acousticdynamics

Rail Noise & Vibration Intrusion Assessment
1A & 1B Queen Street, Auburn NSW

Client:
EG Funds Management

Association of Australian Acoustical Consultants

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CONTENTS

GLOSSARY

NOISE

Noise is produced through rapid variations in air pressure at audible frequencies (20 Hz – 20 kHz). Most noise sources vary with time. The measurement of a variable noise source requires the ability to describe the sound over a particular duration of time. A series of industry standard statistical descriptors have been developed to describe variable noise, as outlined in **Section 2.1.2** below.

NOISE DESCRIPTORS

L_{eq} – The sound pressure level averaged over the measurement period. It can be considered as the equivalent continuous steady-state sound pressure level, which would have the same total acoustic energy as the real fluctuating noise over the same time period.

$L_{Aeq(15\ min)}$ – The A-weighted equivalent continuous sound level over a 15 minute period.

L_{A10} – The A-weighted noise level that has been exceeded for 10% of the measurement duration.

L_{A90} – The A-weighted noise level that has been exceeded for 90% of the measurement duration.

dB – Decibels. The fundamental unit of sound, a Bell is defined as the logarithm of the ratio of the sound pressure squared over the reference pressure squared. A Decibel is one-tenth of a Bell. Probably the most common usage of the Decibel in reference to sound loudness is dB sound pressure level (SPL), referenced to the nominal threshold of human hearing. For sound in air and other gases, dB(SPL) is relative to 20 micropascals (μPa) = 2×10^{-5} Pa, the quietest sound a human can hear.

R_w – Weighted Sound Reduction Index. A measure of sound insulation performance of a building element. The higher the number, the better the insulation performance.

A-WEIGHTING

"A-weighting" refers to a prescribed amplitude versus frequency curve used to "weight" noise measurements in order to represent the frequency response of the human ear. Simply, the human ear is less sensitive to noise at some frequencies and more sensitive to noise at other frequencies. The A-weighting is a method to present a measurement or calculation result with a number representing how humans subjectively hear different frequencies at different levels.

NOISE CHARACTER, NOISE LEVEL AND ANNOYANCE

The perception of a given sound to be deemed annoying or acceptable is greatly influenced by the character of the sound and how it contrasts with the character of the background noise. A noise source may be measured to have only a marginal difference to the background noise level, but may be perceived as annoying due to the character of the noise. Acoustic Dynamics' analysis of noise considers both the noise level and sound character in the assessment of annoyance and impact on amenity.

1 INTRODUCTION

1.1 SUMMARY

Acoustic Dynamics has been engaged by EG Fund Management to provide an assessment of external rail noise & vibration intrusion into the proposed residential development located at 1A & 1B Queen Street, Auburn, NSW for compliance with Cumberland Council's requirements.

This document provides a technical assessment, as well as recommendations for construction materials and methods to achieve compliance with the relevant acoustic design criteria and requirements. It has been prepared in accordance with the requirements of Cumberland Council, the NSW Department of Planning (DoP) and relevant Australian Standards.

1.2 DESCRIPTION OF PROPOSAL AND LOCATION

The site is located at 1A & 1B Queen Street, Auburn in the Cumberland Council area of NSW. The proposal is for the construction of a new residential development that will incorporate 595 units. The proposed development site is set back from the Western Line (T1) and Inner West & South Line (T2) on the north-eastern boundary. The north-western boundary is adjacent to Marion Street and the south-western boundary is adjacent. to Queen Street. The south-eastern boundary is shared with an existing light industrial premise.

Auburn train station is located approximately 600 meters to the northwest of the site. The railway corridor adjacent to the site contains three passenger/freight lines and accommodates two Sydney trains lines (i.e. T1 & T2).

The proposed development is shown in the Location Map & Drawings presented within **Appendix A**.

1.3 SCOPE

Acoustic Dynamics has been engaged to provide an analysis of external noise intrusion of rail noise & vibration into the proposed development.

The scope of the assessment is to include the following:

- Review of legislation, Council criteria and Australian Standards relevant to the external noise & vibration intrusion at the proposed development;
- Assessment of noise and vibration intrusion based on data obtained from unattended and attended measurements at the subject site;
- Review of architectural drawings and review of the proposed construction and materials;

- Calculation of sound transmission reductions required to meet the criteria; and
- Recommendation of materials and construction techniques that may be used in potential residential developments, which will achieve the required noise attenuation, for compliance with the applicable criteria.

2 ASSESSMENT CRITERIA AND STANDARDS

2.1 ASSESSMENT CRITERIA

Acoustic Dynamics has conducted a review of the local council, state government and federal legislation that is applicable to noise assessment for the proposed development. The relevant sections of the legislation are presented below. The most stringent criteria which have been used in the assessment of the proposed development, is summarised below.

The following criteria are specified as the relevant criteria in the following documents:

- Cumberland Council Planning Documents;
- NSW State Environmental Planning Policy (SEPP) (Infrastructure) (2007);
- NSW DP&I, Development Near Rail Corridors and Busy Roads – Interim Guidelines (2008);
- NSW Department of Planning & Environment's Apartment Design Guide (2015);
- Australian Standard 2107 (2016); and
- NSW EPA's "Assessing Vibration: a technical guideline" (2006).

Table 2.1 – Noise criteria for residential buildings

Type of Occupancy	Indoor $L_{Aeq(1\ hr)}$ Criterion [dB(A)]	Applicable Time Period
Sleeping areas (bedroom)	35	Night 10 pm to 7 am
Other habitable rooms (excluding. Garages, kitchens, bathrooms & hallways)	40	At any time

Note 1). Acoustic Dynamics assumes the applicable noise descriptor is $L_{Aeq(1hour)}$

DP&I's "Development Near Rail Corridors and Busy Roads – Interim Guideline" states:

> *Vibration levels such as the intermittent vibration emitted by trains should comply with the criteria in "Assessing Vibration: A Technical Guideline" (DECC 2006).*

2.2 EPA'S TECHNICAL GUIDELINE FOR VIBRATION ASSESSMENT

The NSW EPA document *"Assessing Vibration: a technical guideline"* presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations of the measurement and evaluation techniques.

The criteria presented are non-mandatory goals that should be sought to be achieved through the application of all feasible and reasonable mitigation measures. Sources of vibration, covered in this guideline include construction and excavation equipment, rail and road traffic, and industrial machinery.

When assessing intermittent vibration, the vibration dose value (VDV) is used. The VDV accumulates, the vibration energy received over the daytime and night-time periods. The vibration dose is fully described within British Standard BS 6472-1992.

The VDV is given by the fourth root of the integral of the fourth power of the acceleration after it has been frequency-weighted:

$$VDV = \left(\int_0^T a^4(t)\, dt \right)^{0.25}$$

Where VDV is the vibration dose value (in $ms^{-1.75}$), $a(t)$ is the frequency-weighted acceleration (ms^{-2}) and T is the total period of the day (in seconds) during which vibration may occur.

Acceptable VDVs for intermittent vibration are set out in the guideline and reproduced within **Table 2.2** below.

Table 2.2 – Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	Max. value	Preferred value	Max. value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Officers, Educational institutions & places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Note: 1) Daytime is 7.00am to 10.00pm and night-time is 10.00pm to 7:00am.

2) Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulse of criteria critical areas.

There is low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. Activities should be designed to meet the preferred values where an area is not already exposed vibration.

2.1 NSW DEPARTMENT OF PLANNING & ENVIRONMENT'S 'APARTMENT DESIGN GUIDE'

The review of the Apartment Design Guide 2015 revealed the following acoustic information relating to rail noise intrusion into a residential development, such as the proposed development:

> ***'Development near rail corridors and busy roads***
>
> *The NSW Government's Development near Rail Corridors and Busy Roads – Interim Guideline as called by State Environmental Planning Policy (Infrastructure) 2007 assists in the planning, design and assessment of development in, or adjacent to, rail corridors and busy roads. SEPP 65 development in these locations must have regard to this guideline.*
>
> ***Objective 4H-1***
> *Noise transfer is minimised through the siting of buildings and building layout*
>
> ***Design guidance***
> *Adequate building separation is provided within the development and from neighbouring buildings/adjacent uses (see also section 2F Building separation and section 3F Visual privacy)*
>
> *Window and door openings are generally orientated away from noise sources*
>
> *Noisy areas within buildings including building entries and corridors should be located next to or above each other and quieter areas next to or above quieter areas*
>
> *Storage, circulation areas and non-habitable rooms should be located to buffer noise from external sources*
>
> *The number of party walls (walls shared with other apartments) are limited and are appropriately insulated*
>
> *Noise sources such as garage doors, driveways, service areas, plant rooms, building services, mechanical equipment, active communal open spaces and circulation areas should be located at least 3m away from bedrooms*

Objective 4H-2
Noise impacts are mitigated within apartments through layout and acoustic treatments

Design guidance
Internal apartment layout separates noisy spaces from quiet spaces, using a number of the following design solutions:
• rooms with similar noise requirements are grouped together
• doors separate different use zones
• wardrobes in bedrooms are co-located to act as sound buffers

Where physical separation cannot be achieved noise conflicts are resolved using the following design solutions:
• double or acoustic glazing
• acoustic seals
• use of materials with low noise penetration properties
• continuous walls to ground level courtyards where they do not conflict with streetscape or other amenity requirements

Objective 4J-1
In noisy or hostile environments, the impacts of external noise and pollution are minimised through the careful siting and layouts of buildings

Design guidance
To minimise impacts the following design solutions may be used:
• physical separation between buildings and the noise or pollution source
• residential uses are located perpendicular to the noise source and where possible buffered by other uses
• non-residential buildings are sited to be parallel with the noise source to provide a continuous building that shields residential uses and communal open spaces
• non-residential uses are located at lower levels vertically separating the residential component from the noise or pollution source. Setbacks to the underside of residential floor levels should increase relative to traffic volumes and other noise sources
• buildings should respond to both solar access and noise. Where solar access is away from the noise source, non-habitable rooms can provide a buffer
• where solar access is in the same direction as the noise source, dual aspect apartments with shallow building depths are preferable (see figure 4J.4)
• landscape design reduces the perception of noise and acts as a filter for air pollution
generated by traffic and industry
Achieving the design criteria in this Apartment Design Guide may not be possible in some situations due to noise and pollution. Where developments are unable to achieve
the design criteria, alternatives may be considered in the following areas:
• solar and daylight access
• private open space and balconies
• natural cross ventilation

Objective 4J-2
Appropriate noise shielding or attenuation techniques for the building design, construction and choice of materials are used to mitigate noise transmission.'

