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2-20 Parramatta Road, 11-13 Columbia Lane

Noise and Vibration Assessment

Report Number 610.10150

7 July 2011

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60 Strathallen Avenue
NORTHBRIDGE NSW 2063

Version: Revision 2

2-20 Parramatta Road, 11-13 Columbia Lane

Noise and Vibration Assessment

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DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
610.10150	Revision 2	1 July 2011	David Geiger	Dianne Williams	Neihad Al-Khalidy
610.10150	Revision 1	1 July 2011	David Geiger	Dianne Williams	Neihad Al-Khalidy
610.10150	Revision 0	9 June 2011	David Geiger	Dianne Williams	Dianne Williams

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by PD Mayoh Pty Ltd to prepare a noise and vibration assessment for the proposed development of the Columbia Precinct on 2-20 Parramatta Road and 11-13 Columbia Lane, Homebush. The Proposed Columbia Precinct development consists of a number of residential buildings ranging from 3 to 21 storeys on a series of podiums.

As part of this commissioning, both attended noise measurements and unattended noise logging has been carried in various locations on the site. The results show fairly high existing noise levels, generally caused by road traffic on the M4 Motorway and Parramatta Road, rail noise from the Western Rail Line, the Northern Rail Line and the North Strathfield Goods Loop. There is also significant noise emissions from the substation located immediately south of the proposed development site.

The measurements of the ambient noise levels have been used to calibrate a 3D acoustic model developed in SoundPLAN. The model has been used to predict noise levels at all exposed residential facades, used to determine in-principle measures that will be required to control rail and road traffic noise intrusion to residential areas.

In addition, an assessment of rail vibration has been undertaken.

Based upon the findings of this assessment and subject to the implementation of an appropriate acoustic design, the proposed development site is suitable for residential land uses on the basis of acoustics.

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1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by PD Mayoh Pty Ltd to prepare an Acoustic Assessment for the proposed development of the Columbia Precinct on 2-20 Parramatta Road and 11-13 Columbia Lane, Homebush.

The Proposed Columbia Precinct development consists of a number of residential buildings ranging from 3 to 21 storeys on a series of podiums. There is an increase in building height from the north (facing Parramatta Road) towards the south. It is proposed to extend George Street towards the south so that it runs through the proposed development and to create public parks with pedestrian and bicycle links throughout the development site.

This assessment addresses the impact of existing industrial noise as well as rail and road traffic noise on the amenity of the proposed residential areas. The report also outlines criteria for noise emission from the development and establishes appropriate acoustic design requirements between residential dwellings.

This acoustic assessment is based on the architectural drawings as per 20 May 2011 and issued to SLR Consulting on 20 May 2011. The site plan for the proposed development is shown in **Figure 1**.

Figure 1 Site Plan (A.002 P1)

