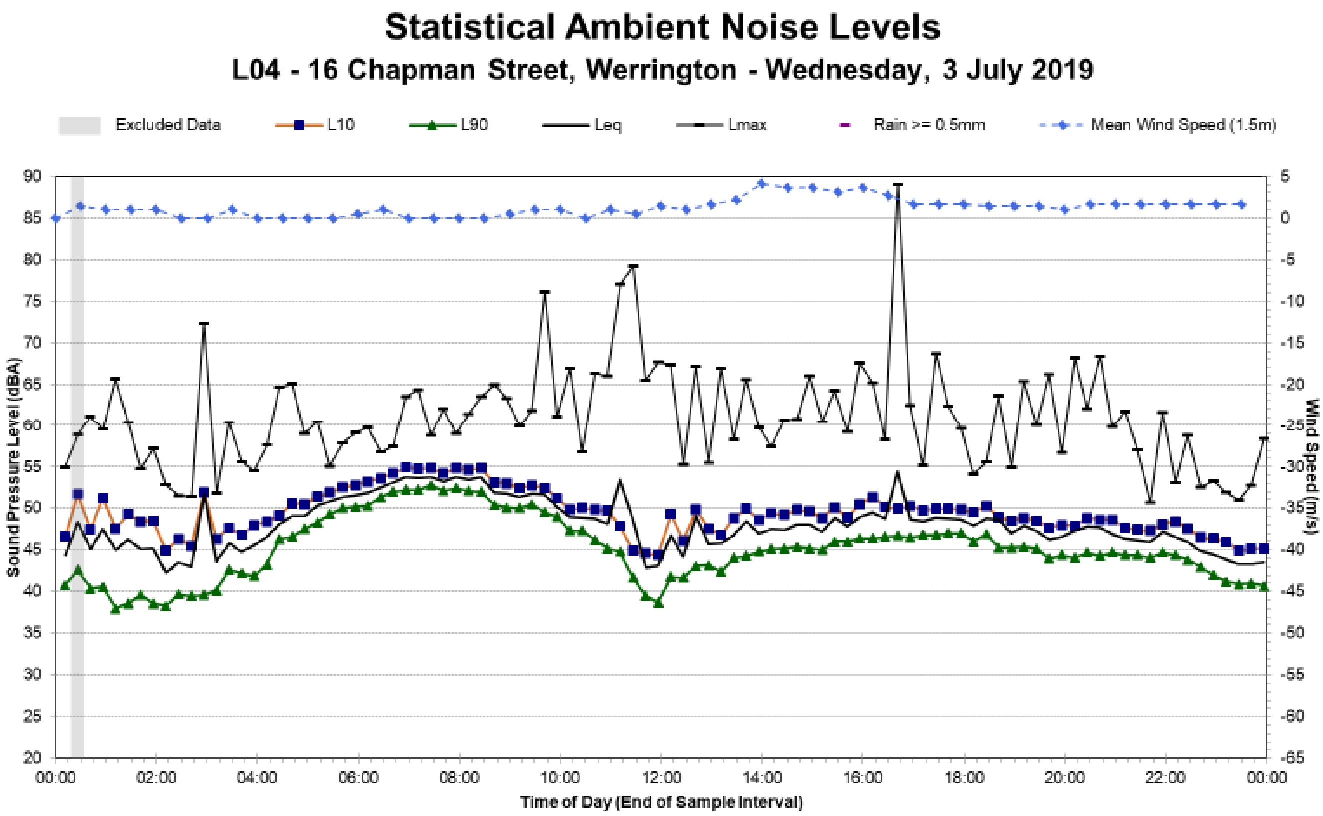
Statistical Ambient Noise Levels
L04 - 16 Chapman Street, Werrington - Saturday, 29 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