Design guidance
Design solutions to mitigate noise include:
- *limiting the number and size of openings facing noise sources*
- *providing seals to prevent noise transfer through gaps*
- *using double or acoustic glazing, acoustic louvres or enclosed balconies (wintergardens)*
- *using materials with mass and/or sound insulation or absorption properties e.g. solid balcony balustrades, external screens and soffits*

With regard to acoustics, the design guide contains advice relating to the use of construction techniques such as winter gardens and appropriate building siting.

Additionally, the design guide also contains advice relating to natural ventilation within Section 4B, and provides the following objectives:

"Objective 4B-1
All habitable rooms are naturally ventilated

Objective 4B-2
The layout and design of single aspect apartments maximises natural ventilation

Objective 4B-3
The number of apartments with natural cross ventilation is maximised to create a comfortable indoor environment for residents."

2.2 CUMBERLAND COUNCIL CRITERIA

2.2.1 LOCAL ENVIRONMENT PLAN

The review of the Auburn City Council *Local Environment Plan (LEP) 2010* did not yield specific acoustic information or criteria relating to road and/or rail noise & vibration intrusion into a residential development, such as the proposed development.

2.2.2 DEVELOPMENT CONTROL PLANS

A review of the Auburn City Council *Development Control Plan (DCP) 2010* was conducted. Reference to rail noise & vibration intrusion into a residential development, such as the proposed development are reproduced below:

Residential Flat Buildings

5.0 Privacy and security

Objectives

a. *To ensure the siting and design of buildings provide visual and acoustic privacy for residents and neighbours in their dwellings and private open spaces.*

b. *To provide personal and property security for residents and visitors and enhance perceptions of community safety.*

5.2 Noise

Performance criteria

P1 *The transmission of noise between adjoining properties is minimised.*

P2 *New dwellings are protected from existing and likely future noise sources from adjoining residential properties and other high noise sources (such as busy roads, railway corridors and industries) and the transmission of intrusive noise to adjoining residential properties is minimised.*

Development controls

D1 *For acoustic privacy, buildings shall:*

- *be designed to locate noise sensitive rooms and private open space away from the noise source or by use of solid barriers where dwellings are close to high noise sources;*
- *minimise transmission of sound through the building structure and in particular protect sleeping areas from noise intrusion; and*
- *all shared floors and walls between dwellings to be constructed in accordance with noise transmission and insulation requirements of the BCA.*

Note*: For development within or adjacent to a rail corridor, or major road corridor with an annual average daily traffic volume of more than 40,000 vehicles, applicants must consult State Environmental Planning Policy (Infrastructure) 2007 and the NSW Department of Planning's Development Near Rail Corridors and Busy Roads – Interim Guidelines, 2008.*

Further to the above, Acoustic Dynamics have been provided a Draft Amendment to the Auburn Development Control Plan 2010 specifically relating to 1A and 1B Queen Street, Auburn. The document reference is C030/17 – Attachment 1, has formed part of the Cumberland Independent Hearing & Assessment Panel (CIHAP) Meeting – 9 August 2017, and details the following information relating to acoustics:

*"**3.4 Acoustic Amenity***

Objectives

a. *Achieving occupant amenity by responding appropriately to noise emitters*

Development controls

D1 *An acoustic assessment prepared by a suitably qualified acoustic consultant is to be submitted with any development application for the site. The assessment should address, at minimum:*
   a. *Impact on acoustic privacy of proposed residential uses from any surrounding noise sources, such as road and rail traffic and industrial uses; and*
   b. *The impact of the development on the surrounding area, through mechanical services, earthworks, excavation and construction phases of development.*
   c. *Design of buildings shall comply with the internal noise levels in the SEPP Infrastructure Clause 102(3)"*

Acoustic Dynamics advises that the impacts from road traffic and industrial uses has not be specifically addressed in this report, as we do not foresee these being an issue. The impacts from road traffic and industrial uses into the development, and impacts from the construction phases of the development may be subject to assessment in the future, if deemed necessary.

2.3 NSW DEPARTMENT OF PLANNING AND INFRASTRUCTURE (DP&I)

2.4.1 STATE ENVIRONMENTAL PLANNING POLICY (SEPP) (INFRASTRUCTURE) 2007

The NSW Department of Planning and Infrastructure's (DP&I) State Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides guidance and criteria for the assessment of infrastructure development within NSW. It also identifies matters to be considered in the assessment of developments adjacent to infrastructure such as rail.

The policy details issues to be considered when assessing the impact of rail traffic noise on residential developments, such as the proposed development. The relevant guidelines and criteria within the policy have been reproduced below:

State Environmental Planning Policy (SEPP) (Infrastructure) 2007

Part 3 – Development Controls

Division 15 – Railways

Subdivision 2 – Development in Rail Corridors

Section 87 Impact of rail noise or vibration on non-rail development

(1) This clause applies to development for any of the following purposes that is on land in or adjacent to a rail corridor and that the consent authority considers is likely to be adversely affected by rail noise or vibration:

a) a building for residential use,
b) a place of public worship,
c) a hospital,
d) an educational establishment or child care centre.

(2) Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.

(3) If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:

a) in any bedroom in the building – 35 dB(A) at any time between 10.00 pm and 7.00 am,
b) anywhere else in the building (other than a garage, kitchen, bathroom or hallway) – 40 dB(A) at any time.

The above planning conditions can be enforced under the Environmental Planning and Assessment Act of 1979.

2.4.2 DEVELOPMENT NEAR RAIL CORRIDORS AND BUSY ROADS

The NSW DP&I document, *Development Near Rail Corridors and Busy Roads – Interim Guidelines*, provides information and criteria for the assessment of developments within close proximity to rail corridors and busy roads.

The interim guidelines include information on the appropriate methodology for assessment of rail traffic noise intrusion into a development. This is in accordance with the general noise assessment requirements contained within the NSW Environment Protection Authority's (EPA) Industrial Noise Policy (INP).

The relevant guidelines and criteria within the document have been reproduced below:

Development Near Rail Corridors and Busy Roads – Interim Guidelines

Section 3.6 What Noise and Vibration Criteria Should be Applied

3.6.1 Airborne Noise

The noise criteria for residential buildings in Table 3.1 for both road and rail are specified in the Infrastructure SEPP. Other values in Table 3.1 are based on the Environmental Criteria for Road Traffic Noise (EPA 1999).

These criteria apply to all forms of residential buildings as well as aged care and nursing home facilities. For some residential buildings, the applicants may wish to apply more stringent design goals in response to market demand for a higher quality living environment.
The night-time 'sleeping areas' criterion is 5 dB(A) more stringent than the 'living areas' criteria to promote passive acoustic design principles. For example, designing the building such that sleeping areas are less exposed to road or rail noise than living areas may result in less onerous requirements for glazing, wall construction and acoustic seals. If internal noise levels with windows or doors open exceed the criteria by more than 10 dB(A), the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia.

Table 2.3 – Noise criteria for residential buildings (Extract from Interim Guidelines Table 3.1)

Residential Buildings		
Type of Occupancy	***Noise Levels dB(A)***	***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*

3.6.1 Ground borne Noise

Generally, ground borne noise is associated more closely with rail operations than roads. Where buildings are constructed over or adjacent to land over tunnels, ground-borne noise may be present without the normal masking effect of airborne noise. In such cases, residential buildings should be designed so that the 95th percentile of train pass-bys complies with a ground-borne L_{Amax} noise limit of 40 dB(A) (daytime) or 35 dB(A) (night-time) measured using the "slow" response time setting on a sound level meter.

The Interim Guidelines for the Assessment of Noise from Rail Infrastructure Projects (DECC 2007) provides further guidance on this issue.

In some rare instances, ground borne noise may be an issue for noise sensitive locations adjacent to surface or elevated track (i.e. not just track in tunnel locations). These instances are uncommon, are not easily predicted, and will need to be assessed and managed on an individual basis, with the assistance of an acoustic consultant.

As a general guide, ground borne noise may be an issue in habitable rooms which are shielded from airborne noise from the railway. Examples are rooms that are not facing the railway, and where cuttings or noise barriers block the line of sight between the receiver room and the rail line. In addition, some structures such as suspended slabs can lend to vibration amplification.

3.6.3 *Vibration criteria*

Vibration levels such as the intermittent vibration emitted by trains should comply with the criteria in Assessing Vibration: a technical guideline (DECC 2006). The standards used for assessing the risk of vibration damage to structures are German Standard DIN 4150 Part 3 1999 and British Standard BS 7385 Part 2 1993. Human comfort is normally assessed with reference to the above British Standard or Australian Standard AS 2670.2 1990.

2.4 AUSTRALIAN STANDARDS

2.5.1 AS 2107 – "ACOUSTICS – RECOMMENDED DESIGN SOUND LEVELS..."

Australian Standard 2107:2016 recommends satisfactory and maximum design sound levels for various types of occupancy within buildings. AS 2107 recommends the following design sound levels for areas within a residential development:

Table 2.4 – Recommended design sound levels for different areas of occupancy in buildings (Extract from Australian Standard 2107 Table 1)

Type of Occupancy / Activity	Design Sound Level ($L_{Aeq,t}$) Range	Design Reverberation Time (T) Range, s
7 RESIDENTIAL BUILDINGS		
Houses and apartments in suburban areas or near minor roads –		
Living Areas	*35 to 45*	-
Sleeping Areas (night time)	*35 to 40*	-

2.5 INSTRUMENTATION & MEASUREMENT STANDARDS

All noise measurements are conducted in accordance with Australian Standard 1055.1-1997, *"Acoustics – Description and Measurement of Environmental Noise Part 1: General Procedures"*. Acoustic Dynamics' sound measurements are conducted using precision sound level meters conforming to the requirements of IEC 61672-2002 *"Electroacoustics: Sound Level Meters – Part 1: Specifications"*.

Vibration monitoring procedures are guided by the requirements of BS 7385: Part 2:1993 *"Evaluation and measurement for vibration in buildings, Part 2 – Guide to damage levels from ground-borne vibration"*. This Standard sets out the survey method for determining short-term and steady-state vibration levels on a structure and presents guideline velocity values for evaluating their effects. The survey instrumentation used during the survey is set out below.

Table 2.5 – Noise and Vibration Instrumentation

Model	Serial Number	Instrument Description
NTi XL2	A2A-06858-E0	Environmental Noise Logger
NTi XL2	A2A-06816-E0	Environmental Noise Logger
716A0406	BE9117	Instantel Minimate Plus
714A8302	BQ8234	Instantel Low Level Triaxial Vibration Transducer

The reference sound pressure level was checked prior to and after the measurements using the acoustic calibrator and remained within acceptable limits.

