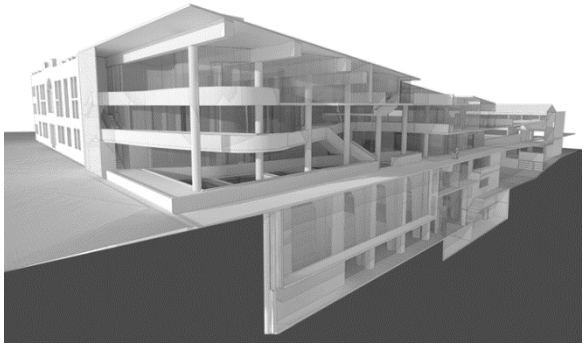
ACOUSTICS AND AIR

PROJECT ARCHIMEDES

CONSTRUCTION AND OPERATIONAL NOISE AND VIBRATION ASSESSMENT



REPORT NO. 14351-1
VERSION D

JULY 2015

PREPARED FOR

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DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
A	Final	23 March 2015	Ben Lawrence	Neil Gross
B	Final	7 April 2015	Ben Lawrence	-
C	Final	16 July 2015	Ben Lawrence	-
D	Final	17 July 2015	Ben Lawrence	-

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Wilkinson Murray is an independent firm established in 1962, originally as Carr & Wilkinson. In 1976 Barry Murray joined founding partner Roger Wilkinson and the firm adopted the name which remains today. From a successful operation in Australia, Wilkinson Murray expanded its reach into Asia by opening a Hong Kong office early in 2006. 2010 saw the introduction of our Queensland office and 2011 the introduction of our Orange office to service a growing client base in these regions. From these offices, Wilkinson Murray services the entire Asia-Pacific region.

TABLE OF CONTENTS

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

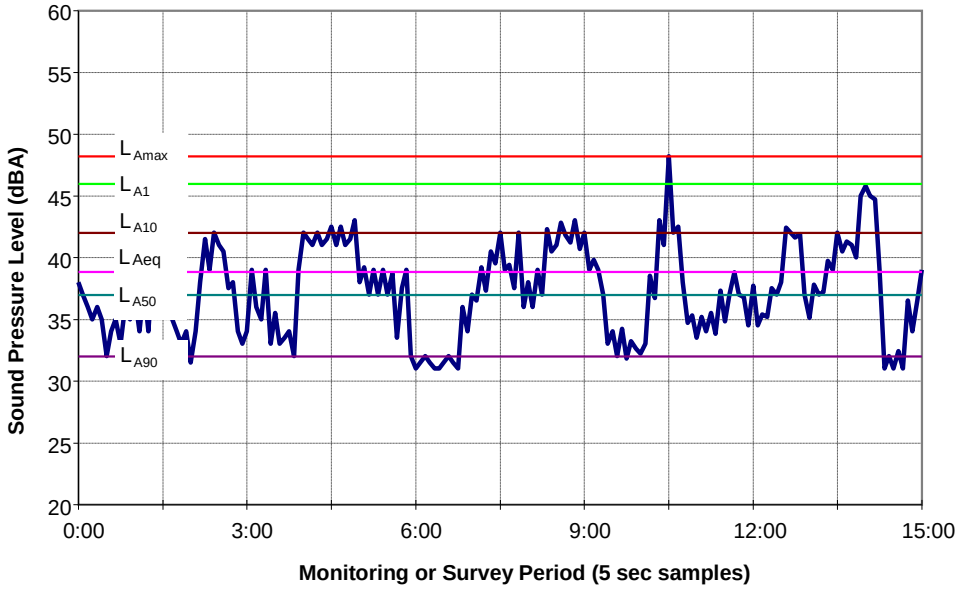
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

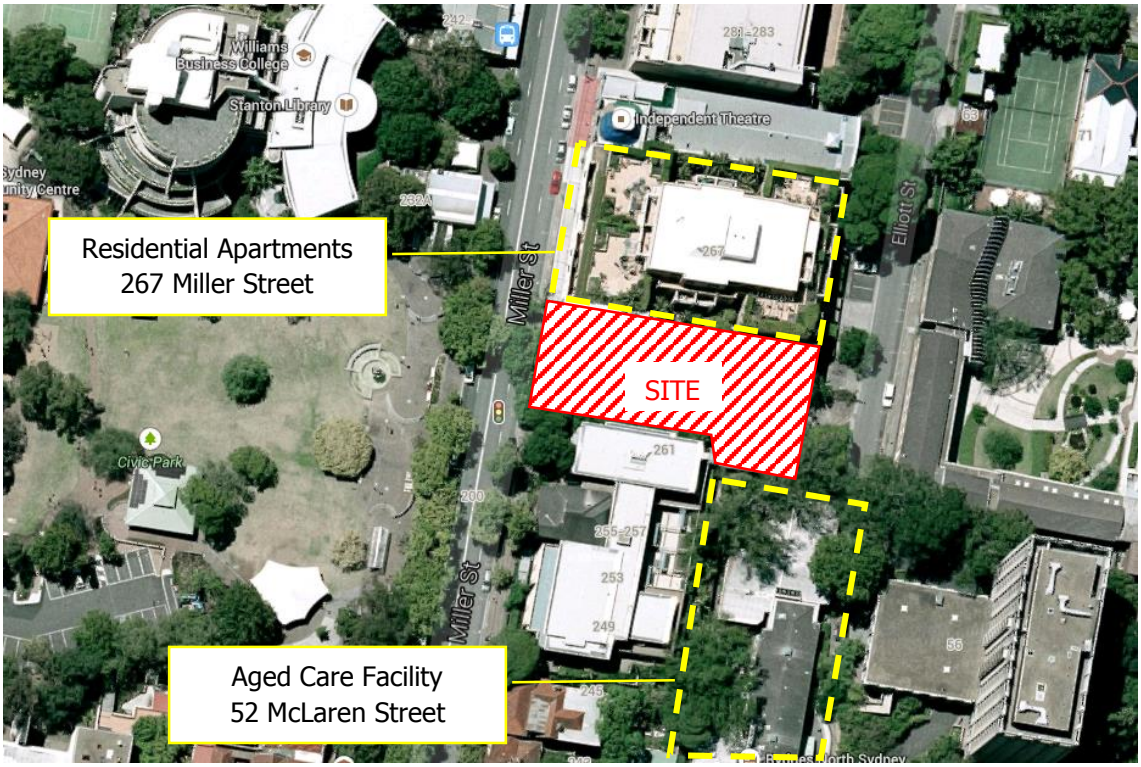
A new swim centre and educational facility has been proposed by Wenona School that will cover existing lots at 249-265 Miller Street and 6 Elliot Street, North Sydney. This new multi-storey building will link to other areas of the existing campus to the east (via a footbridge) and south. Wilkinson Murray has been commissioned to assess noise and vibration produced by this development during construction and operation phases, and its potential acoustic impact on the surrounding community. This report addresses:

- Noise and vibration produced by construction activities;
- Operational noise and vibration produced by school activities;
- Noise and vibration produced by mechanical plant; and
- Traffic noise ingress from Miller Street.

2 SITE DESCRIPTION

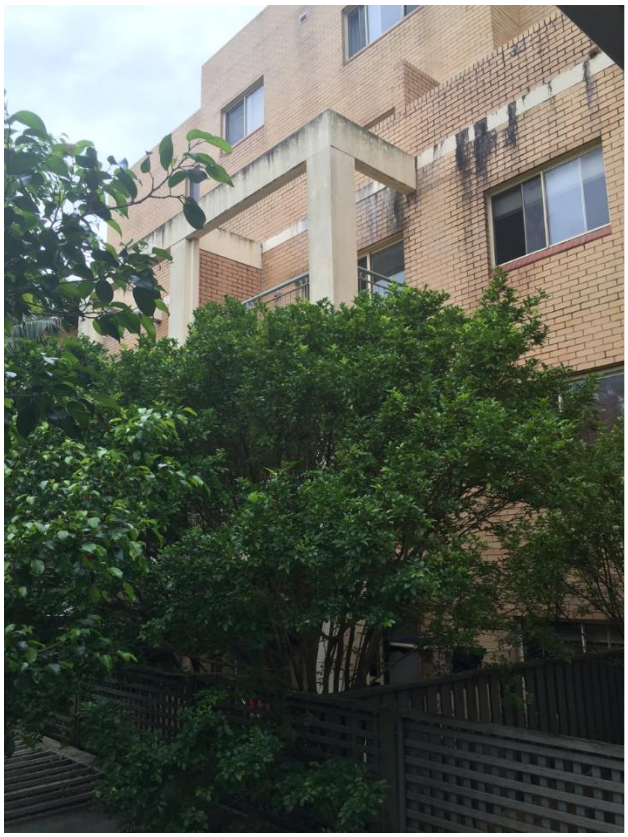
The proposed site location and proximity to neighbouring residential and aged care receivers is shown in Figure 2-1. This will include parts of the existing Wenona Miller Street campus to the south.

Figure 2-1 Site Location



The site shares the northern boundary with a multi-storey residential apartment building 'Regency Park'. This adjacent development contains several apartments with balconies and windows facing south, towards the proposed site as shown in Figure 2-2.

Figure 2-2 Regency Park Apartments



The Georgian House Seniors Day Centre is located to the south east of site, as shown in Figure 2-3. This centre provides long day respite care to support working and non-working carers between the hours of 8.00am and 6.00pm Monday to Friday. This site is subject to a Stage 1 development consent for a new aged care facility, but we are unclear on the future plans here.

Figure 2-3 Northern Boundary of Aged Care Facility (View from Elliot Street)

There are two spaces on Levels 1 and 2 of the proposed facility that are exposed to potential traffic noise from Miller Street. These are the Staff Offices and the Senior Ecosystem. Both of these spaces have operable glazed facades with breakout areas (balconies) overlooking Miller Street. The Senior Ecosystem will be used for informal study and group work, without formal teaching. Balconies in this area will not be used to teaching purposes.

The new facility is expected to be used during the daytime period (7.00am to 6.00pm), with occasional use during the evening period.

3 EXISTING AMBIENT NOISE LEVELS

Two unattended noise monitors were installed between Monday, 23 February and Monday, 11 March 2015. The logging particulars of these monitors is presented in Table 3-1.

Table 3-1 Logging Particulars

Location	Start	End	Comment
Level 1 Balcony, 265 Miller Street	23/2/15 14:30	4/3/15 21:45*	Representative of residential apartments to the north
Level 1 Balcony, 255 Miller Street	23/2/15 14:45	9/3/15 14:30*	Representative of western facade exposed to traffic noise on Miller Street

Note: *logger stopped due to expected battery depletion.

The noise monitoring equipment used for the noise measurements consisted of an ARL EL215 Noise Logger set to A-weighted, fast response, continuously monitoring each 15-minute period. This equipment is capable of monitoring and storing various noise level descriptors for later detailed analysis. From the background noise levels (L_{A90}), the Rating Background Levels (RBL's) were determined using the methodology recommended by the EPA's *NSW Industrial Noise Policy (INP)*. EPA considers the RBLs to represent the background noise level. The equipment calibration was checked before and after the survey and no significant drift was noted.

Table 3-2 summarises the results, for daytime, evening and night time periods as defined in the *INP*. Detailed charts are included in Appendix A.

Table 3-2 Measured Rating Background Noise Levels (RBLs)

Time Period	RBL* (dBA)	
	265 Miller Street	255 Miller Street
Daytime	54	59
Evening	47	54
Night Time	40	50

* See Glossary of Acoustic Terms for full RBL definition.

For the purposes of assessing construction noise, further analysis has been conducted to assess Saturday works. Table 3-3 summarises the results, for daytime, evening, night time, and Saturday periods used for assessing construction noise. Detailed charts are included in Appendix A.

Table 3-3 Measured Rating Background Noise Levels (RBLs)

Time Period	RBL* (dBA)
	265 Miller Street
Daytime (7am to 6pm)	54
Evening (6pm to 10pm)	47
Night Time (10pm to 7am)	40
Saturday (8am to 1pm)	49
Saturday (8am to 5pm)	50

* See Glossary of Acoustic Terms for full RBL definition.

Background noise levels at all locations were free of the influence of extraneous noise sources, such as plant or construction activities. Noise data measured during inclement weather was excluded in accordance with EPA procedures.

4 EXISTING TRAFFIC NOISE LEVELS

The second logger was placed on the Level 1 balcony at 255 Miller Street to also measure the existing level of traffic noise at a similar setback to the balconies / breakout spaces in the new facility. This would give valuable feedback to the design of the western facade and whether traffic noise would adversely affect the proposed spaces in this region. A photograph showing the location of this logger is shown in Figure 4-1.