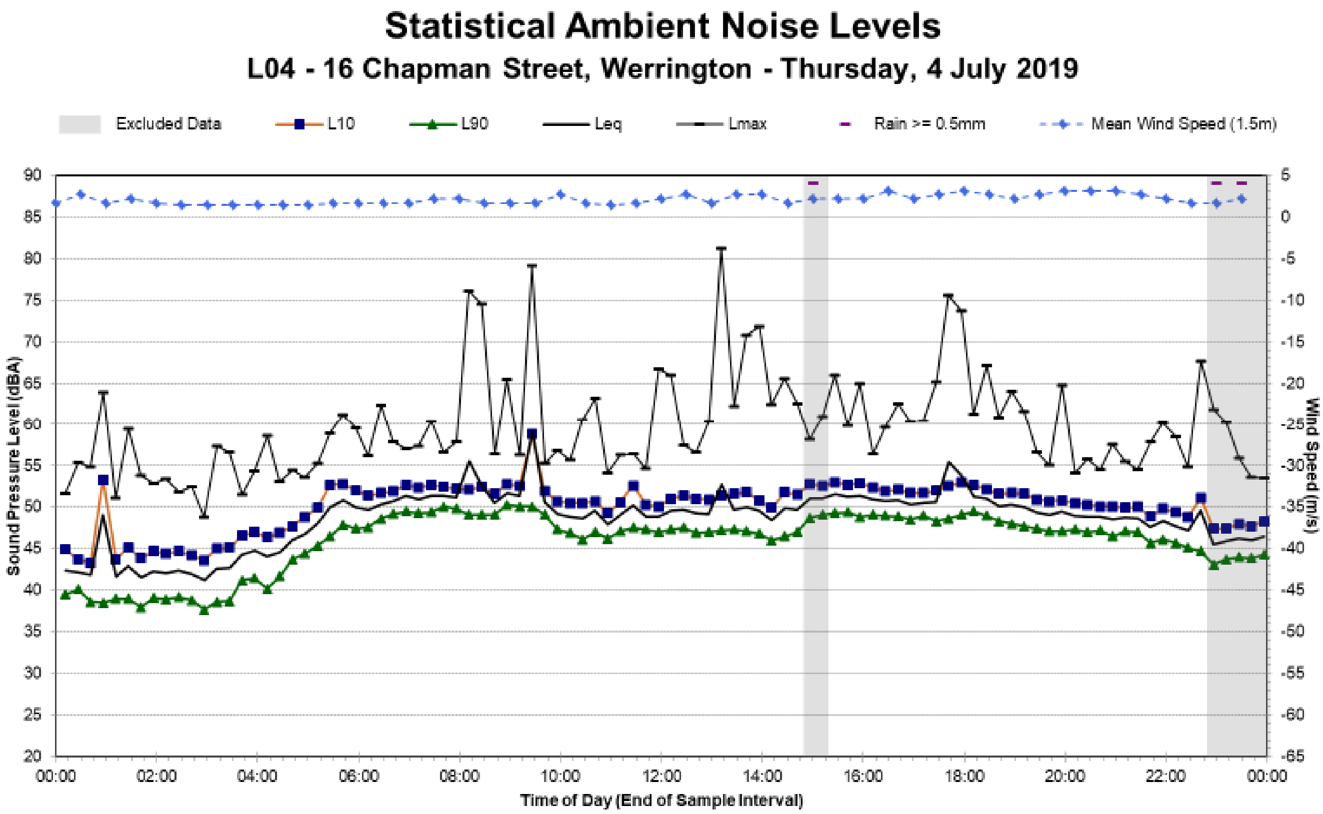


Statistical Ambient Noise Levels
L04 - 16 Chapman Street, Werrington - Sunday, 30 June 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L04 - 16 Chapman Street, Werrington - Monday, 1 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L04 - 16 Chapman Street, Werrington - Tuesday, 2 July 2019
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