3 SITE SURVEY AND NOISE & VIBRATION MONITORING

Acoustic Dynamics attended site on Wednesday 22 June 2016. An unattended noise logger was deployed at a location representative of the most affected façade (for the proposed development). The noise logger was retrieved on Tuesday 28 June 2016.

Acoustic Dynamics attended site on Tuesday 21 March 2017. Attended vibration measurements were conducted over a one (1) hour period at a location representative of the most affected façade (for the proposed development).

The logging and measurements were used to establish the maximum noise and vibration levels from the use and operation of the adjacent road and rail corridor. Noise and vibration measurements were conducted in accordance with the assessment requirements of Cumberland Council and the Department of Planning and Infrastructure.

The prevailing weather conditions during the operator-attended noise and vibration measurements were generally calm and did not influence the noise measurements taken. The measurement location is shown in **Appendix A.**

3.1 RAIL TRAFFIC NOISE MONITORING

The external L_{Aeq} noise level have been determined for the daytime and night-time periods, in accordance with the relevant assessment guidelines. The following table presents the processed noise data obtained from the unattended noise loggers.

Table 3.1 – Measured $L_{Aeq(1\ hr)}$ Noise Levels

Location	Time of Day	Measured Maximum $L_{Aeq(1hour)}$ Noise Level[1] [dB]
1B Queen St, Auburn	Daytime (7am – 10pm)	69
	Night-time (10pm – 7am)	68

Note: 1) Measured noise levels at ground level location with no corrections included.
2) The assessment of external noise intrusion uses the procedure outlined in AS 3671.

3.2 RAIL TRAFFIC VIBRATION MONITORING

Following the rail vibration measurement survey, the results obtained were processed in accordance with the relevant standards to determine vibration dose values (VDVs). The results of our on-site rail traffic vibration measurement survey are presented in **Table 3.2**.

Table 3.2 – Operator Attended Vibration Measurement Results of Road & Rail Traffic Pass-bys

Train Direction	Measurement Description	Approximate Distance from Measurement Location to Rail Traffic [m]	Overall VDV_{event} [$mm/s^{1.75}$]
Eastbound	4 Car Passenger Train	7	3.0
Eastbound	8 Car Passenger Train	7	5.9
Eastbound	8 Car Passenger Train	7	4.3
Eastbound	8 Car Passenger Train	7	2.4
Eastbound	8 Car Passenger Train	16	2.7
Eastbound	8 Car Passenger Train	7	3.9
Westbound	8 Car Passenger Train	20	3.4
Eastbound	8 Car Passenger Train	16	2.8
Westbound	8 Car Passenger Train	7	3.7
Eastbound	8 Car Passenger Train	16	5.0
Westbound	8 Car Passenger Train	20	4.3
Westbound	4 Car Passenger Train	11	7.1
Eastbound	8 Car Passenger Train	16	4.0
Eastbound	8 Car Passenger Train	7	6.5
Westbound	4 Car Passenger Train	11	3.4
Eastbound	8 Car Passenger Train	7	3.1
Eastbound	8 Car Passenger Train	16	3.5
Eastbound	8 Car Passenger Train	7	3.1
Eastbound	8 Car Passenger Train	16	12.2
Eastbound	4 Car Passenger Train	7	3.2
Eastbound	4 Car Passenger Train	7	3.2

4 RESULTS

The following subsections provide an assessment of the proposed development against the various noise and vibration criteria and objectives outlined in **Section 2** above.

4.1 RAIL NOISE INTRUSION ASSESSMENT

Based on the measured noise levels of 20-rail pass-bys at the subject site, shown in **Table 3.2**, Acoustic Dynamics has calculated the maximum external noise level, shown in **Table 4.1** generated by rail traffic, at the most exposed facade of the proposed development. The overall external noise level ($L_{Aeq(1hr)}$) is conservatively calculated using the maximum measured rail traffic pass-by sound exposure level (L_{AE}) and the maximum frequency of trains per hour relevant to the assessment period (daytime and night-time).

Acoustic Dynamics has conservatively calculated the noise levels received from rail traffic at the facades of the proposed development based on an extremely conservative maximum of 20 trains per hour during the daytime and 8 trains per hour during the night-time. Further to the above, calculated noise levels do not incorporate any acoustic barrier/fence at the northern boundary.

Following the determination of the maximum external noise levels at the proposed development, Acoustic Dynamics has conducted calculations to determine the minimum required component noise attenuation performance (R_w) for the various building components, to achieve the relevant required internal noise levels. The minimum required component R_w's are also detailed in **Table 4.1** below.

4.1.1 COMPONENT NOISE ATTENUATION PERFORMANCE (R_W)

Using the maximum calculated external sound levels and indoor criteria presented within **Table 2.1**, the minimum required noise attenuation performance (R_w) for critical building components was calculated in order to achieve the required internal noise levels. The minimum required component R_w's are detailed in **Table 4.1** below.

The internal design sound level for any particular area of the subject development is the maximum permissible L_{Aeq} noise level within that area, with external windows and doors closed. The internal design sound levels applicable to the critical areas of the proposed development have been determined in accordance with the criteria and guidelines of Cumberland Council and the NSW DP&I, and are presented in **Table 4.1** below.

Table 4.1 – Component Noise Attenuation & Rw for Most Exposed Facades

Unit #	Type of Area	Maximum Indoor Design Sound Level L_{Aeq} (windows closed) [dB][1]	Calculated Maximum External Rail Noise Level $L_{Aeq,\ 1hr}$ [dB][2]	Required Component Noise Attenuation					
				Walls[5]		Glazing[5]		Roof[3]	
				ANA_C	R_W	ANA_C	R_W	ANA_C	R_W
Building A1 B1 C1									
Ground Floor									
G01	Lounge	40	65	28	34	25	31	N/A	N/A
	Bed 1	35	65			28	34		
	Bed 2	35	65			27	33		
G02 G06 G07	Bed	35	65			28	34		
	Lounge	40	65			23	29		
G03	Bed 1	35	65			28	34		
	Lounge	40	65			25	31		
G04	Lounge	40	65			23	29		
G05	Bed 1	35	65			28	34		
	Lounge	40	65			23	29		
G08	Bed	35	65			28	34		
	Lounge	40	65			23	29		
G09 G10 G011			**NB: All remaining units and facades not listed above require standard construction materials to adequately achieve internal sound level criteria.**						
First Floor to Fifth Floor									
101 201 301 401 501	Lounge[4]	40	65	28	34	25	31	N/A	N/A
	Bed 1[4]	35	65			27	33		
	Bed 2	35	65			25	31		
102 202	Bed 1	35	65			23	29		
302 402	Bed 2[4]	35	65			18	24		
502	Lounge[4]	40	65			13	19		
103 104 203	Bed 1[4]	35	65			16	22		
204 303 304 403	Lounge[4]	40	65			13	19		
404 503 504	Bed 2	35	65			19	25		

Unit #	Type of Area	Maximum Indoor Design Sound Level L_{Aeq} (windows closed) [dB][1]	Calculated Maximum External Rail Noise Level $L_{Aeq,\ 1hr}$ [dB][2]	Required Component Noise Attenuation					
				Walls[5]		Glazing[5]		Roof[3]	
				ANA_C	R_W	ANA_C	R_W	ANA_C	R_W
105 106 205 206 305	Bed[4]	35	65			16	22		
306 405 406 505 506	Lounge[4]	40	65			13	19		
107	Bed[4]	35	65			18	24		
	Lounge[4]	40	65			11	17		
108 109 110 111 208 209 210 211 308 309 310 311 408 409 410 411 508 509 510 511			**NB: All remaining units and facades not listed above require standard construction materials to adequately achieve internal sound level criteria.**						
Sixth Floor and Seventh Floor									
703	Bed 1	35	60	28	34	24	30 (East)	31	37
	Lounge	40	60			15	21		
	Bed 2	35	60			24	30 (West)		
601 602 603 604 605 606 607 608 609 701 702 704 705 706 707 708			**NB: All remaining units and facades not listed above require standard construction materials to adequately achieve internal sound level criteria.**						
All Remaining Building (A2 B2 C2, A3 B3 C3 & A4 B4 C4)									
Standard construction material will be adequate to achieve internal sound level criteria									

Note: 1) Maximum indoor design sound level based on SEPP criteria. See **Table 2.1**.

2) The calculated maximum external rail noise levels are $L_{Aeq(1\ hr)}$ noise levels, based on the calculated maximum daytime/night-time noise levels, and include adjustments to take account of distance losses and shielding provided by the structure of the development.

3) Applicable to rooms with sections of exposed roof.

4) Incorporates the attenuation provided by the wintergarden in the partially open position. A conservative transmission loss of 10 dB via the wintergarden is assumed.

5) Rw values for each unit are based on the most affected façade. Unless otherwise stated, assume northern façade.

Further to the information presented in **Table 4.1**, noise intrusion calculations have also been carried out for areas throughout the development less exposed to road and rail traffic noise intrusion, to enable appropriate recommendations for external construction systems to be provided.

During peak periods of high rail noise levels, the calculated noise levels within the majority of residential units on the northern façade of building A1 B1 C1 of the

development will exceed the relevant internal noise level criteria by more than 10 dB, with the most exposed façade (northern) windows and/or glass doors open. We advise that alternative, less exposed windows of these residential units would be able to remain open (where available) during these periods. This will provide the option for appropriate ventilation of the dwelling, and provide building occupants with the option to leave most exposed external doors and windows closed, during peak periods of external noise levels. Accordingly, the proposed development is assessed as achieving compliance with the relevant acoustic requirements.

4.2 RAIL VIBRATION INTRUSION ASSESSMENT

Table 4.2 presents a summary of the processed operator-attended vibration measurements results presented in **Table 3.3** for the vibration measurement location.

Table 4.2 – Summary of Maximum Vibration Dose Values (VDVs) for Road & Rail Traffic Pass-bys

Measurement Description	Maximum Measured Overall VDV_{event} [$mm/s^{1.75}$]	Calculated Maximum Overall Daytime VDV [$mm/s^{1.75}$]	Calculated Maximum Overall Night-time VDV [$mm/s^{1.75}$]	Acceptable Daytime VDV (Residential) [$mm/s^{1.75}$]	Acceptable Night-time VDV (Residential) [$mm/s^{1.75}$]
8 Car Passenger Train	12.2	30.9	21.7	200 ($0.2m/s^{1.75}$)	130 ($0.13m/s^{1.75}$)

The calculated VDVs are significantly below the daytime and night-time vibration dose criteria for a residential building of 200 $mm/s^{1.75}$ ($0.2m/s^{1.75}$) and 130 $mm/s^{1.75}$ ($0.13m/s^{1.75}$) respectively.