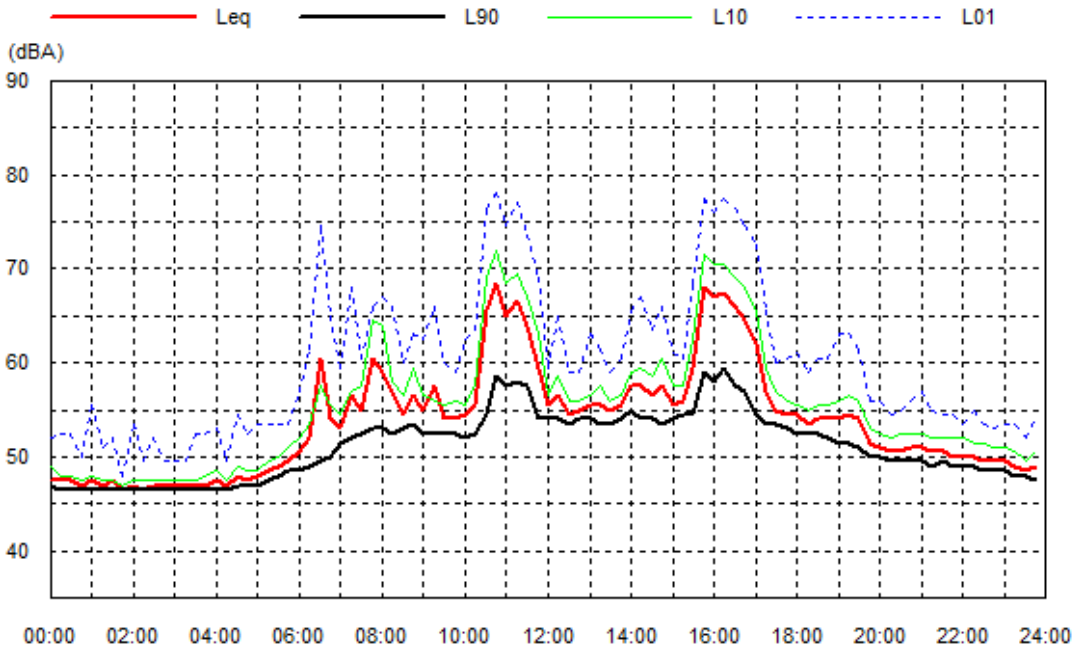
Figure 4-1 Location of Logger at 255 Miller Street

During our site visits on 23 February and 11 March, only light traffic was observed. For example, over an average 2-minute period (23 February, 3.00pm) the following traffic counts were logged:

- 20 cars;
- 1 bus; and
- 1 truck.

We acknowledge that this is not always the case, as shown in the following typical weekday noise logging graph. There appears to be a noticeable increase in noise activity (assumed to be traffic) between 10.30am and 12.00pm in the morning, and 3.30pm and 5.00pm in the afternoon, as depicted in the **red** L_{Aeq} trace.

Figure 4-2 Typical Daily Noise Plot – 255 Miller Street, 24 February 2015



Even so, typical worst case L_{Aeq} levels from traffic are no greater than 67dBA. During our site survey, the following noise spectrum was measured from traffic noise. This spectrum has been used for the calculation of glazing requirements.

Table 4-1 Measured Traffic Noise Spectrum

	Octave Band Leq,15min (dB)							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Traffic Noise	42	46	51	56	58	55	50	42

5 CONSTRUCTION NOISE & VIBRATION ASSESSMENT

The following sections detail the applicable site-specific noise and vibration criteria based on the guidelines from EPA, being the *Interim Construction Noise Guideline* and *Assessing Vibration: A Technical Guideline*.

5.1 Construction Noise Management Levels (NML's)

The EPA released the "*Interim Construction Noise Guideline*" *(CNG)* in July 2009. The guideline provides noise goals that assist in assessing the impact of construction noise.

For residences, the basic daytime construction noise goal is that the $L_{Aeq,\ 15min}$ noise management level should not exceed the background noise by more than 10dBA. This is for standard hours: Monday to Friday 7.00am-6.00pm, and Saturday 8.00am-1.00pm. Outside the standard hours, where construction is justified, the noise management level would be background + 5dBA. Table 5-1 details the *ICNG* noise management levels and its application.

Table 5-1 Construction Noise Management Levels at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

Note that for other receivers (aged care facility/nursing home), the construction noise management levels $L_{Aeq,15\ min}$ depends on the intended use of the centre and refers to the recommended 'maximum' internal levels in '*AS/NZS 2107:2000 Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors'*. An examination of the maximum internal noise levels for this area range from 40 to 50dBA (or 50 to 60dBA external), and in this instance, the approach based on RBL + 10dB (64dBA) to set the external construction noise management level is considered appropriate.

Based on the above, the following applicable noise management levels (NML's) for construction activities at surrounding residential receivers, including the aged care facility, have been adopted:

- Day (7am to 6pm) $L_{Aeq,(15min)}$ 64 dBA
- Saturday (8am -1pm) $L_{Aeq,(15min)}$ 59 dBA
- Saturday (8am - 5pm) $L_{Aeq,(15min)}$ 55 dBA
- Highly noise affected $L_{Aeq,(15min)}$ 75 dBA

5.2 Vibration Criteria

5.2.1 Human Comfort

Criteria for assessment of the effects of vibration on human comfort are set out in British Standard 6472-1992. Methods and criteria in that Standard are used to set "preferred" and "maximum" vibration levels in the document "*Assessing Vibration: A Technical Guideline*" (2006) produced by the NSW DECCW.

Acceptable values of human exposure to continuous vibration, such as that associated with drilling, are dependent on the time of day and the activity taking place in the occupied space (e.g. workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is presented in Table 5-2.

Table 5-2 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2

In the case of intermittent vibration, which is caused by plant such as rock breakers, the criteria are expressed as a Vibration Dose Value (VDV) and are presented in Table 5-3.

Table 5-3 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Calculation of VDV requires knowledge of the number of events, and their duration in the relevant time period.

5.2.2 Building Damage

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

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

The recommended limits (guide values) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 5-4.

Table 5-4 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

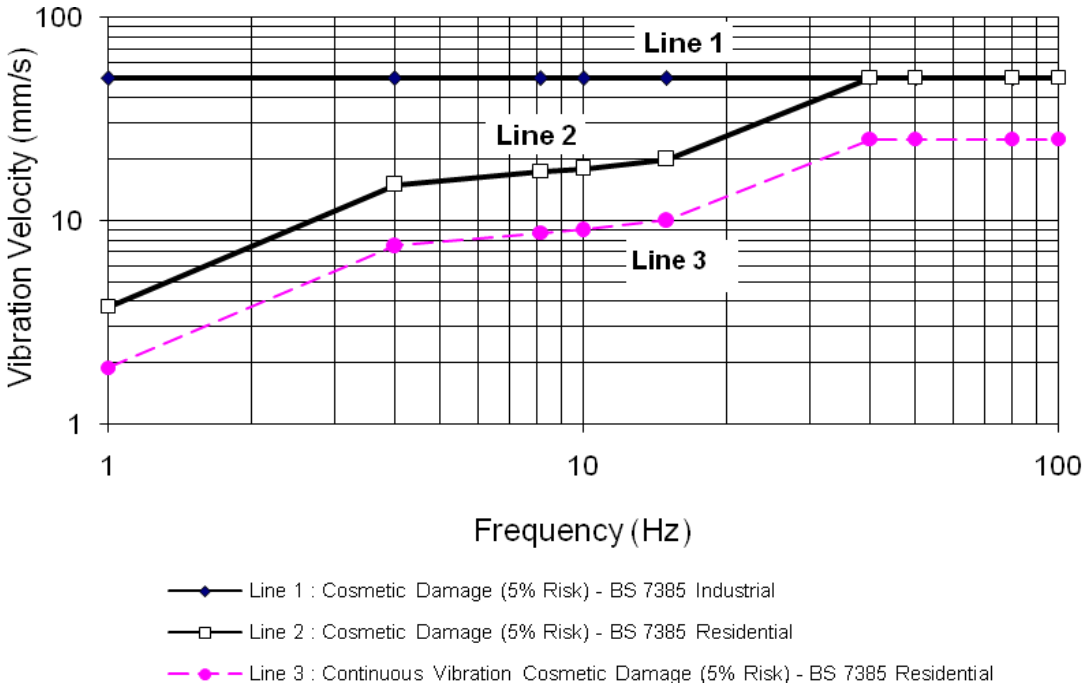
Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	N/A
Un-reinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

The Standard states that the guide values in Table 5-4 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

Note that rock breaking / hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50%.

The British Standard goes on to state that "*Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity*". In addition, a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

Figure 5-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



In addition to the British Standard, for the case of nearby heritage buildings, guidance for structural damage is derived from the German Standard DIN 4150 -3 *"Structural Vibration Part 3 – Effects of Vibration on Structures"*. The following Table 5-5 details these recommendations for heritage buildings.

Table 5-5 DIN 4150 Recommend PPV Vibration Level for Heritage Buildings

Guideline Values for Velocity – mm/s		
1-10 Hz	10 to 15 Hz	40 to 50 Hz
3	3 to 8	8-10

5.3 Construction Equipment & Noise Source Levels

Sound Power Levels (SWLs) for typical construction plant are detailed in Table 5-6. These SWLs have been measured at other similar construction sites. The table provides both Sound Power Level and Sound Pressure Levels (SPL) at 7m for the equipment. Sound Power Level is independent of measurement position.

Table 5-6 Typical Construction Plant Sound Levels – dBA

Plant	Sound Power Level	Sound Pressure Level at 7m
Concrete Truck	109	84
Angle Grinder	109	84
Concrete Pump – 120 mm diameter / 50 bar	112	87
Concrete Saw	116	91
Mobile Crane	98	73
Dump Truck	108	83
Compressor	100	75
Bobcat	103	78
Hand Tools	90	65
Bulldozer	114	89
Excavator	108	83
Crawler Cranes	98	73
Front End Loader	112	87
Excavator	107	82
Hammer Hydraulic	122	97
Bored Pile Rig	112	87

5.4 Construction Noise Predictions

Assessment of likely construction noise at surrounding receivers has been undertaken for the proposed construction works.

Site-related noise emissions were modeled with the "CadnaA" noise prediction program, using the ISO 9613 noise prediction algorithms. Factors that are addressed in the noise modeling are:

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- ground absorption; and,
- atmospheric absorption.

Modelling has been conducted for a number of construction scenarios. The three scenarios considered are summarised in Table 5-7.

Table 5-7 Construction Scenarios for Construction Works

Scenario	Description	Works
A	Building Demolition	This scenario includes demolition of existing buildings and clearing of site. 1 x 25t excavator assumed. Truck Movements – loaded into trucks sent offsite.
B	Site Excavation	This scenario includes excavation of site, including removal of 9000m^3 of sandstone with rockbreakers, rocksaws, and ripping. 2 x 25t excavator and 1x 20t dozer assumed. Truck Movements – loaded into trucks sent offsite.
C	Building Construction	This scenario includes concreting and lifting. 1 concrete pump, 2 forklifts, 1 compressor, 2 cranes (1 mobile one fixed) are assumed to operate in 15 minutes. Also concrete trucks and normal delivery trucks assumed to be 2 movements in 15 minutes.
D	Fitout	Internal Fitout works . Forklift, truck, crane and power tools assumed. 2 truck movements in 15minutes assumed.

Noise modelling has been conducted for each of the above scenarios, with plant located across the construction site as follows.

Line Noise Source – Truck movement is modelled as short line noise sources entering and exiting from Elliot Street with the number of trucks on the haulage route in a 15-minute period applied to these sources.

Point Noise Sources – Fixed plant and equipment are modelled as point sources.

The modelling assumes a "typical worst-case" scenario whereby all plant, is running continuously. As such, the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore, the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

Once noise sources have been applied to the model, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site-specific noise criteria.

Table 5-8 details results of noise modelling for each scenario.

Table 5-8 Predicted Construction Noise Levels at Residence – $L_{Aeq(15\ min)}$ – dBA

Residential Receiver	Predicted Noise Level	Weekday NML	Exceedance	Sat NML*	Exceedance
		Scenario A – Demolition			
267 Miller Street	89	64	**25**	59 (55)	30 (34)
52 McLaren Street	81	64	**17**	59 (55)	22 (26)
		Scenario B – Excavation			
267 Miller Street	89	64	**25**	59 (55)	30 (34)
52 McLaren Street	81	64	**17**	59 (55)	22 (26)
		Scenario C – Building Construction			
267 Miller Street	81	64	**17**	59 (55)	22 (26)
52 McLaren Street	73	64	**9**	59 (55)	14 (18)
		Scenario D – Façade / Fitout			
267 Miller Street	77	64	**13**	59 (55)	18 (22)
52 McLaren Street	68	64	**4**	59 (55)	9 (13)

Note: Values in brackets are Noise Management Levels for extended hours on Saturdays

A review of results of construction noise indicates that these may be above construction noise management levels at nearby noise sensitive receivers during demolition, excavation and construction. On Saturdays, the exceedance is likely to be greater for extended construction hours.