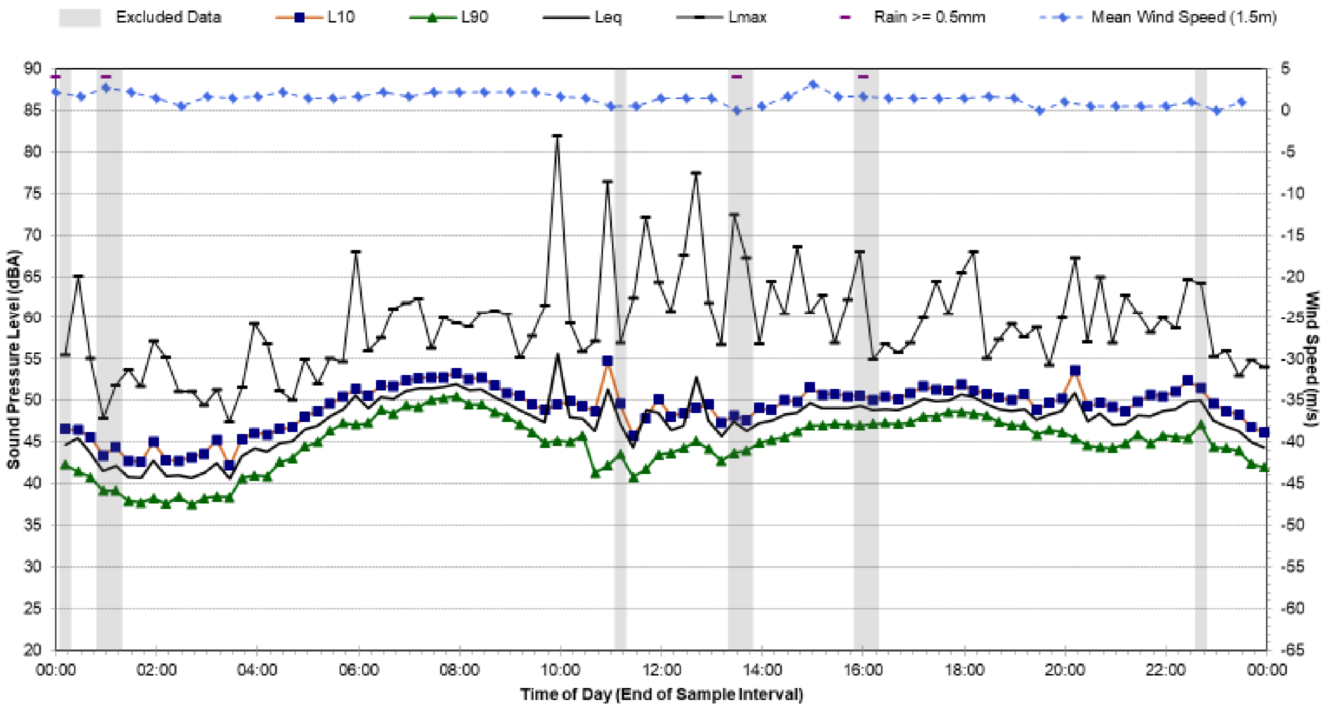




Document Set ID: 8888162
Version: 1, Version Date: 15/10/2019

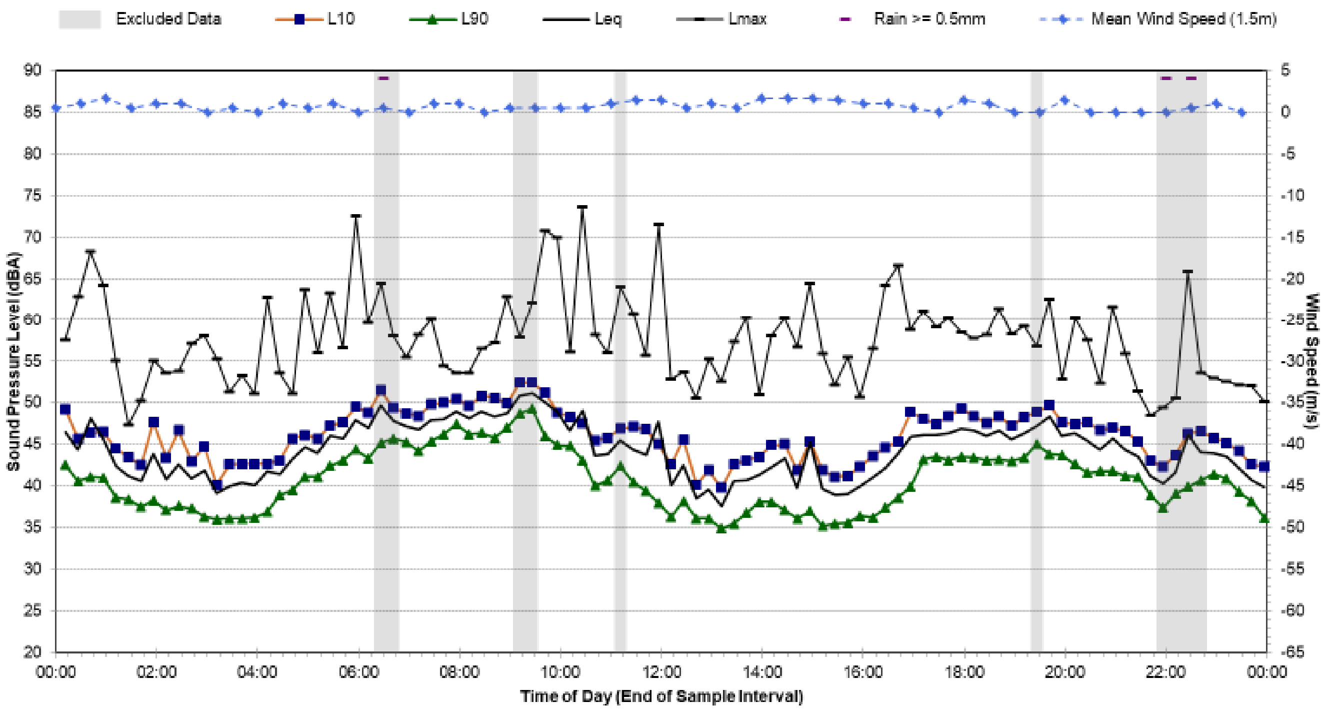
Statistical Ambient Noise Levels