Based on the above information and the results of our vibration measurements and analyses, we advise that normal construction methods and techniques will ensure that levels of vibration received within the proposed development, from rail traffic, are well within acceptable limits.

5 RECOMMENDATIONS AND DESIGN ADVICE

Acoustic Dynamics' analysis and prediction calculations indicate the following recommendations should be incorporated into the proposed development, as a minimum, to ensure that the internal design sound levels are achieved.

5.1 EXTERNAL WALL SYSTEMS

Acoustic Dynamics advise that standard construction will be adequate to achieve internal sound level criteria. A minimum Rw 45 for the external wall construction system will adequately reduce rail noise intrusion and other external noise intrusion into the subject development.

5.2 ROOF SYSTEM

Acoustic Dynamics advise that standard construction will be adequate to achieve internal sound level criteria. A minimum Rw 45 for the external wall construction system will adequately reduce rail noise intrusion and other external noise intrusion into the subject development.

5.3 WINDOWS / GLASS DOORS

The following table sets out the minimum required glazing for the windows and glass doors throughout the proposed development to ensure that the internal design sound levels are achieved.

Table 5.1 – Window & Glass Door Glazing Thickness Schedule

Unit #	Area of Window/ Door	Minimum R_W Required for Window/ Door System[1]	Minimum Glazing Recommended	
			Option 1 (Preferred)	Option 2 (Alternative)
Building A1 B1 C1				
Ground Floor (Northern Façade)				
G01	Lounge	31	6.5 mm Hush Laminated	8.38 mm Laminated
	Bed 1	34	10.38 mm Laminated	6.5 mm VLam Hush
	Bed 2	33	10.38 mm Laminated	6.5 mm VLam Hush
G02 G06 G07	Bed	34	10.38 mm Laminated	6.5 mm VLam Hush
	Lounge	29	6.38 mm Laminated	10 mm Monolithic
G03	Bed 1	34	10.38 mm Laminated	6.5 mm VLam Hush
	Lounge	31	6.5 mm Hush Laminated	8.38 mm Laminated
G04	Lounge	29	6.38 mm Laminated	10 mm Monolithic
G05	Bed 1	34	10.38 mm Laminated	6.5 mm VLam Hush
	Lounge	29	6.38 mm Laminated	10 mm Monolithic
G08	Bed	34	10.38 mm Laminated	6.5 mm VLam Hush
	Lounge	29	6.38 mm Laminated	10 mm Monolithic
G09 G10 G011	**NB: All remaining units and facades not listed above require standard glazing to adequately achieve internal sound level criteria.**			
First Floor to Fifth Floor				
101 201 301 401 501	Lounge[4]	31	6.5 mm Hush Laminated	8.38 mm Laminated
	Bed 1[4]	33	10.38 mm Laminated	6.5 mm VLam Hush
	Bed 2	31	6.5 mm Hush Laminated	8.38 mm Laminated

Unit #	Area of Window/ Door	Minimum R_w Required for Window/ Door System[1]	Minimum Glazing Recommended	
			Option 1 (Preferred)	Option 2 (Alternative)
102 202 302 402 502	Bed 1	29	6.38 mm Laminated	10 mm Monolithic
	Bed 2[4]	24	5 mm Monolithic	-
	Lounge[4]	19	5 mm Monolithic	-
103 104 203 204 303 304 403 404 503 504	Bed 1[4]	22	5 mm Monolithic	-
	Lounge[4]	19	5 mm Monolithic	-
	Bed 2	25	5 mm Monolithic	-
105 106 205 206 305 306 405 406 505 506	Bed[4]	22	5 mm Monolithic	-
	Lounge[4]	19	5 mm Monolithic	-
107 207 307 407 507	Bed[4]	24	5 mm Monolithic	-
	Lounge[4]	17	5 mm Monolithic	-
108 109 110 111 208 209 210 211 308 309 310 311 408 409 410 411 508 509 510 511		**NB: All remaining units and facades not listed above require standard glazing to adequately achieve internal sound level criteria.**		
Sixth Floor and Seventh Floor				
703	Bed 1	30 (East)	6.5 mm Hush Laminated	8.38 mm Laminated
	Lounge	21	5 mm monolithic	-
	Bed 2	30 (West)	6.5 mm Hush Laminated	8.38 mm Laminated
601 602 603 604 605 606 607 608 609 701 702 704 705 706 707 708		**NB: All remaining units and facades not listed above require standard glazing to adequately achieve internal sound level criteria.**		
All Remaining Building (A2 B2 C2, A3 B3 C3 & A4 B4 C4)				
Standard glazing will be adequate to achieve internal sound level criteria				
All Wintergarden Glazing (A1 B1 C1)				
Wintergardens should have minimum 6.38mm laminated glazing				

Note: 1) Minimum glazing has been specified to meet acoustic requirements. Acoustic Dynamics advises that some windows/glass doors may also need to meet applicable safety standards. Additional advice should be sought to verify such requirements.

Acoustic Dynamics advises that the installation of all windows and glass doors must ensure an adequate acoustic (air tight) seal when closed. Any sound flanking paths around the windows must be sealed to provide adequate acoustic insulation. All gaps between the window frame and the wall structure should be sealed using polystyrene rods and silicone mastic sealant, prior to the fitting of architraves.

It is advised that the acoustic performance of the selected windows frames should be confirmed with the suppliers, to ensure that the glazing and frame systems will achieve the minimum acoustic performance levels (R_w) recommended in **Table 5.1** above.

6 CONCLUSION

Acoustic Dynamics has conducted an assessment of road and rail noise and vibration intrusion into the proposed residential development at 1A & 1B Queen Street, Auburn, NSW. A review of applicable noise standards and local authority noise criteria was conducted. Noise levels were assessed in accordance with the requirements of:

(a) Cumberland Council;
(b) NSW Department of Planning; and
(c) Australian Standards.

The performance of the building components proposed for use in the development have been assessed against the R_w values presented in **Table 4.1**, to determine their suitability for achieving compliance with the noise criteria.

The assessment examined the facades most exposed to noise intrusion, as well as facades less exposed to rail traffic noise intrusion, providing a minimum requirement and allowing for the optimised selection of components for the respective areas within the development.

Recommendations and advice have been provided in **Section 5** for material selection to be used in construction for:

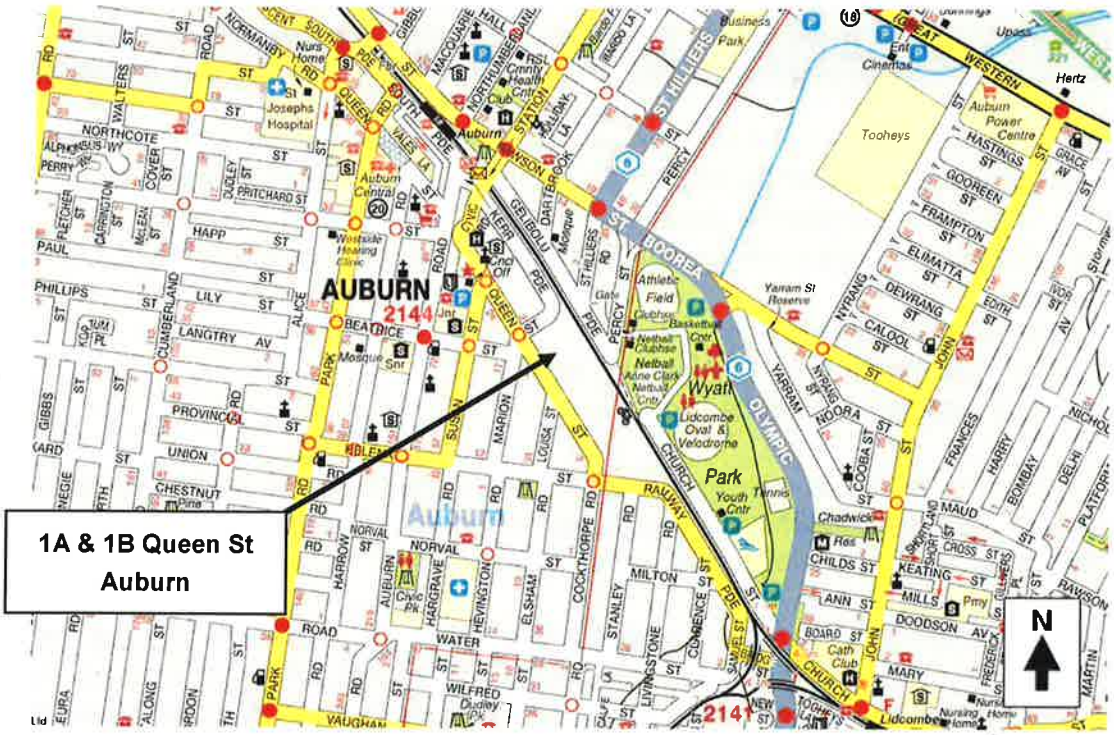
(a) Walls;
(b) Ceiling and roof; and
(c) Windows and doors.

Should alternative construction systems and materials be selected, they must meet the required objective design noise reduction shown in **Table 4.1** for the respective areas within the development.