5.5 Discussion of Results

Exceedances of up to 25dBA during the week and 30dBA on Saturdays are expected during standard construction hours at the 267 Miller Street residences during the demolition/excavation period. If no noise mitigation is implemented, receivers at 267 Miller Street would exceed the 75dBA highly affected management level. The highest exceedances are due to the excavator and rockbreaker modelled during these scenarios. This magnitude of exceedance is consistent with similar sites where residences overlook the development in such close proximity.

Construction and Fitout works are less noise intensive and this is reflected with lower exceedances during these stages.

Greater exceedances are predicted on Saturdays due to more stringent noise management levels that are triggered by the proposed extended hours of operation on this day. It is noted that all predicted noise levels at 267 Miller Street are above the "highly noise affected" noise objective.

Based on these findings the adoption of reasonable and feasible noise management and mitigation will be required. These measures should be determined in detail when a contractor, with defined construction techniques, has been engaged on the project. With appropriate planning, it is feasible that the levels predicted here could be reduced by 15dBA, meaning that no receiver would exceed the "highly affected" management level. To provide further guidance on how this can be achieved, "in-principle" mitigation measures are detailed in the following sections.

5.6 Construction Vibration Assessment

The potential for vibration will be greatest when excavation occurs. In the case of this project excavation works are significant due to the close proximity to neighbouring residences. At this stage, it is envisaged that significant amounts of rock will need to be excavated from site.

The operation of construction equipment generates ground vibration that has the potential to transmit to nearby buildings. Table 5-9 sets out the typical ground vibration levels at various distances for safe working distances.

Table 5-9 Recommended Safe Working Distances for Vibration Intensive Plant

Item	Description	Safe working Distance	
		Cosmetic Damage	Human Response
Small Hydraulic Hammer	(300 kg – 5 to 12t excavator)	2m	7m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	23m
Pile Boring	≤ 800 mm	2m (nominal)	N/A
Jackhammer	Hand held	1m (nominal)	Avoid contact with structure

- Construction Noise Strategy, 2012, Transportation Construction Authority

Any use of medium rockbreakers should be carefully managed at distances closer than 20 metres from residential buildings. Alternative use of small rockbreakers would result in less potential for any impact at surrounding residences.

It is recommended that trial testing of vibration levels be conducted where identified equipment having the potential to exceed the human comfort criteria is proposed.

Structural damage vibration criteria in residential and heritage buildings are much higher than human comfort criteria, and predicted vibration levels are within these criteria under most circumstances. The exception will be when excavating close to the northern boundary. Therefore, the uses of alternative excavation measures, such as rocksaw attachments on excavators and ripping (conventional ripping or eccentric ripping excavator attachments) are recommended.

5.7 Construction Noise & Vibration Mitigation Measures

Without mitigation, noise levels from construction activities have been predicted to exceed the noise management levels nominated in the guidelines and cause significant impact. Therefore, noise control measures are recommended to ensure that noise is reduced where feasible.

The following project specific mitigation measures are recommended;

- Selection of quietest feasible construction equipment;
- Localised treatment such as barriers, shrouds and the like around fixed plant such as pumps, generators and concrete pumps;
- Provision of respite periods, particularly on Saturdays; (louder items to operate after 8 am) and
- Trial testing of vibration levels is conducted where equipment identified as having the potential to exceed the human comfort criteria.

In addition, the following measures should be included in a Noise and Vibration Management Plan to be prepared prior to issue of a CC.

- *Plant Noise Audit* – Noise emission levels of all critical items of mobile plant and equipment should be checked for compliance with noise limits appropriate to those items prior to the equipment going into regular service. To this end, testing should be established with the contractor.
- *Operator Instruction* – Operators should be trained in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emission.
- *Equipment Selection* – All fixed plant at the work sites should be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures in order to ensure that the total noise emission from each work site complies with EPA guidelines.
- *Site Noise Planning* – Where practical, the layout and positioning of noise-producing plant and activities on each work site should be optimised to minimise noise emission levels.
- Install a 2.4 metre type-A hoarding between the site and residences. This should be a minimum 17mm thick structural plywood or equivalent panel.

The adoptions of the above measures are aimed at working towards achieving the noise management levels established at surrounding receivers.

5.8 Community Liaison & General Approaches to Mitigation

An effective community relations programme should be put in place to keep the community that has been identified as being potentially affected appraised of progress of the works, and to forewarn potentially affected groups (e.g. by letterbox drop, meetings with surrounding owners/tenants, etc) of any anticipated changes in noise and vibration emissions prior to critical stages of the works, and to explain complaint procedures and response mechanisms.

Close liaison should be maintained between the communities overlooking work sites and the parties associated with the construction works to provide effective feedback in regard to perceived emissions. In this manner, equipment selections and work activities can be coordinated where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints, should they occur.

5.9 Noise & Vibration Management Plan

A Construction Noise and Vibration Management Plan for the site is recommended prior to issue of a CC. Areas that should be addressed in plan include:

- Real time noise and vibration monitoring;
- response to complaints**;**
- responsibilities;
- monitoring of noise emissions from plant items;
- reporting and record keeping;
- non-compliance and corrective action; and
- Community consultation and complaint handling.

The plan should be developed by the successful contractor and be part of their Environmental Management Plan.

6 OPERATIONAL NOISE AND VIBRATION CRITERIA

This section of the report discusses criteria for the assessment of operational noise (Section 6.1) and vibration (Section 6.3) which includes:

- Fixed mechanical plant and equipment; and
- Operational Noise from the school.

The recommended noise criteria for occupied internal areas within the development (for the purposes of assessing traffic noise) are discussed in Section 6.2.

The only on-site parking for this development will be a single loading space. Student pickups and drop offs are catered for in another part of the existing campus. As such, this proposal is not expected to generate significant additional traffic noise so this is not considered further in this assessment.

6.1 Criteria for Noise Emission

Noise criteria are based on the following guidelines:

- *North Sydney Development Control Plan 2013;*
- *Noise guide for local government (NGLG); and*
- *Industrial Noise Policy (INP).*

The *INP* while specifically aimed at large and complex industrial activities, defines a number of terms such as 'intrusiveness' and can be used to provide guidance to planning authorities on assessing and measuring noise. We note that this is a non-mandatory policy.

To assist planning authorities in assessing smaller commercial activities, the EPA has prepared the *NGLG*. Within this document local Councils are encouraged to develop noise policies which specify intrusive noise level criteria using appropriate noise level descriptors.

The *NGLG* suggests that Councils develop an intrusiveness criterion that limits the permissible level of noise from mechanical plant at commercial or industrial premises to no more than the background noise plus 5dBA when measured over a 15-minute period ($L_{Aeq,15min}$).

The time periods for which intrusive criteria are applied is defined in the *INP*. The different time periods are daytime (7.00am-6.00pm), evening (6.00pm-10.00pm) and night time (10.00pm-7.00am).

The background level is the Rating Background Noise Level (RBL) which is determined from measurement of L_{A90} noise levels, in the absence of noise from the source.

While not referenced in the *NGLG*, the *INP* also provides amenity criteria which set recommended and maximum limits in addition to intrusiveness criteria. The purpose of amenity criteria is to prevent noise levels increasing indefinitely with each successive development which could occur if using the intrusiveness criteria alone.

Whilst intrusiveness is generally the governing criteria in local government areas, the recommended amenity criteria may be used as a guide to evaluate whether use of the intrusiveness criteria are likely to result in offensive noise.

Table 6-1 shows the relevant intrusiveness noise criteria and the *INP* "maximum" amenity levels for reference.

Table 6-1 Project-Specific Intrusiveness Criteria

Time Period [1]	RBL (dBA)	Intrusiveness Criterion $L_{Aeq,15min}$ (dBA)	Urban Amenity Criteria, Recommended & Maximum (dBA)
Daytime	54	59	60-65
Evening	47	52	50-55
Night Time	40	45	45-50

Note: 1. Daytime 7.00am–6.00am; Evening 6.00pm–10.00pm; Night 10.00pm-7.00am

Given the proposed facility will primarily be used during the daytime, only the daytime period will be considered further. However, the criteria determined above should be adopted at all times.

6.2 Criterion for Traffic Noise Ingress

The proposed development is potentially exposed to high levels of traffic noise from Miller Street. Australian Standard 2107 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors* recommends the following internal noise criteria for educational spaces.

Table 6-2 AS2107 Recommended Internal Noise Criteria

Space	Recommended Design Sound Level Satisfactory-Maximum (L_{Aeq}, dBA)
Teaching Spaces – Primary	35-45
Teaching Spaces – Secondary	35-45
Libraries – Reading Areas	40-45
Office Areas	40-45

Based on this standard, we recommend the following internal noise criteria.

Table 6-3 Project Specific Internal Noise Criteria

Space	Recommended Design Sound Level (L_{Aeq}, dBA)
Staff Offices	45
Senior Ecosystem	40

6.3 Vibration Criteria

Criteria for assessment of the effects of vibration on human comfort are set out in British Standard 6472-1992. Methods and criteria in that Standard are used to set "preferred" and "maximum" vibration levels in the document "*Assessing Vibration: A Technical Guideline*" (2006) produced by the NSW DECCW.

Acceptable values of human exposure to continuous vibration, such as that associated with drilling, are dependent on the time of day and the activity taking place in the occupied space (e.g. workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is presented in Table 6-4.

Table 6-4 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2

In the case of intermittent vibration, the criteria are expressed as a Vibration Dose Value (VDV) and are presented in Table 6-5.

Table 6-5 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Calculation of VDV requires knowledge of the number of events, and their duration in the relevant time period.

7 ASSESSMENT OF OPERATIONAL NOISE AND VIBRATION

The following sections describe the calculation and assessment of operational noise.

7.1 Mechanical Plant

The majority of mechanical plant equipment will be located in the LG2 levels of the development below pool level. There will be some heat rejection equipment located on Level 2, in the south east corner of the development. There will also be an exhaust air riser near this corner on Level 1. Based on indicative equipment sound power levels, Table 6-1 presents the calculated noise levels at each receiver.

Table 7-1 Calculated Noise Levels from Mechanical Plant

Receiver	Sound Pressure Level at Boundary, $L_{Aeq,15min}$ (dBA)	Noise Criterion	Assessment Complies? (Yes/No)
Regency Apartments	48	59	Yes
Aged Care Facility	56	59	Yes

Based on the indicative levels assumed, noise from mechanical services will meet the required criteria at both receivers. As the design matures, there is scope to add further noise controls to control noise should the final design warrant them.

Vibration produced by mechanical plant will be minimised using standard techniques such as spring hangers, isolation joints, elastomeric bearing pads, inertia bases. These will be incorporated in the detailed design. Using these techniques, vibration from mechanical plant is not expected to be measurable at the nearest receivers, and significantly below the required criteria.

7.2 Operational Noise

Operational noise from school activities will mostly be contained within the built envelope of the new facility. The new main entrance will be approximately 50m from the two receivers and will be well shielded. The outdoor learning area on Level 1 is expected to be used for group learning activities with no amplified speech or music. Assuming a typical group or class of 20 students talking at normal levels in this area, we calculate that noise levels at both receivers will be 44dBA or less, below the 59dBA daytime criterion.

The closest point to the Regency Apartments will be a glass atrium. We understand this atrium will be sealed or provide acoustically treated ventilation openings, and be constructed using a minimum of 6.38mm laminated glass. Based on indicative calculations, all noise from operation of the Pool Area, Science Hub, Amphitheatre, and Senior Ecosystem will be no greater than 50dBA. This will meet the required 59dBA daytime criterion.

The green roof on Level 2 will not be accessible and therefore have no acoustic impact.

Vibration from normal school operations are not expected to be measurable at the nearest receivers, and significantly below the required vibration criteria.

8 ASSESSMENT OF TRAFFIC NOISE INGRESS

The general purpose learning areas on Ground floor will be shielded from traffic noise and unlikely to require special acoustic treatment. Both the Staff Offices and Senior Ecosystem (Level 1 and Level 2 respectively) have facades exposed to traffic noise from Miller Street. Noise logger data was used to calculate the internal noise levels within these two spaces, assuming an indicative 10.38mm laminated operable glazing system. The final specification will need to be considered during the detail design phase.