L04 - 16 Chapman Street, Werrington - Friday, 5 July 2019



Statistical Ambient Noise Levels

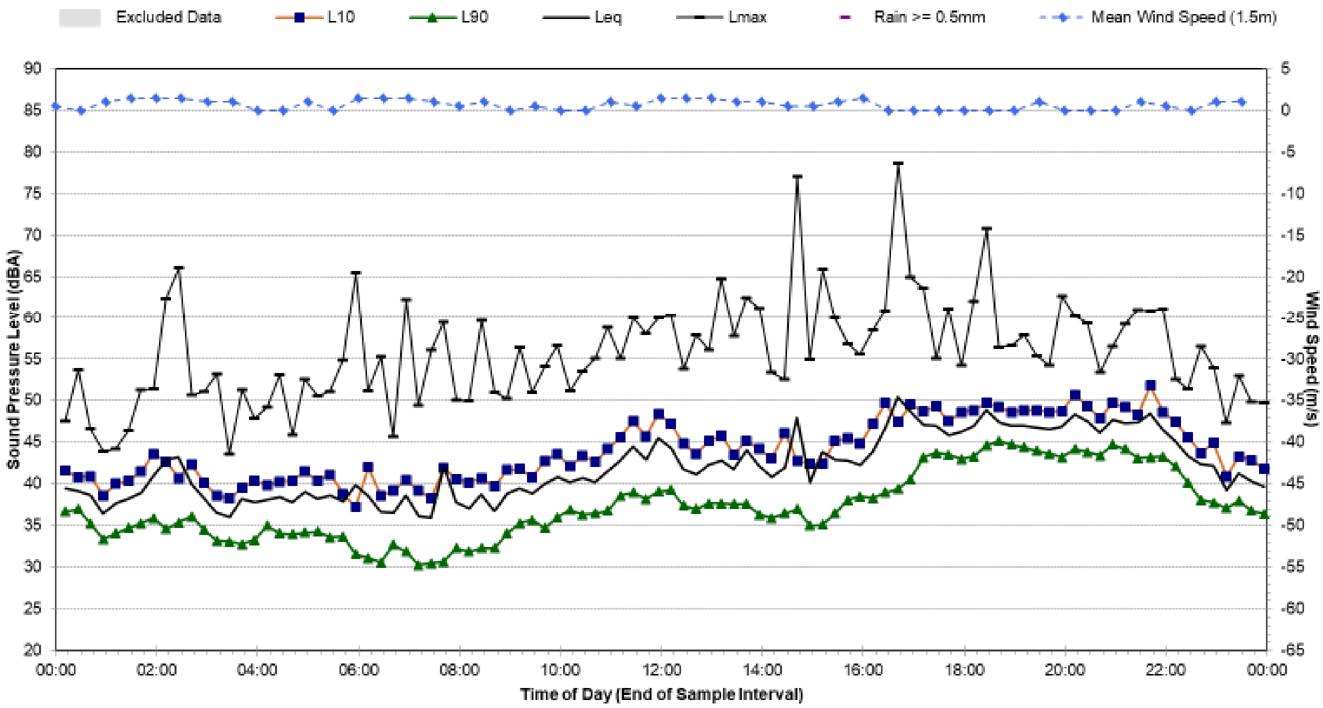
L04 - 16 Chapman Street, Werrington - Saturday, 6 July 2019