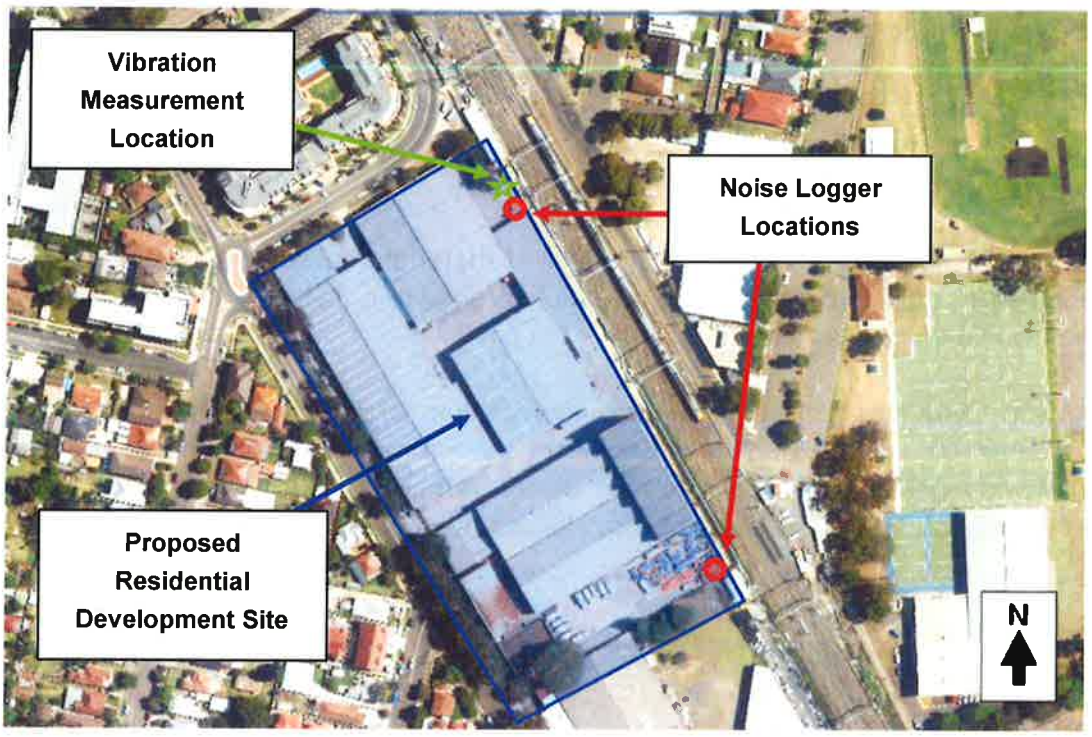
Acoustic Dynamics advises that the incorporation of the recommendations of this report into the design and construction of the proposed development will achieve compliance with the relevant acoustic design requirements of Cumberland Council, the NSW Department of Planning and relevant Australian Standards.

APPENDIX A – LOCATION MAP, AERIAL PHOTO & DRAWINGS

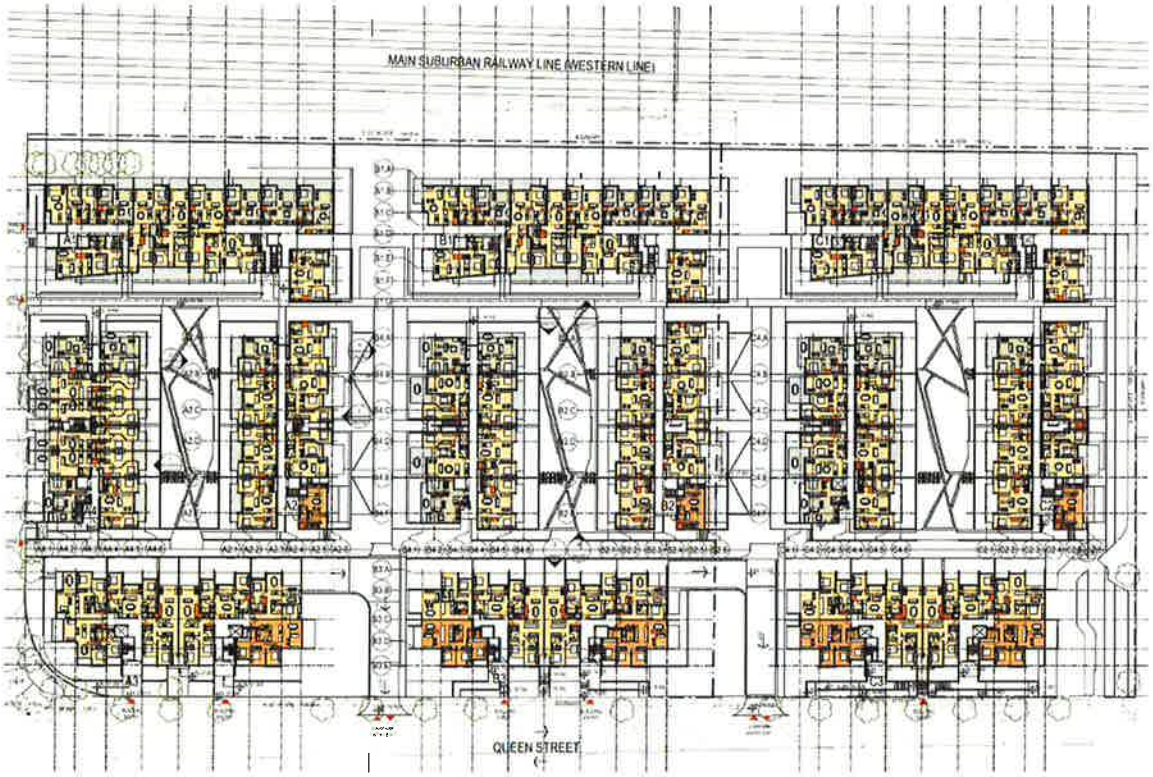
A.1 LOCATION MAP



A.2 AERIAL PHOTO WITH NOISE & VIBRATION LOGGING LOCATIONS



A.2 DRAWINGS



General Site Plan (GF plan show)