Carpet is expected to be used in both of these spaces in conjunction with other sound absorptive elements to control reverberation.

The results of these calculations and assessment is shown in Table 8-1.

Table 8-1 Calculated Internal Noise Levels from Traffic Noise

Space	Calculated internal Sound Pressure Level $L_{Aeq,15min}$ (dBA)	Noise Criterion	Assessment Complies? (Yes/No)
Staff Offices	39	45	Yes
Senior Ecosystem	38	40	Yes

Based on the calculated noise levels, recommended internal noise criteria will be achieved when windows and doors are closed.

The $L_{Aeq,15min}$ as measured on the balconies/breakout spaces will be approximately 67dBA. We understand that these spaces will be used for small group interaction or socially during breaks. Maximum noise levels (from occasional loud vehicles) will be in the order of 75dBA to 80dBA. These levels are considered 'normal' for this type of space. In a recent meeting with the architect, we discussed several design features that will help reduce noise levels in this area. These included:

- Applying acoustic absorption to the underside of the slab above;
- Increasing the height of the balcony wall to provide some acoustic shielding (either masonry construction or glazed section);
- Create balcony cladding in such a way that it is acoustically absorptive; and
- Include other absorptive finishes where possible.

Although not required, these will all be considered during the detail design.

It should be noted that noise levels such as these are common in this scenario such as outdoor cafes or courtyards. Traffic noise has become a part of the modern urban soundscape and is becoming more prevalent in everyday life. Traffic noise can provide benefits such as sound masking and additional acoustic privacy.

9 CONCLUSION

Wilkinson Murray has conducted a noise and vibration assessment of project Archimedes, a new swim centre and educational facility which has been proposed by Wenona School, North Sydney.

Operational noise impacts associated with the proposal are expected to be within the intrusiveness criteria recommended by the EPA. We recommend that the project specific intrusiveness criteria (as detailed in Table 6-1) be adopted for assessing all operational noise.

Vibration impacts from normal school operations are expected to be significantly below the required criteria.

Traffic noise intrusion into the two spaces on the western facade will meet the recommended internal noise criteria using standard glazing systems.

Potential noise and vibration impacts from construction has been assessed at surrounding receivers. In most cases, this impact on residential receivers is likely to be high using conventional excavation methods.

Vibration associated with on-site construction activities has a potential to impact on receivers to the north and east of the site. Should equipment, such as rock breakers be used in close proximity of residences then consideration of vibration monitoring and selection of less vibration intensive equipment is recommended.

Accordingly, management of noise and vibration from construction activities is recommended to be included and carefully considered in the Site Construction Environmental Management Plan prepared by the successful contractor.

APPENDIX A

NOISE MEASUREMENT RESULTS

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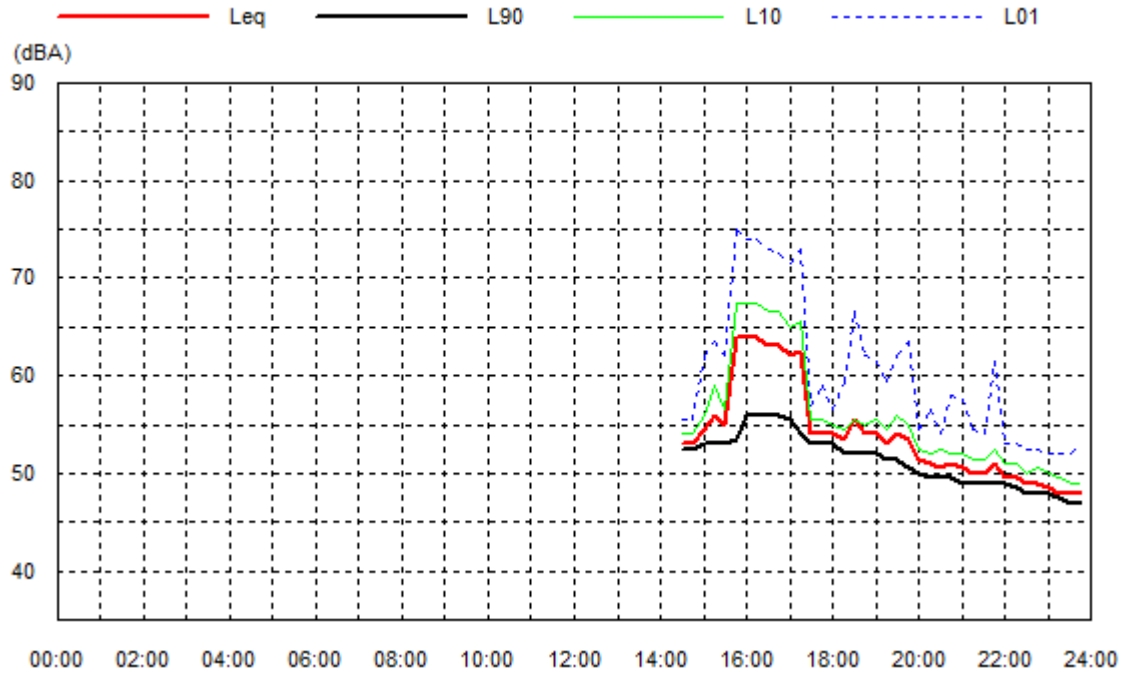

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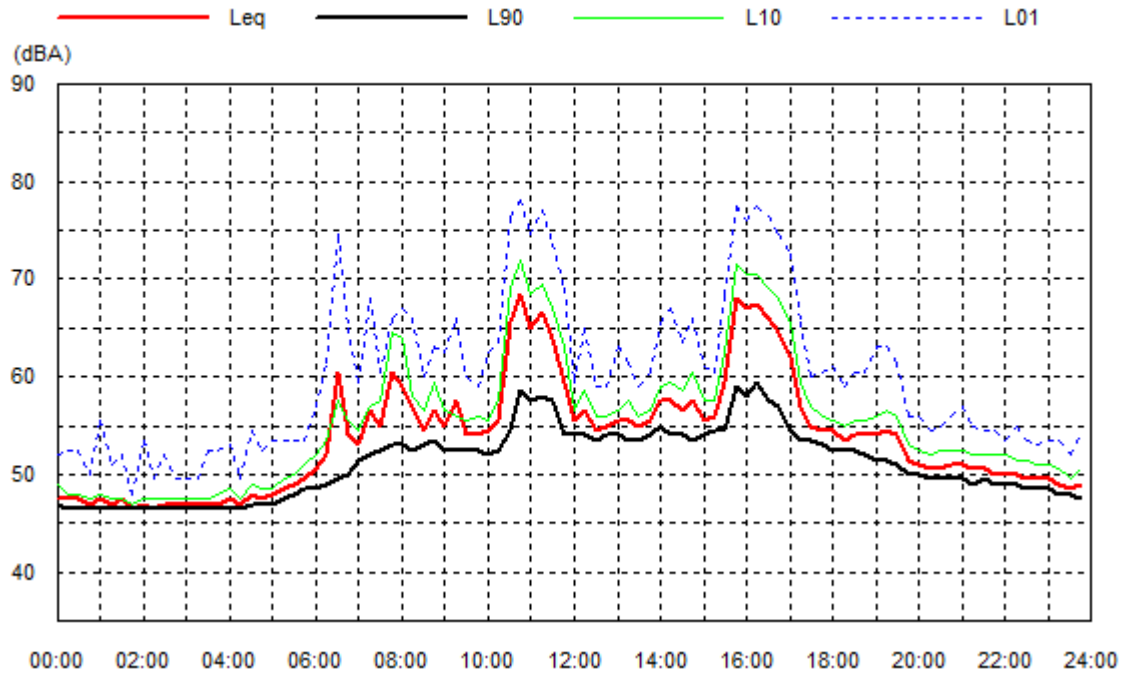

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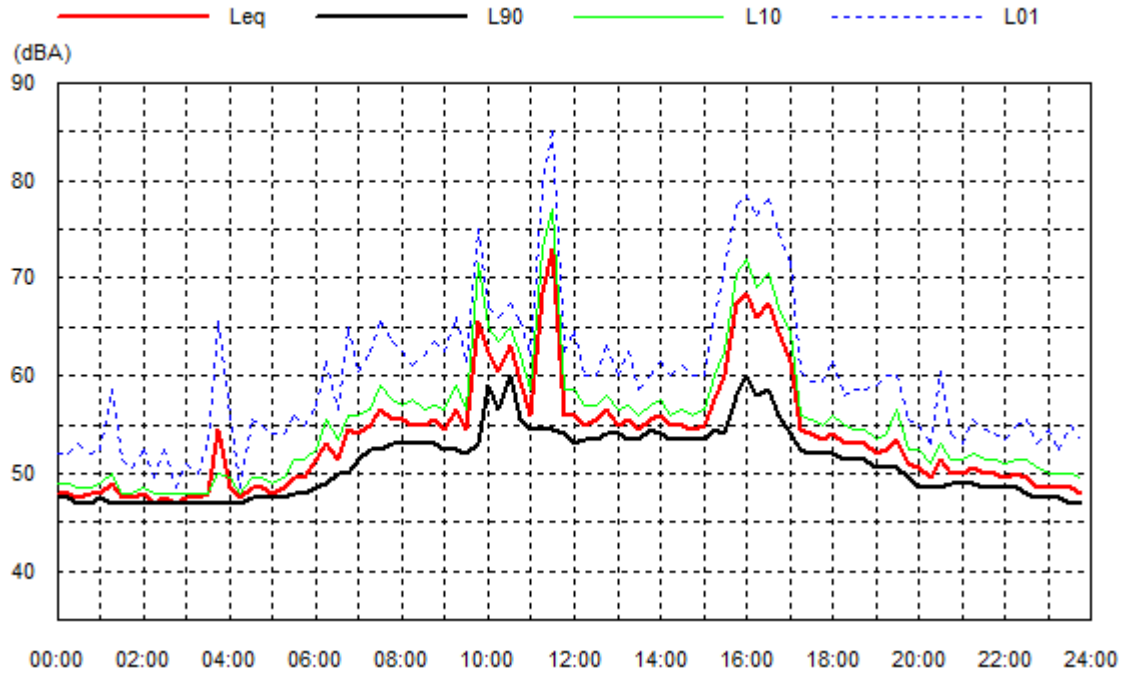

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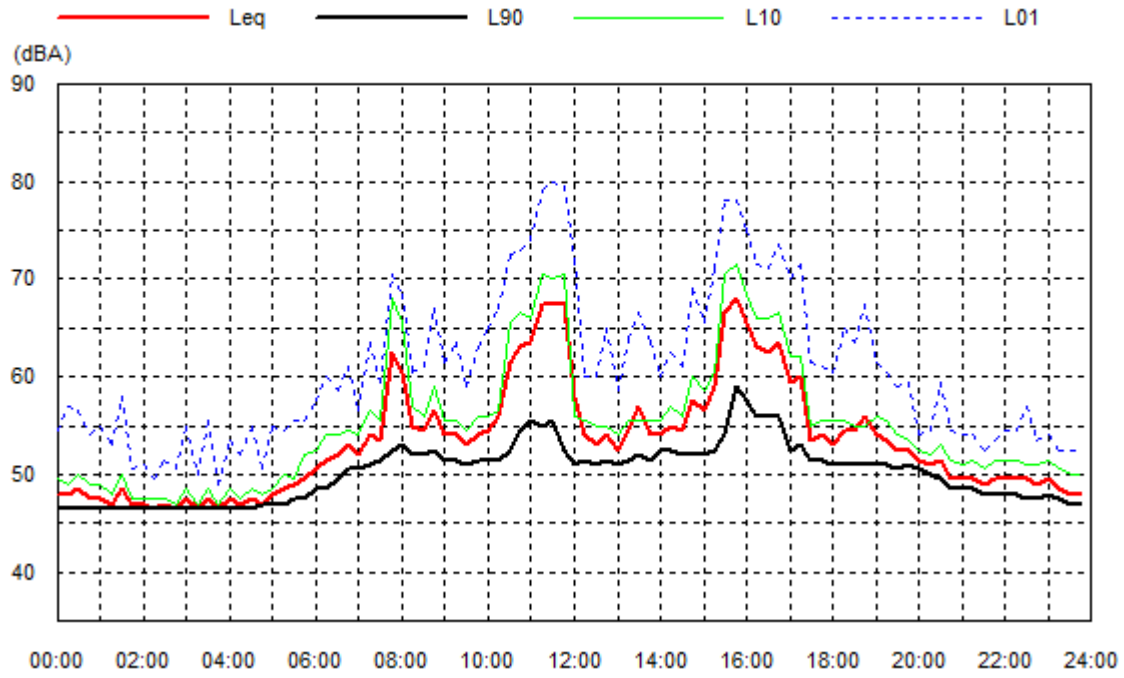