Document Set ID: 8888162
Version: 1, Version Date: 15/10/2019

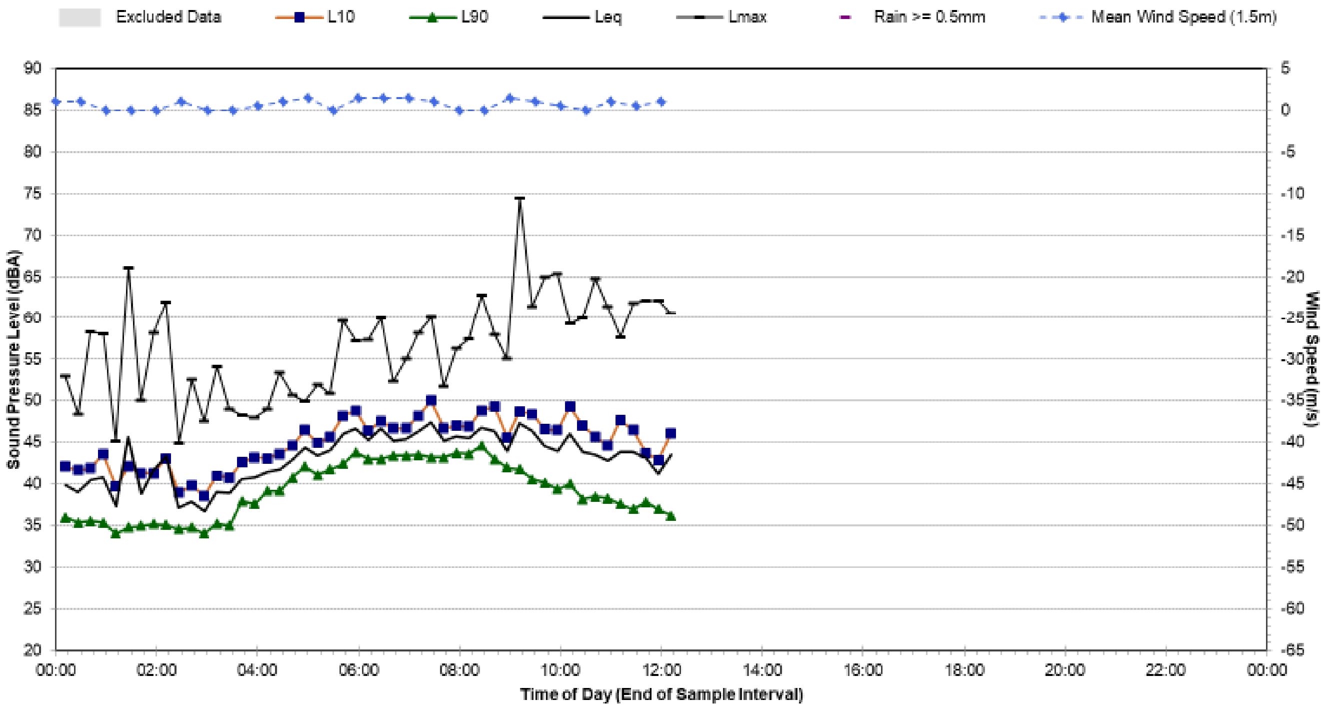
Statistical Ambient Noise Levels

L04 - 16 Chapman Street, Werrington - Sunday, 7 July 2019



Statistical Ambient Noise Levels

L04 - 16 Chapman Street, Werrington - Monday, 8 July 2019



ASIA PACIFIC OFFICES

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

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

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

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

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

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

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

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

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

TOWNSVILLE SOUTH
12 Cannan Street
Townsville South QLD 4810
Australia
T: +61 7 4772 6500

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 404 939 922

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

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

www.slrconsulting.com