Northern Elevation – C1 B1 A1

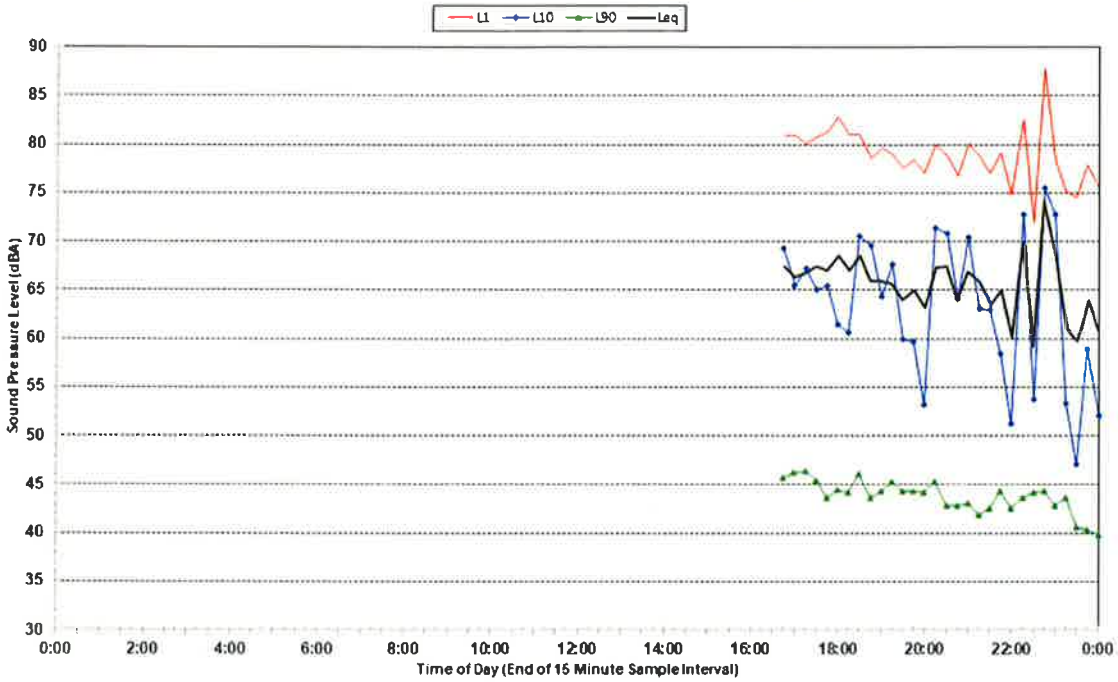
Southern Elevation

Eastern Elevation – C3 C2 C1

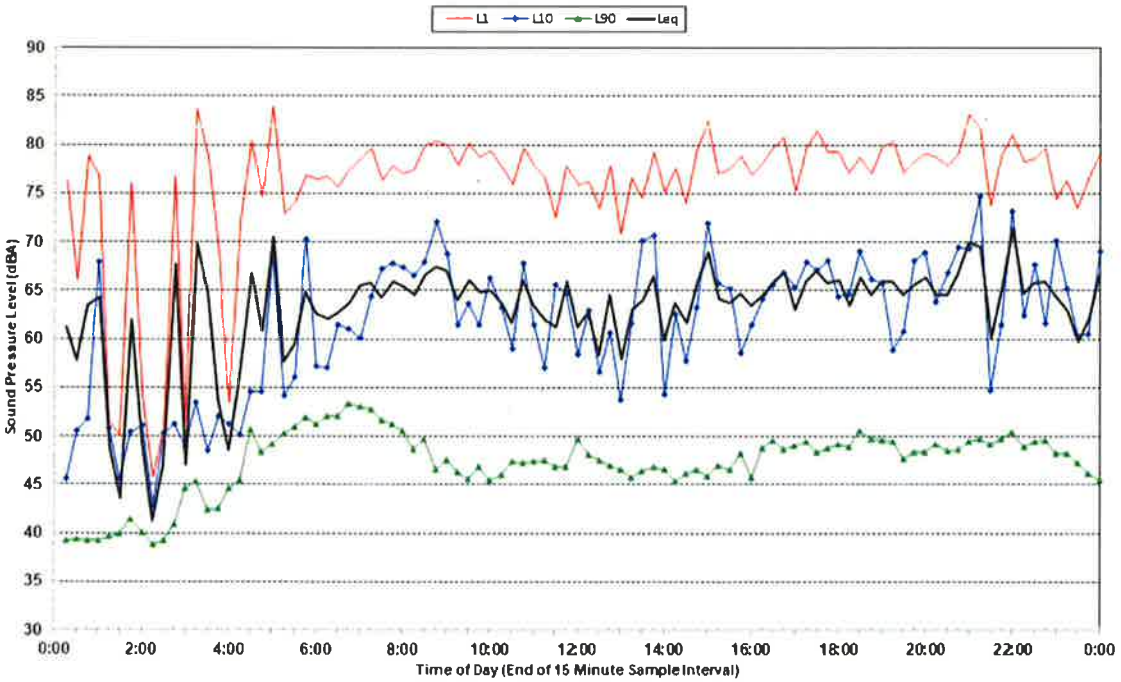
Western Elevation – A1 A4 A3

APPENDIX B – UNATTENDED NOISE LOGGER DATA

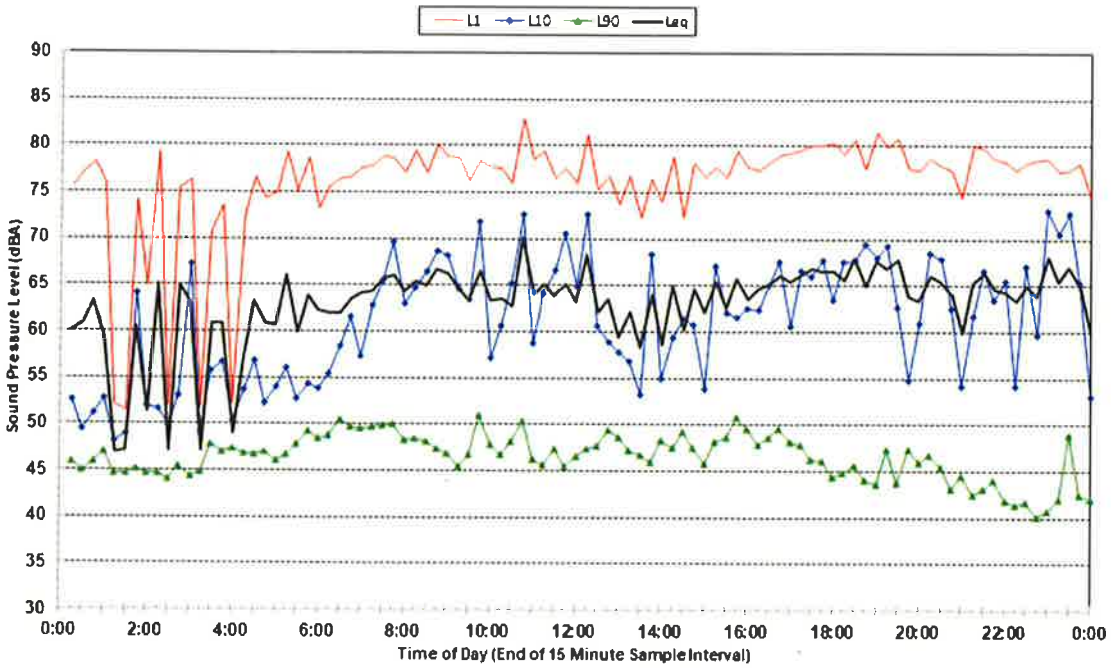
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Wednesday 22 June 2016



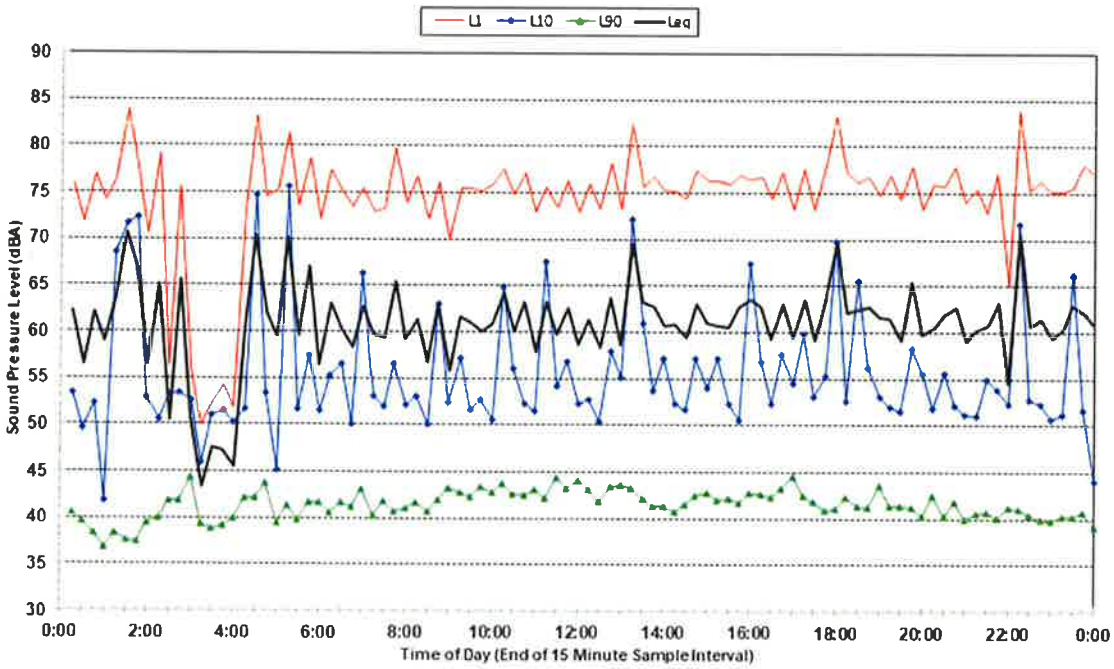
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Thursday 23 June 2016



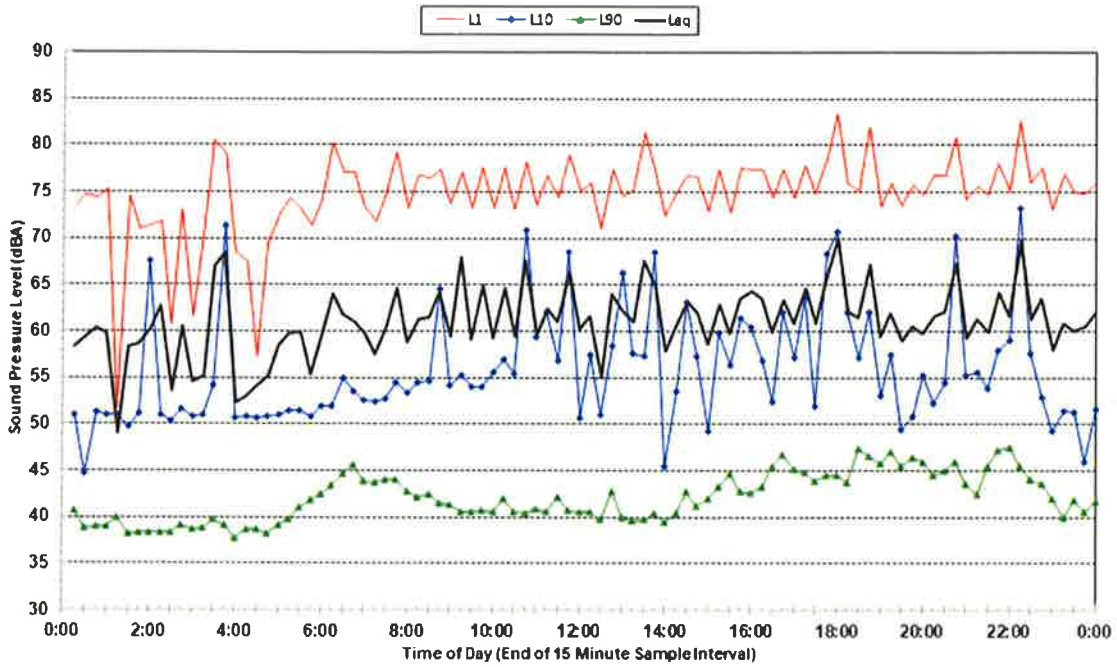
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Friday 24 June 2016



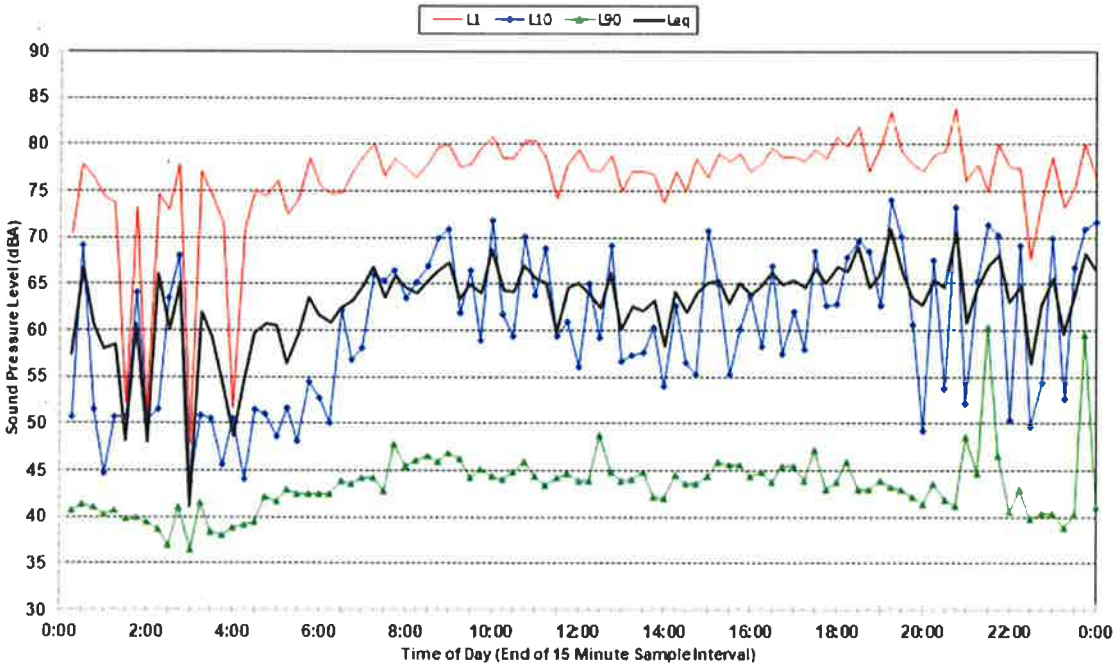
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Saturday 25 June 2016