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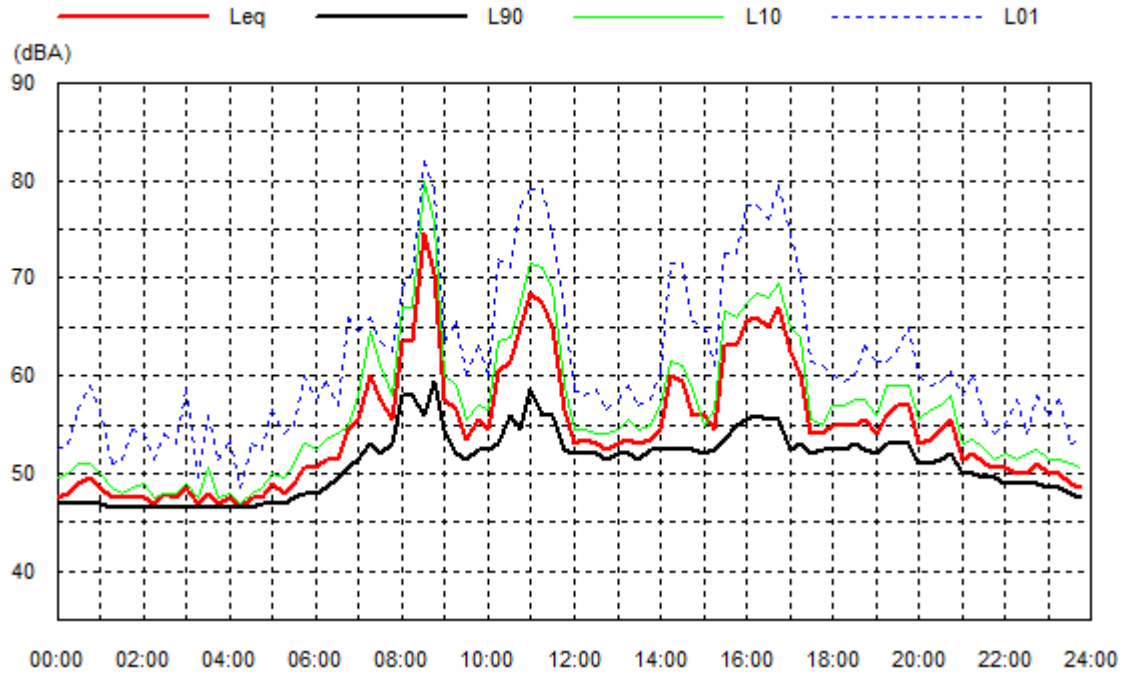

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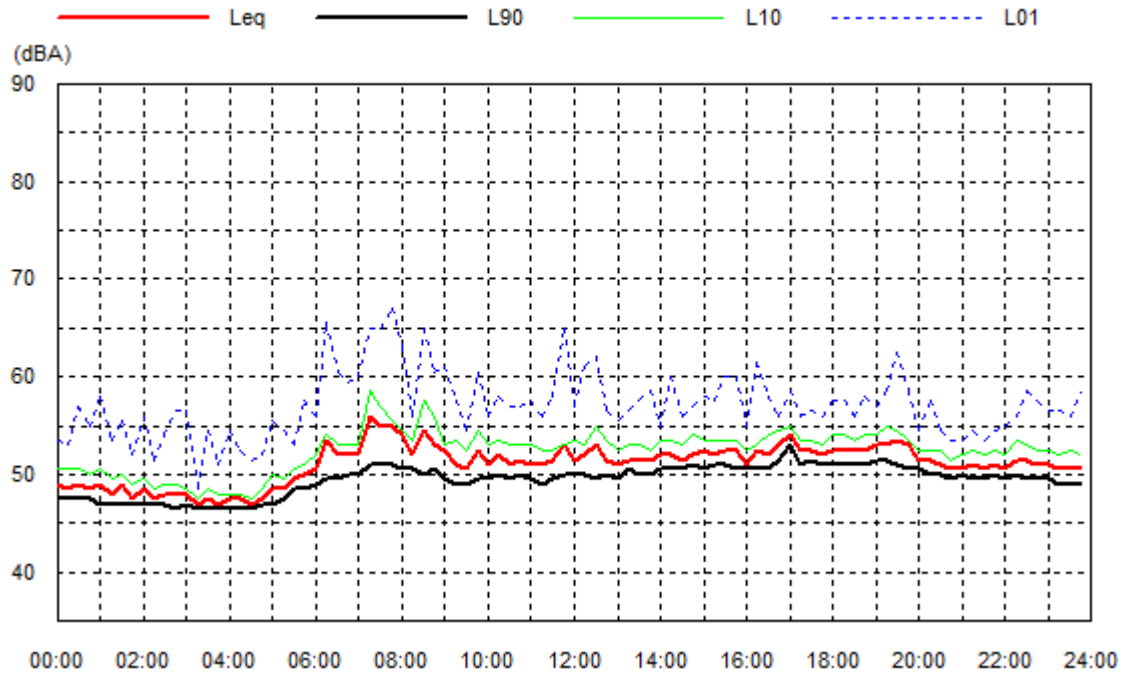

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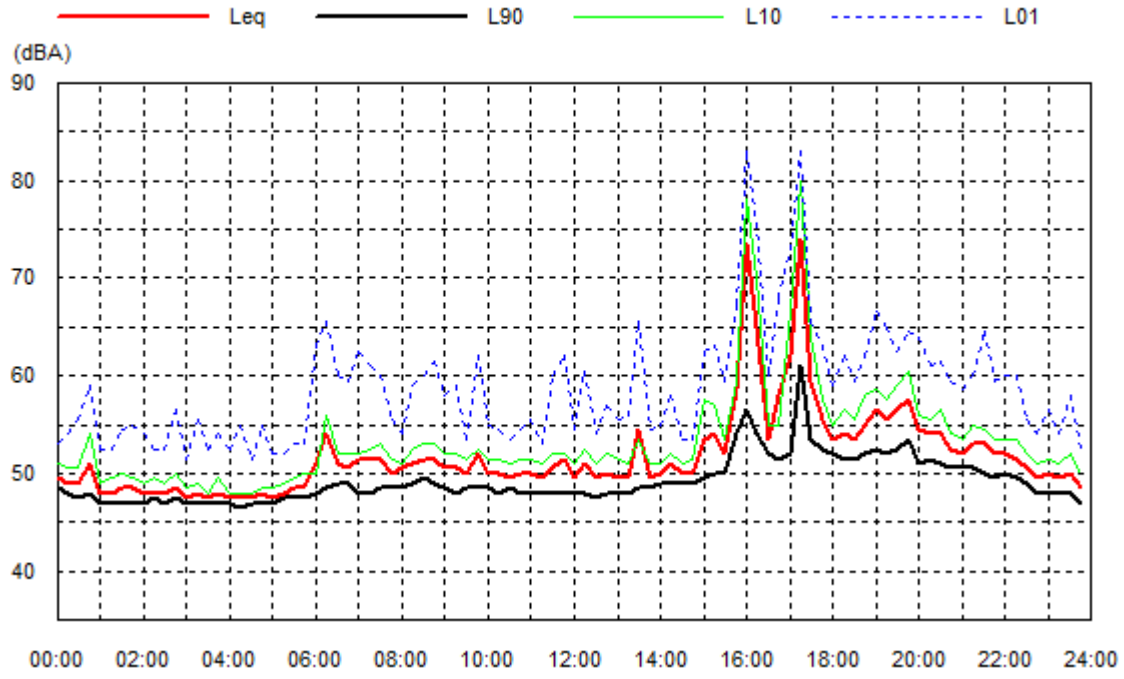

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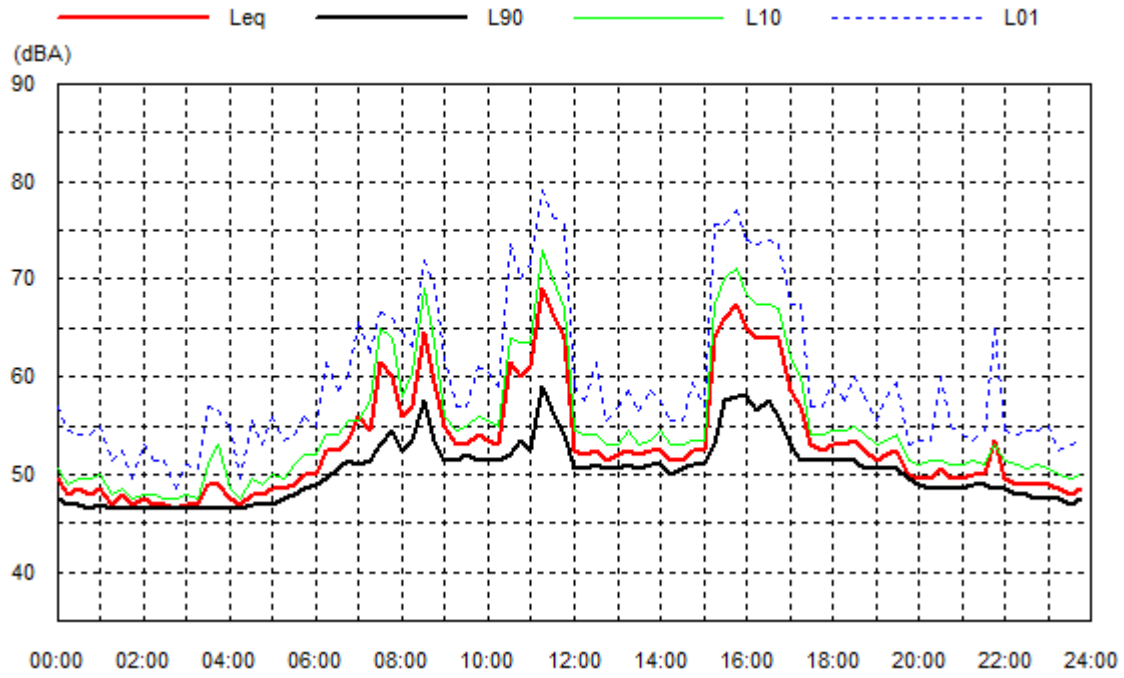

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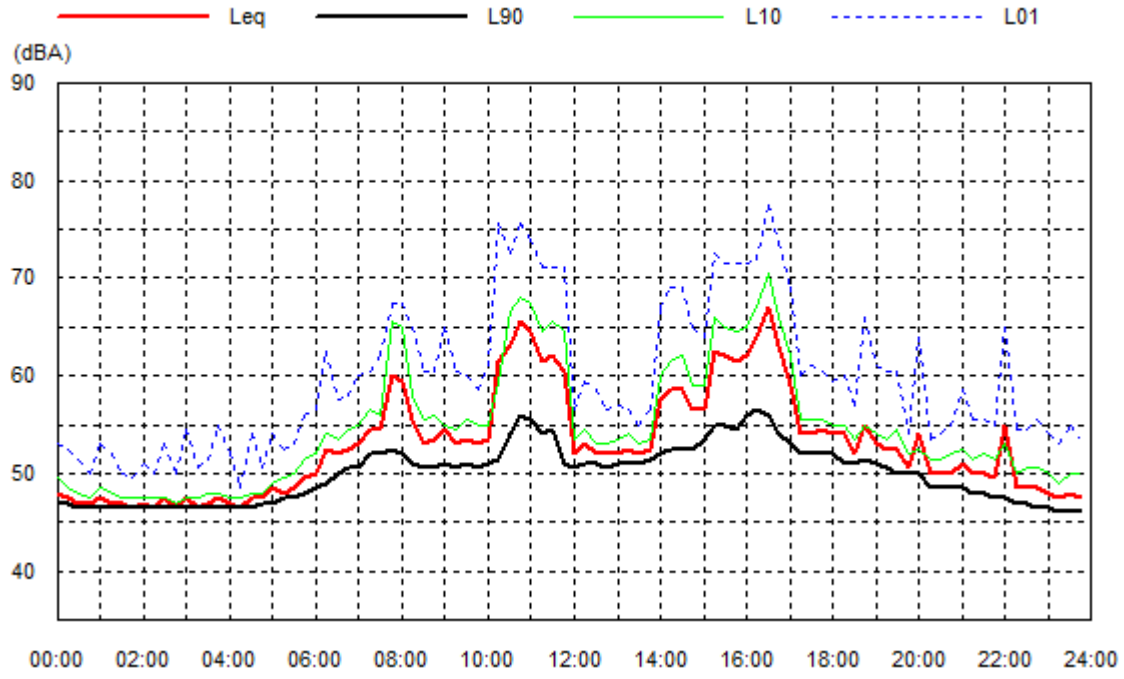