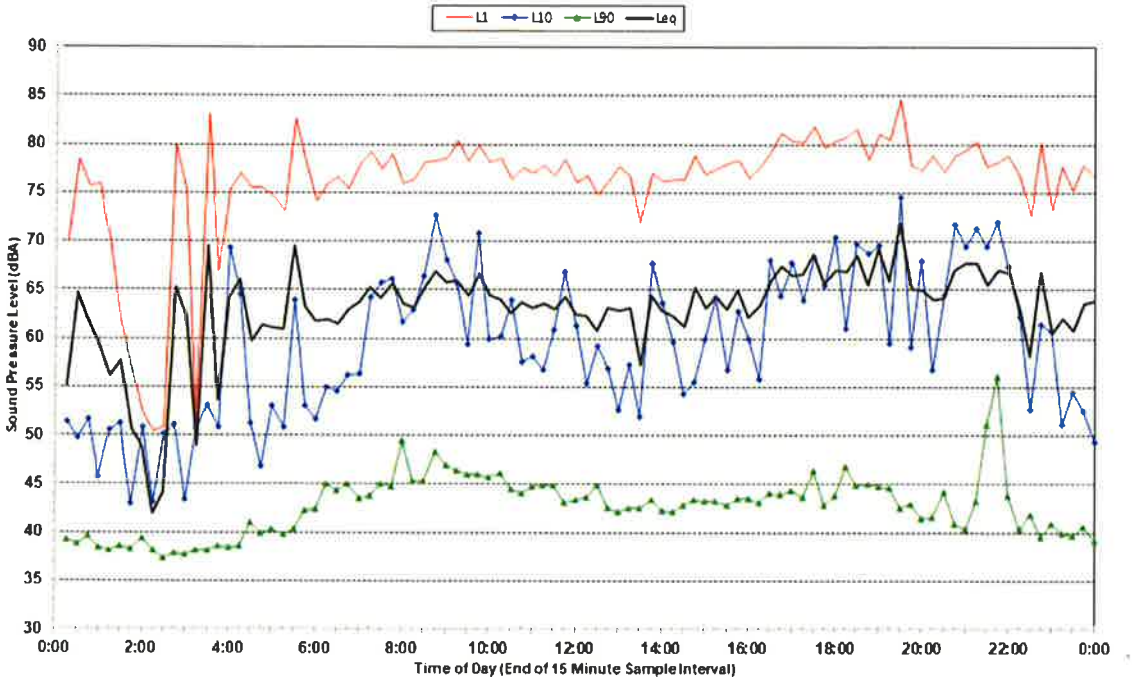
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Sunday 26 June 2016



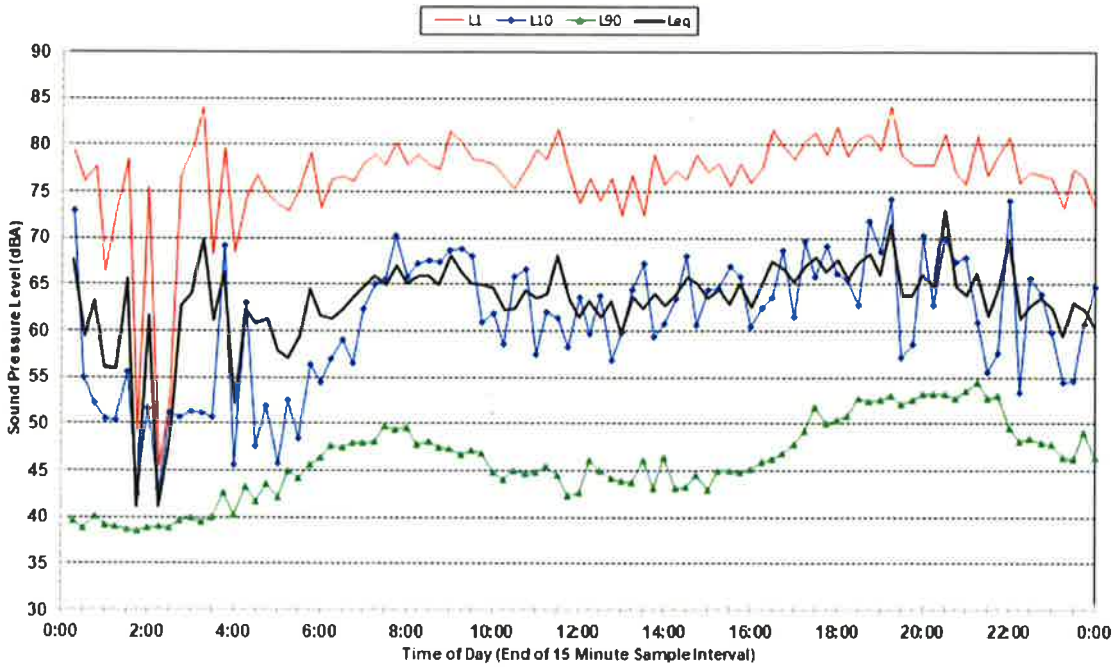
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Monday 27 June 2016



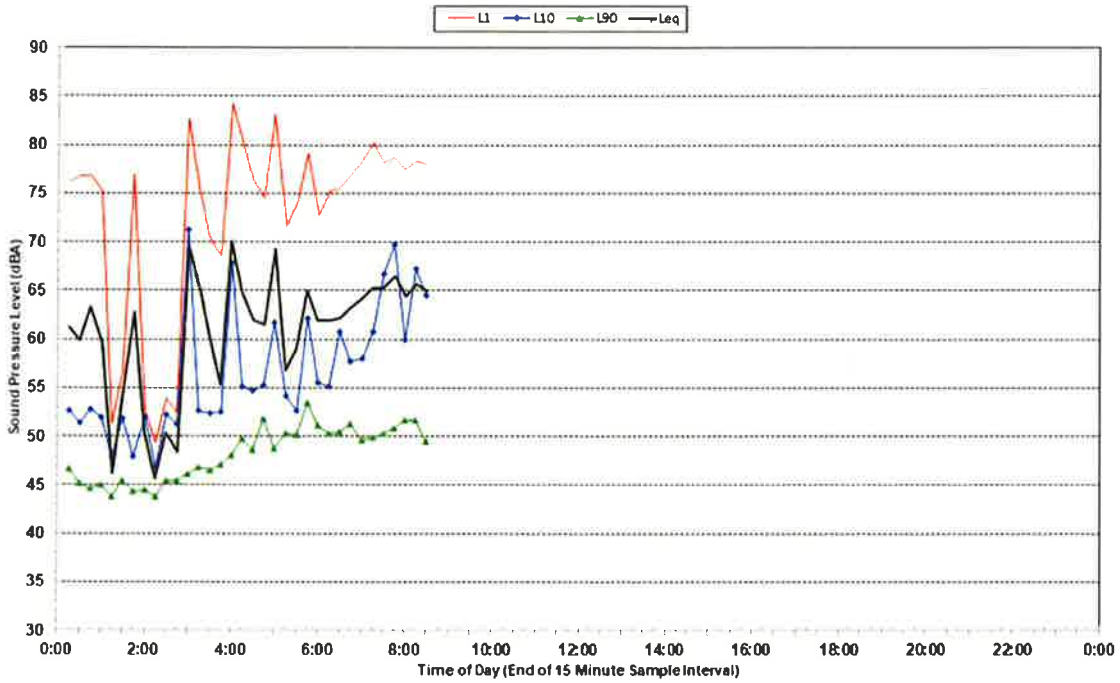
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Tuesday 28 June 2016



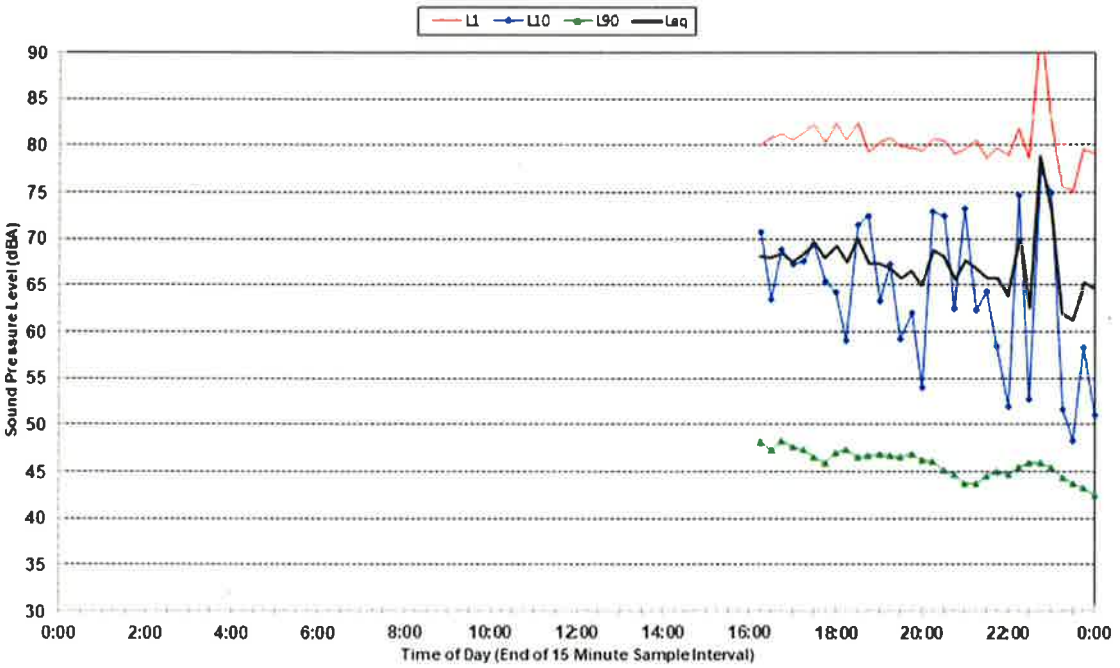
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Wednesday 29 June 2016



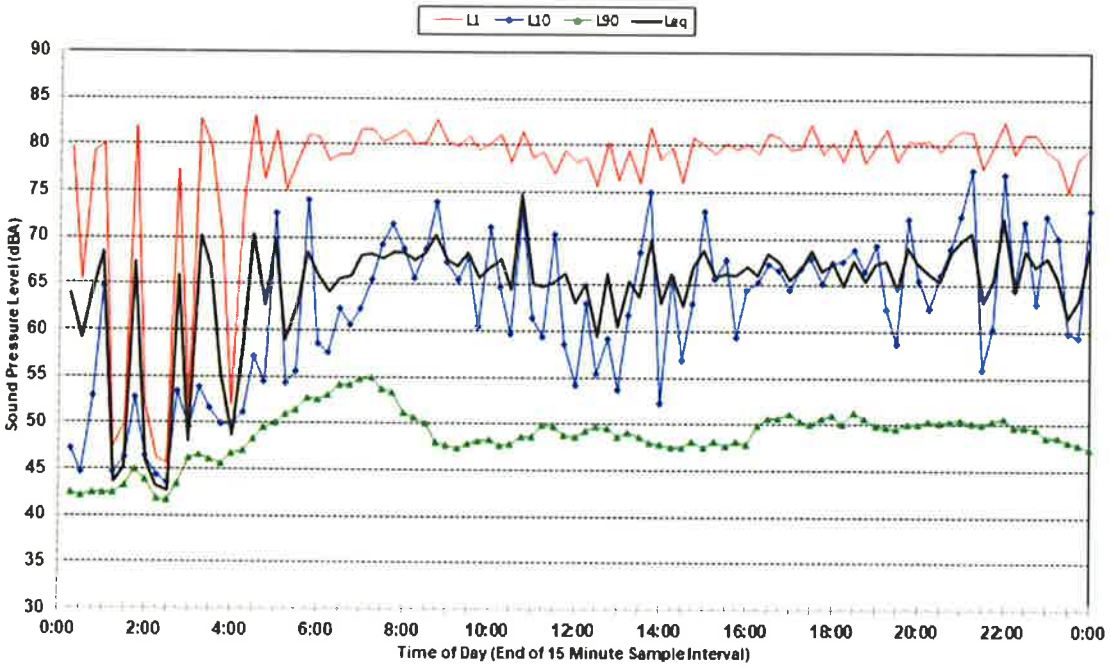
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Thursday 30 June 2016



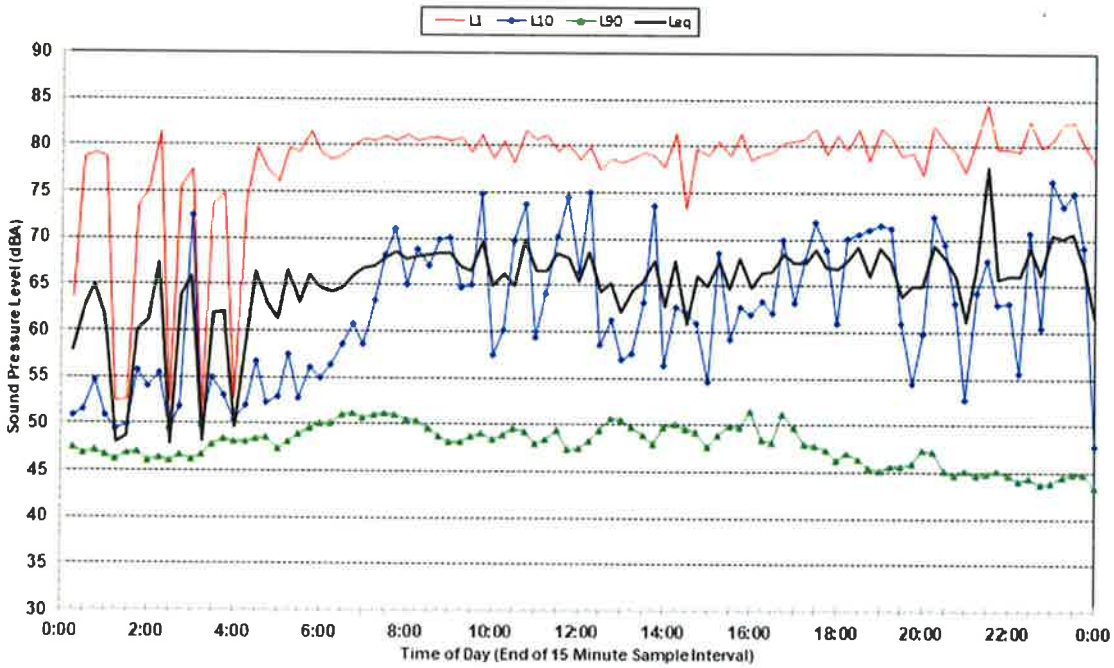
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Wednesday 22 June 2016



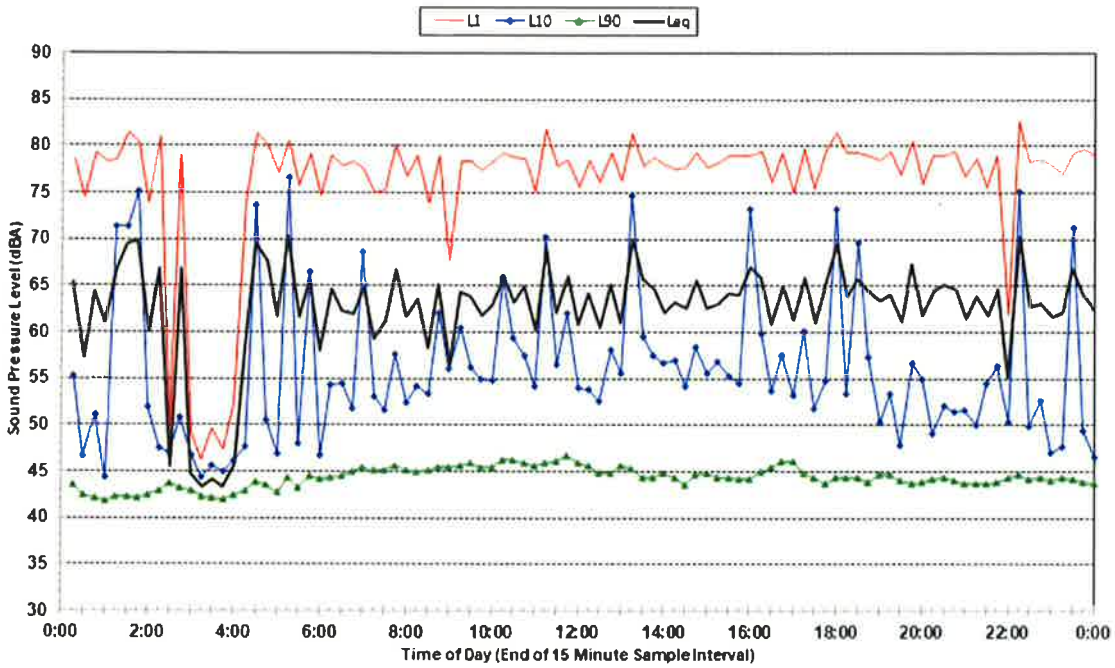
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Thursday 23 June 2016



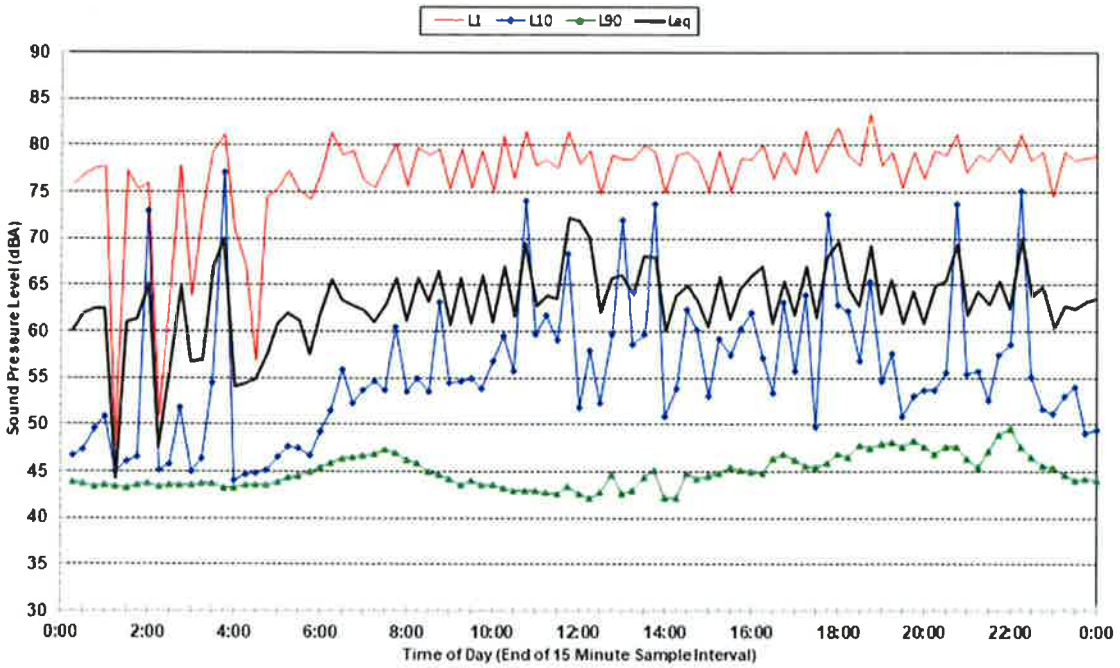
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Friday 24 June 2016



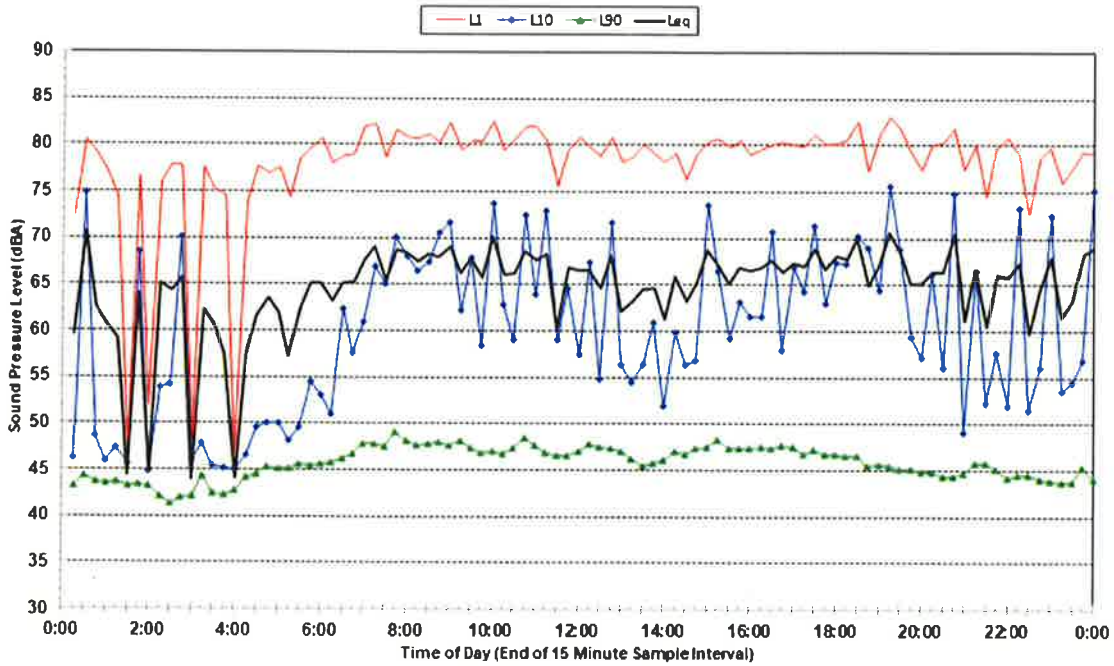
Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Saturday 25 June 2016



Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Sunday 26 June 2016



Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Monday 27 June 2016



Statistical Ambient Noise Levels
3872 1A & 1B Queen St Auburn - Tuesday 28 June 2016