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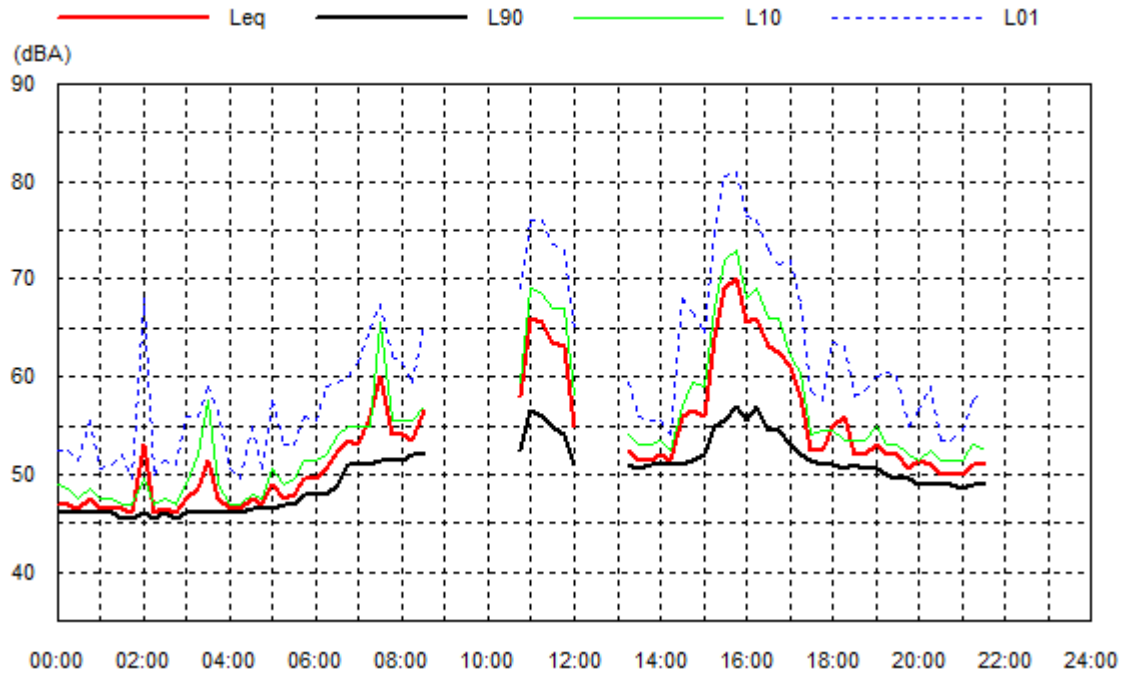

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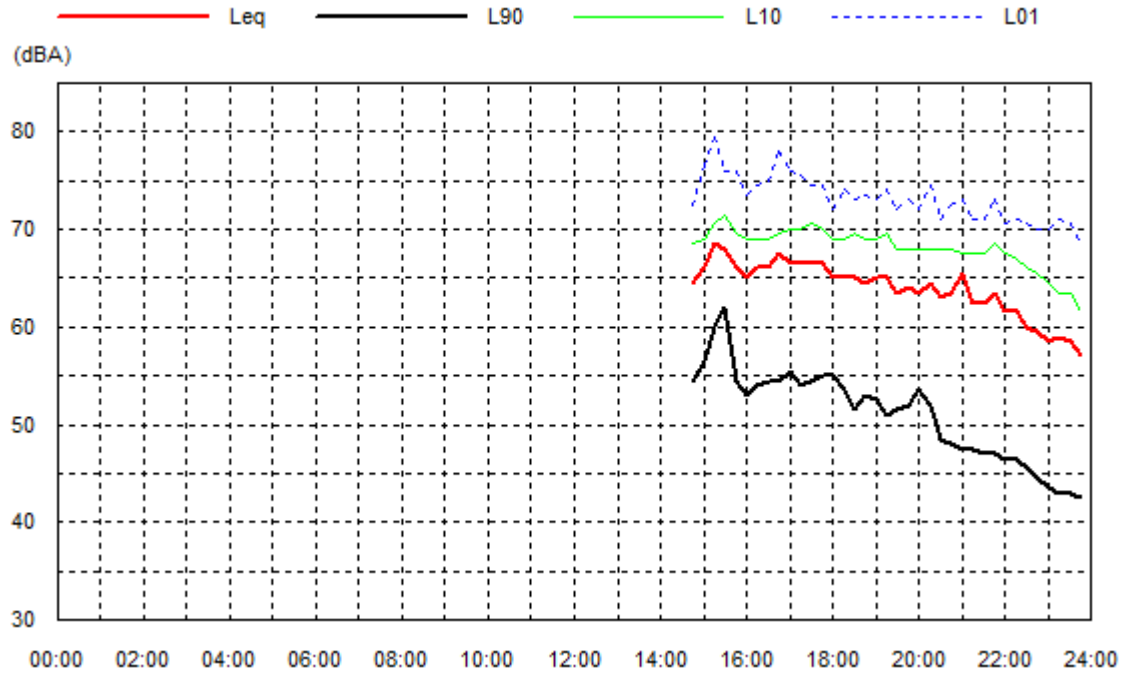

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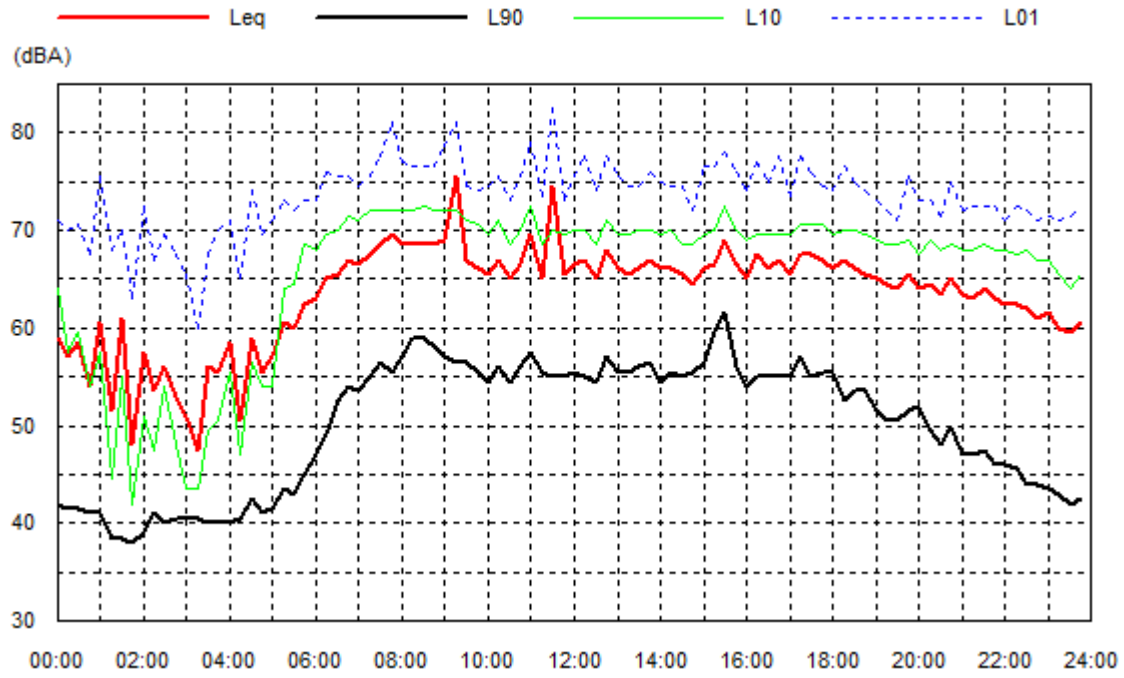

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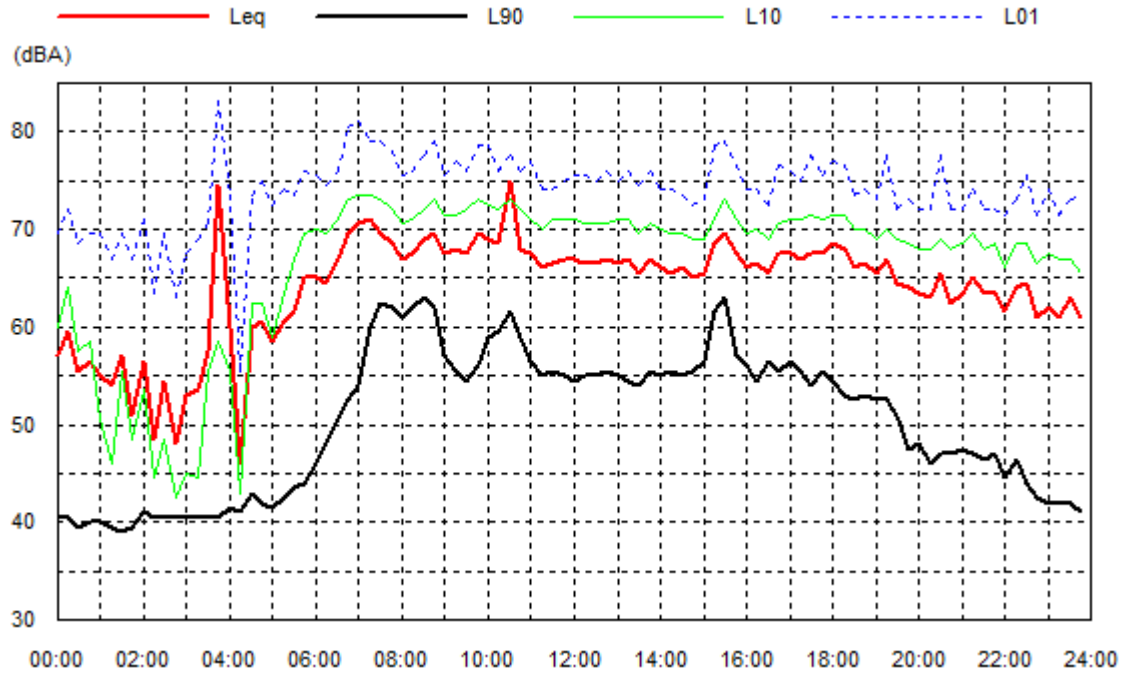

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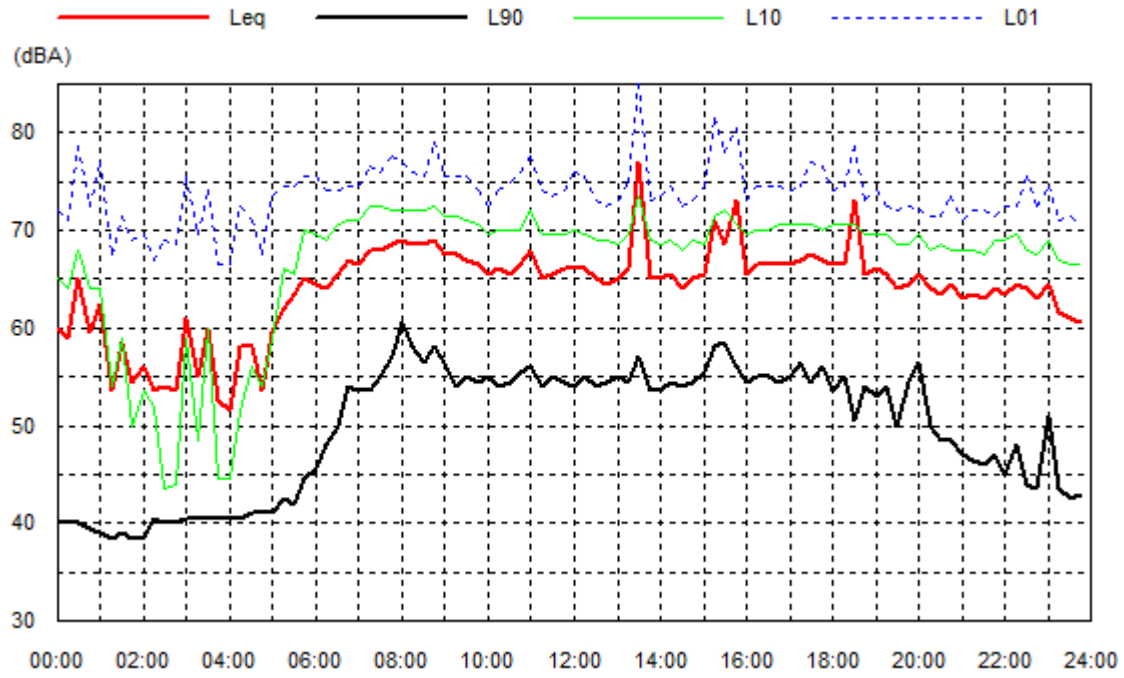

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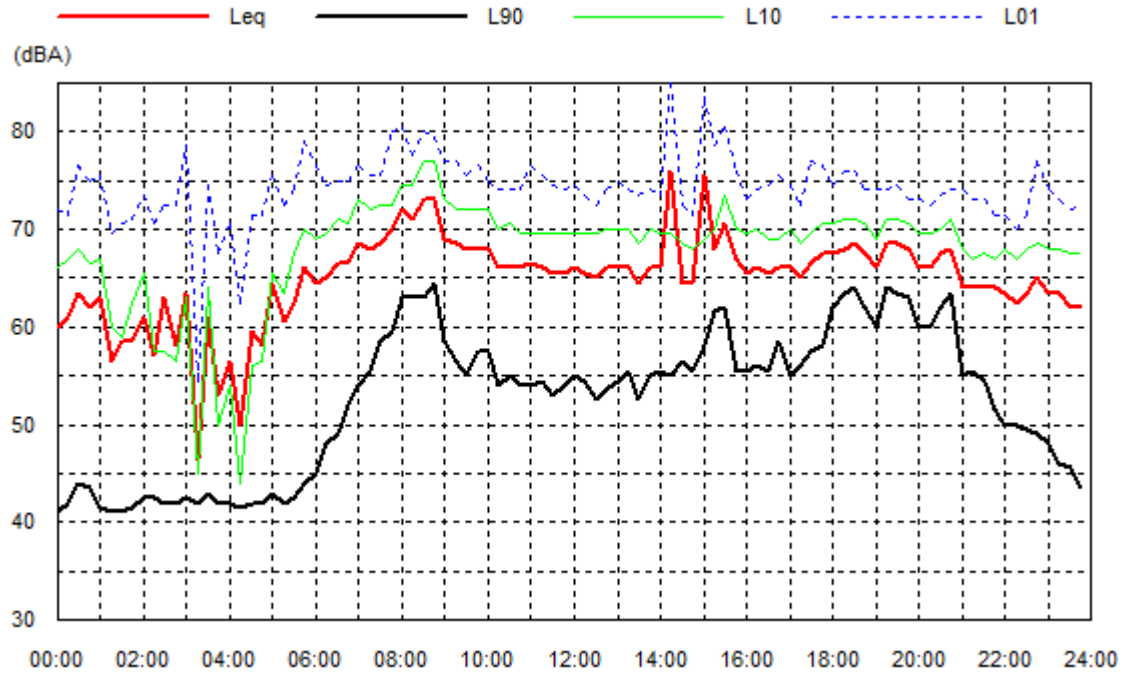

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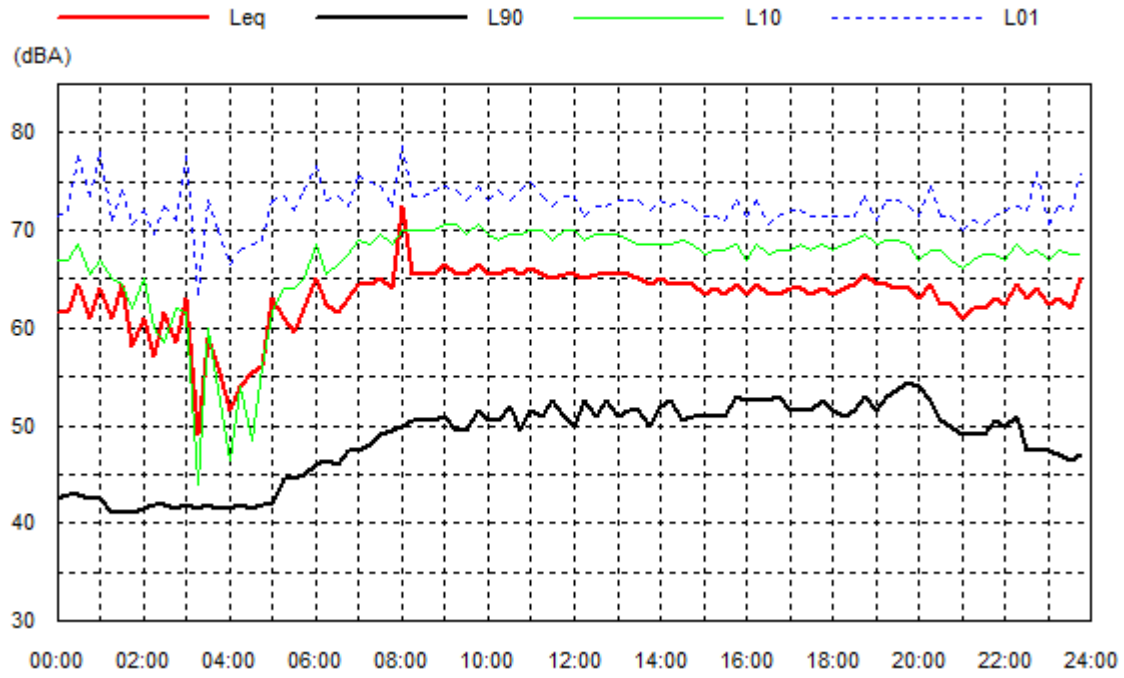

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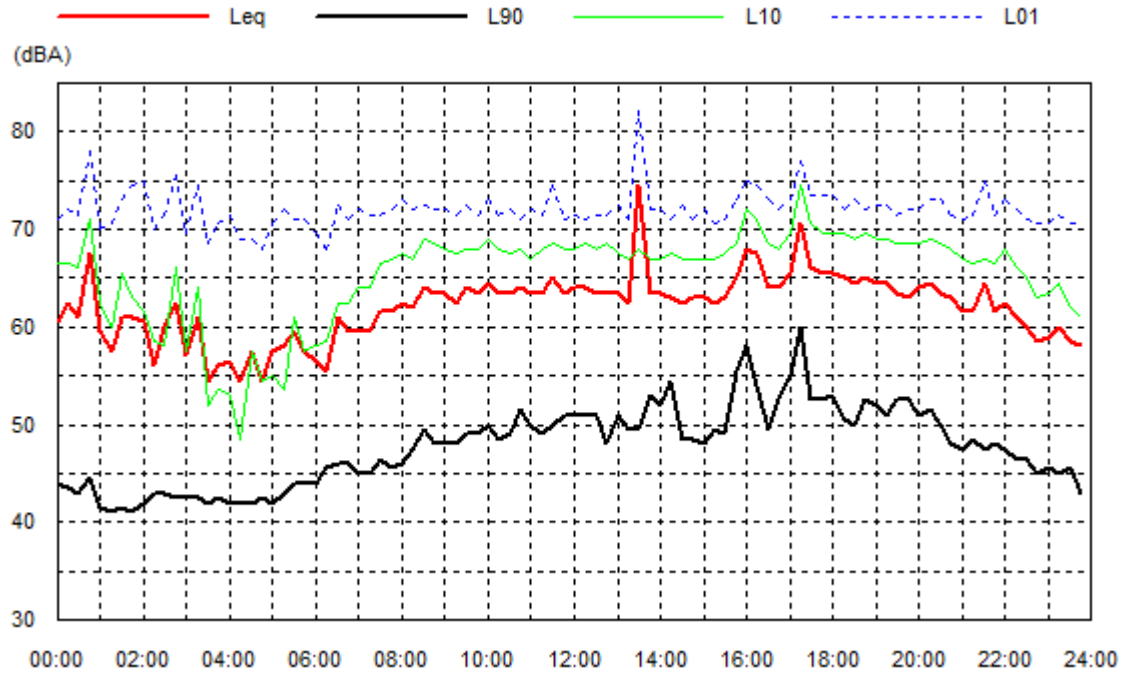

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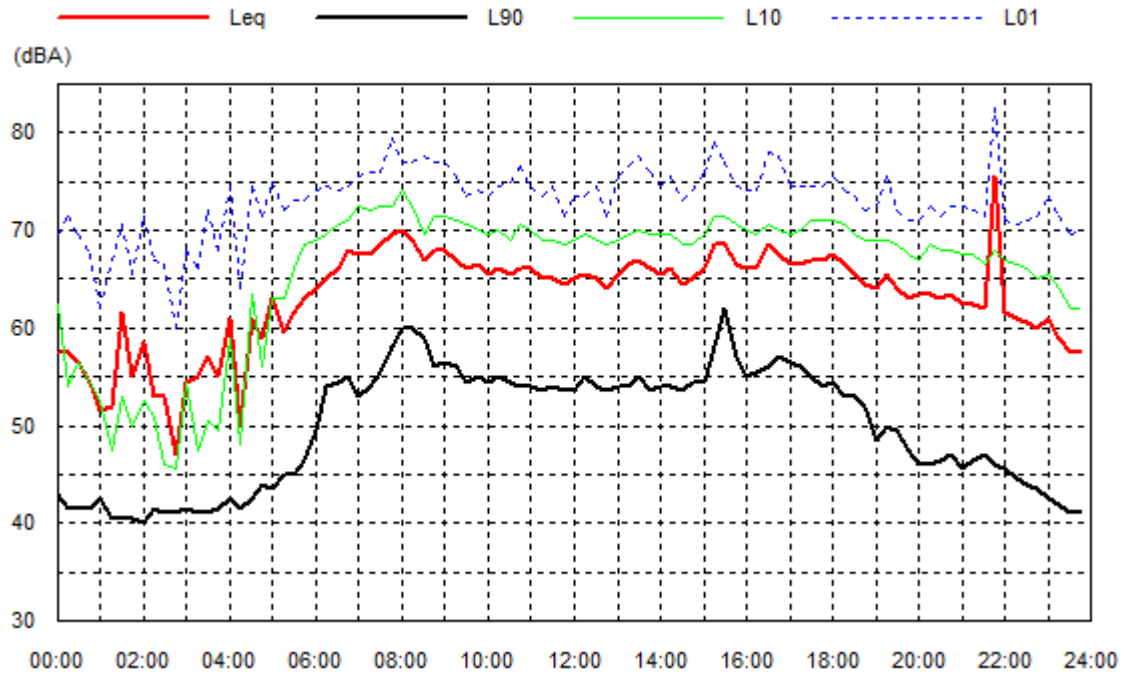

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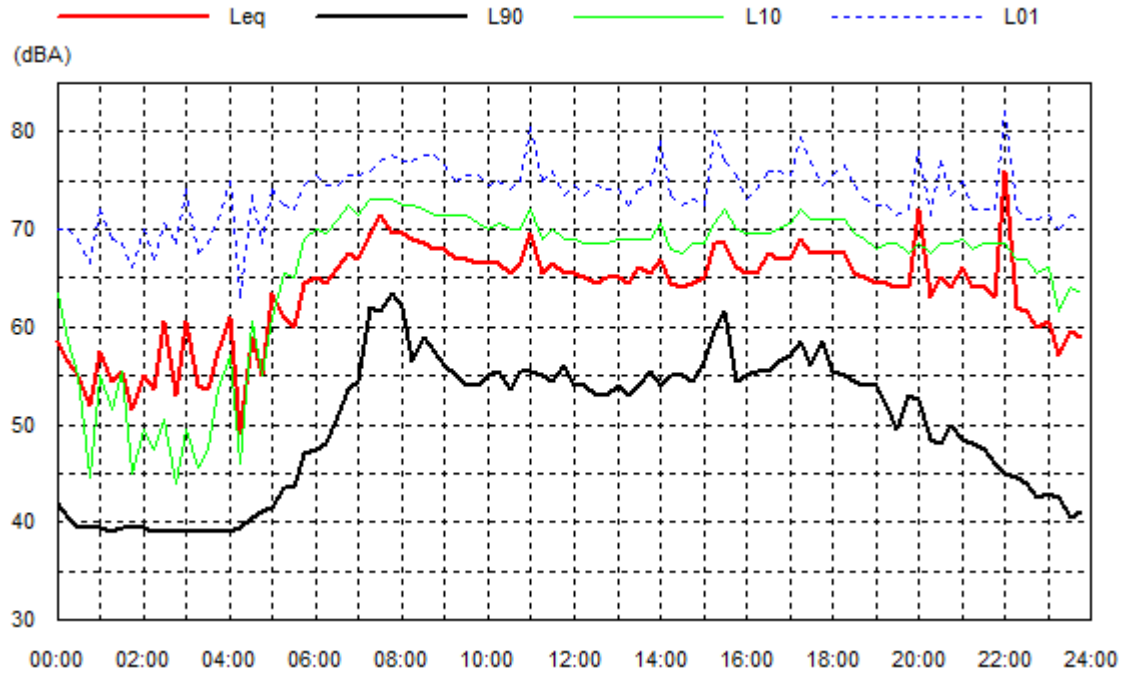

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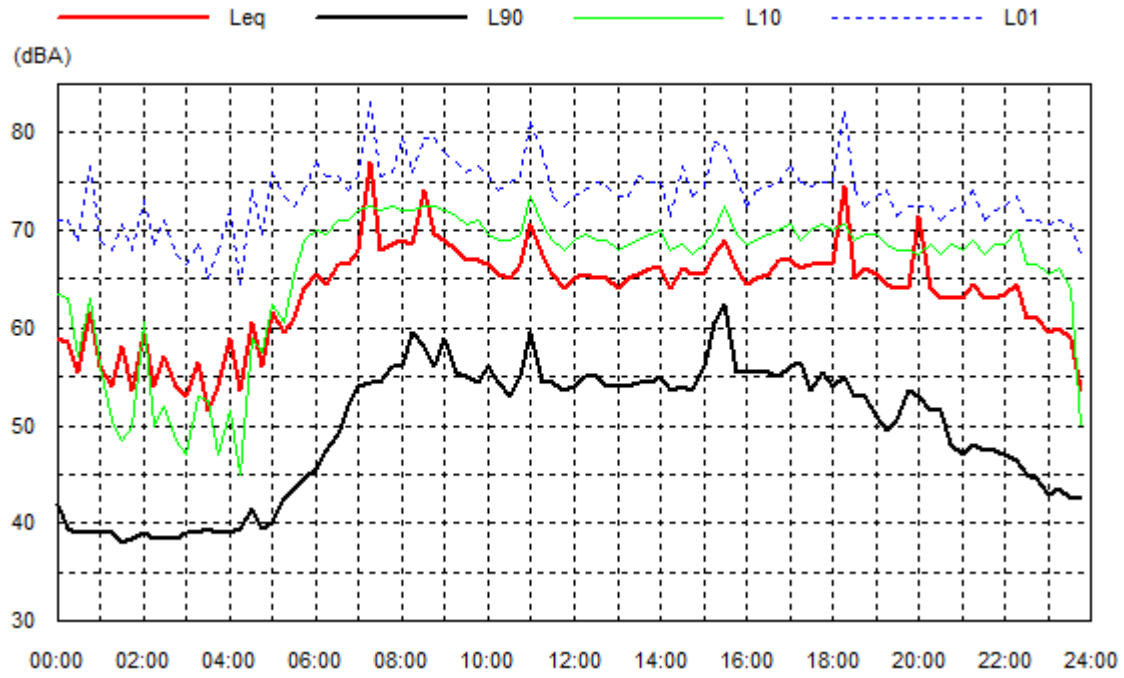

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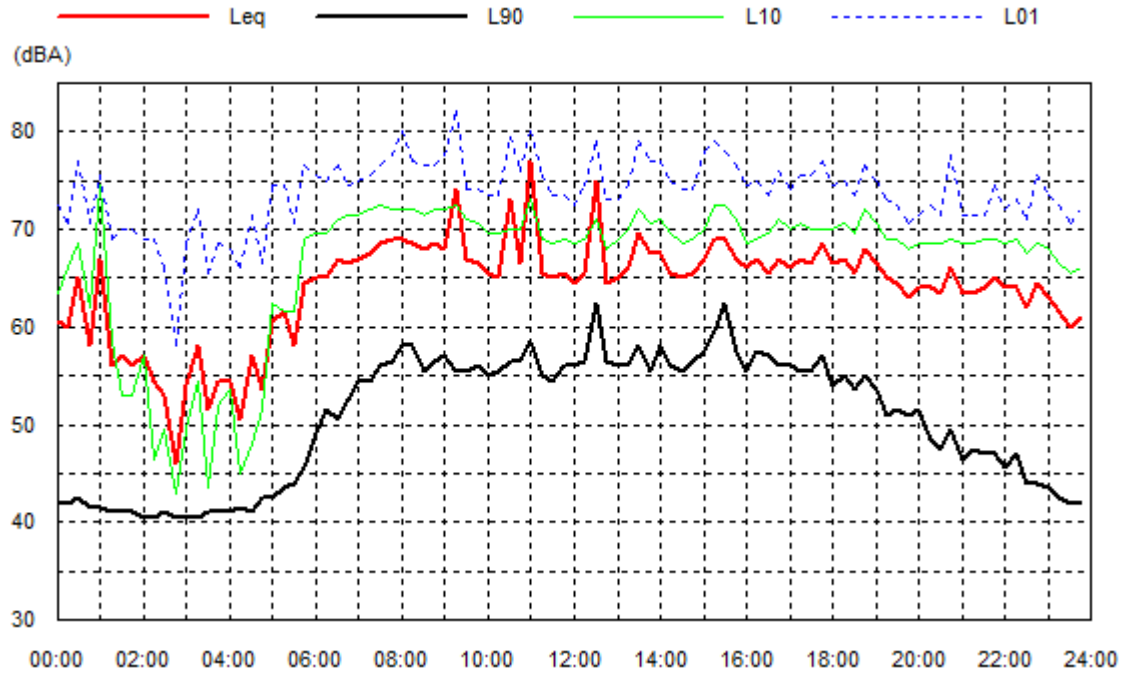

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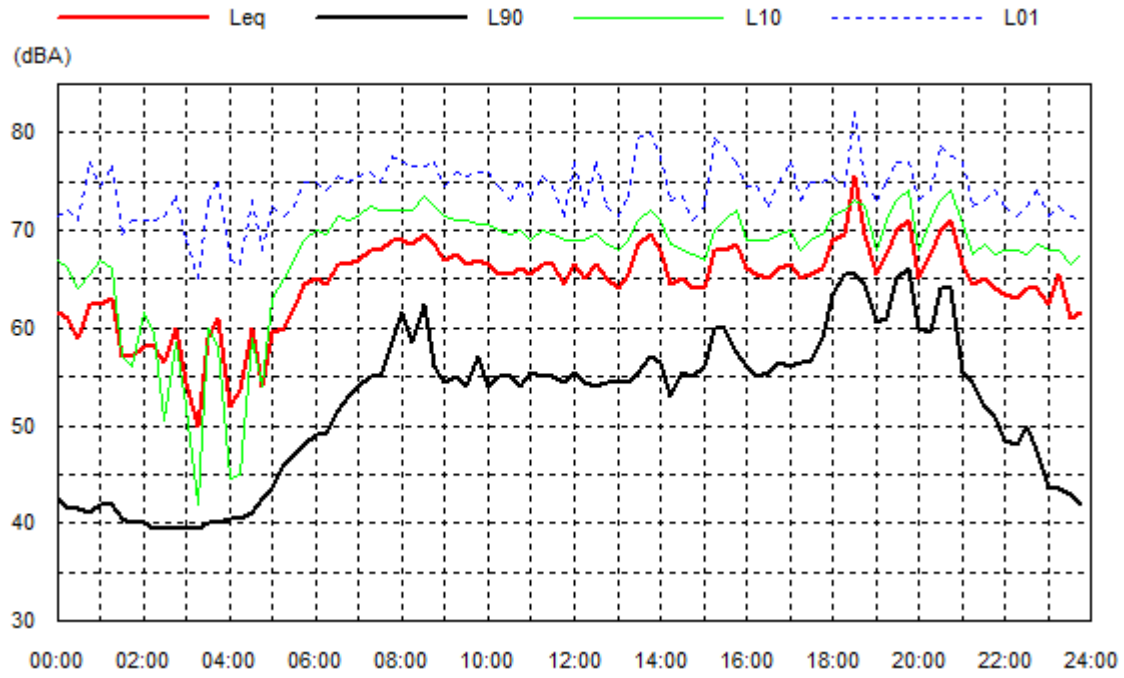

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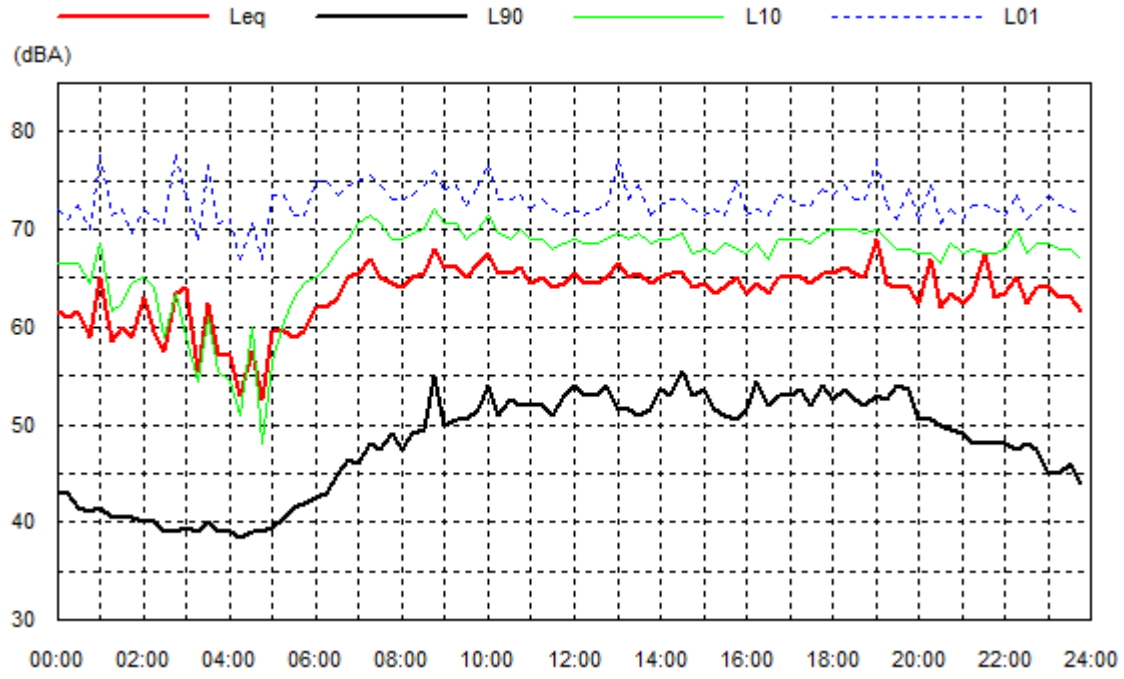

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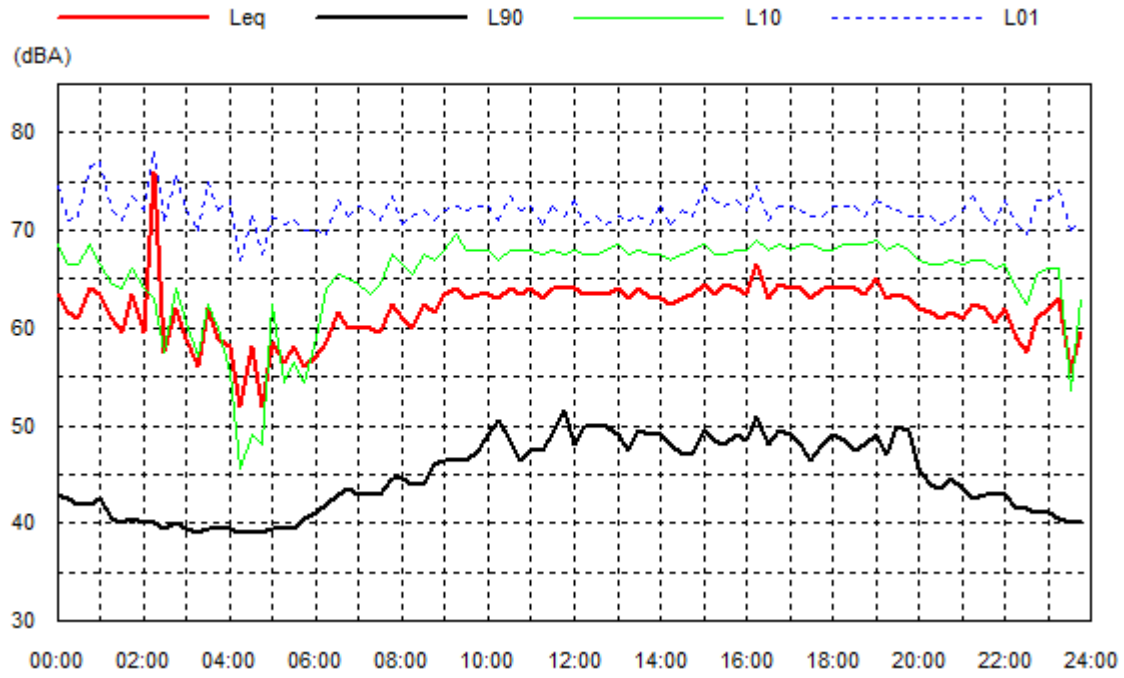

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