2 NOISE SURVEY

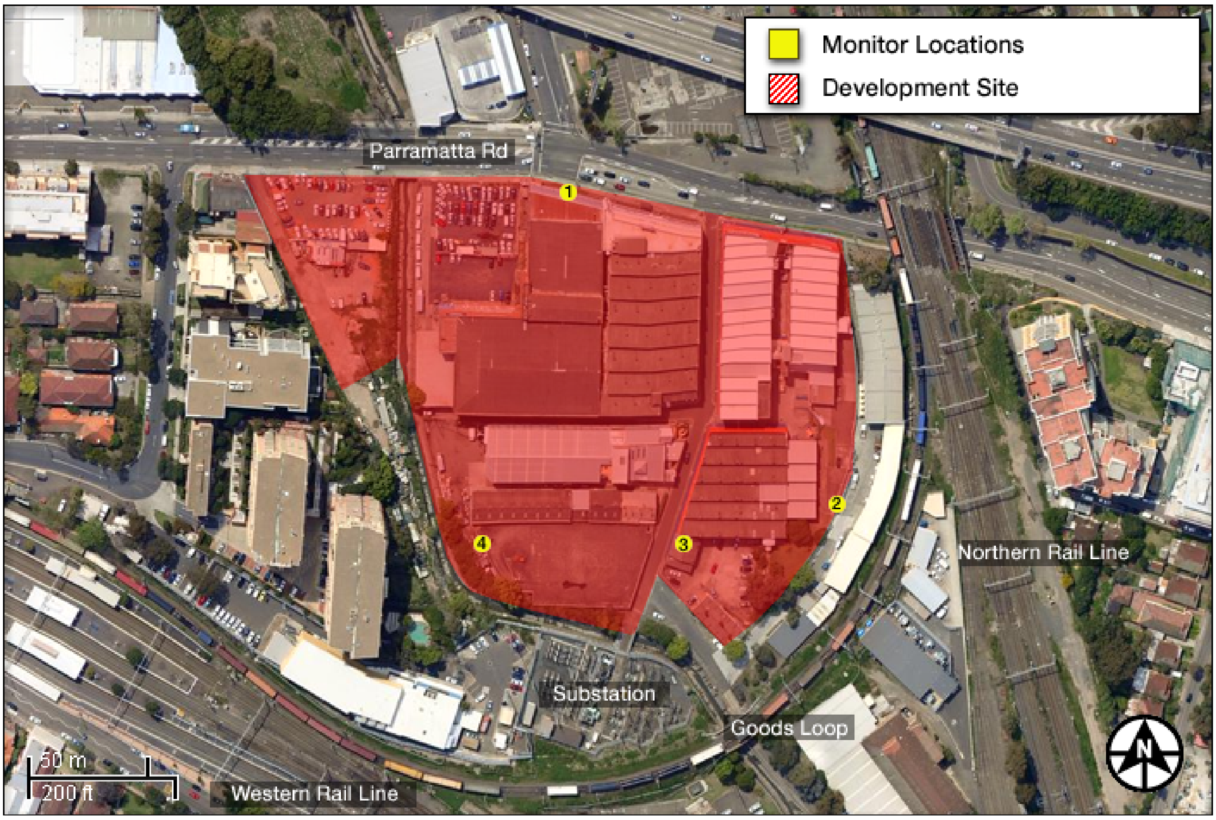
2.1 Site Description

The development site is bounded by:

- Parramatta Road to the north.
- Station Street residential premises to the west.
- Substation to the south
- Railcorp's industrial property to the east.

An aerial photo of the site is shown in **Figure 2** below.

Figure 2 Proposed Columbia Precinct Development Site, Homebush



Courtesy of Google Earth

The closest residential properties are located on Station Street to the west of the development site and on Clarence Street to the east.

The Northern Rail Line runs approximately 40 to 90 metres east of the nearest point of the proposed development site. The Western Rail Line runs south of the site, with Homebush Station south-west of the site. The North Strathfield Goods Loop connects the two rail lines and is operated by freight trains and empty passenger trains.

The North Strathfield Goods Loop is a substantial noise source due to the tight curvature of the line and because trains operating on the line have a tendency to produce curve squeal. This was apparent during from SLR Consulting's site visits and also from the noise logging results.

2.2 Unattended Noise Monitoring

2.2.1 Methodology

Unattended noise monitoring was conducted at the proposed development site between Thursday 20 January and Friday 28 January 2011.

Prior to noise monitoring, SLR Consulting personnel assessed the site and resolved that there are two particular noise environments at the subject site which are of relevance to this study and warrant the siting of (at least) one unattended noise logger at each location. The acoustic environment on the northern part of the site is dominated by road traffic noise from mainly Parramatta Road and the M4 Motorway. The eastern and southern site boundaries are dominated by noise from the railway lines and the adjacent substation.

Measuring at locations with different noise environments allows the separate assessment of noise intrusion into the development and noise emission from the development. Four environmental noise loggers were positioned at the selected locations, identified in **Figure 2** and further in **Table 1** to continuously record ambient noise levels at the site. The loggers were calibrated before and after the noise monitoring with a drift in noise levels not exceeding **±**0.5 dBA. The sample time interval was set at 15 minutes and the time weighting function set to “Fast”.

Table 1 Ambient Noise Loggers and Locations

Ref	Logger Serial Number	Location
Logger 1	EL215-193410	First floor balcony
Logger 2	EL316-16-306-043	Top of fence
Logger 3	EL215-194592	Top of stairs, approximately 5 m elevation
Logger 4	EL215-194591	Upper storey of car park, western boundary

Logger 4 was vandalised around midday on Monday 24 January and concurrently stopped recording. As four days of data had successfully been obtained, it was decided that the monitoring in this location would not be repeated.

2.2.2 Statistical Noise Levels

The statistical descriptors shown on the graphs are:

- RBL The Rating Background Level is used for assessment purposes and is based on 15-minute measurements of the L_{A90} noise level.
- L_{A90} The L_{A90} is the level of noise exceeded for 90% of the sample time (15 minutes). The L_{A90} noise level is described as the average minimum background sound level or simply the background level.
- L_{Aeq} The L_{Aeq} is the energy-average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

A further explanation of acoustic terminology is provided in **Appendix A**.

2.2.3 Result Summary

A summary of the unattended noise monitoring results is presented in **Table 2**.

Table 2 Logging Result Summary (dBA)

Ref	Period	RBL	$L_{Aeq(period)}$	Lmax[1]	Comments
Logger 1	Day	65	73	100	The RBL, L_{Aeq} and L_{Amax} noise levels determined by road traffic on Parramatta Road and the M4 Motorway.
	Eve	64	72		
	Night	53	70		
Logger 2	Day	49	66	100	Background levels determined by substation noise emissions and 'urban hum'.
	Eve	48	66		
	Night	46	66		
Logger 3	Day	53	62	93	Background levels determined by substation noise emissions. The L_{Aeq} and L_{Amax} levels determined by freight trains.
	Eve	54	63		
	Night	51	62		
Logger 4	Day	53	59	89	Background levels determined by substation noise emissions. The L_{Aeq} and L_{Amax} levels determined by freight trains.
	Eve	54	61		
	Night	52	58		

Note 1. The typical repeating maximum noise levels obtained during the logging periods.

The full results from the unattended noise monitoring are provided in a graphical format in **Appendix B**.

2.3 Attended Noise & Vibration Measurements

Attended Noise and Vibration Measurements were undertaken in the afternoon on Thursday 20 January 2011.

2.3.1 Noise Measurements

The noise measurements were performed using a calibrated Brüel and Kjær 2260 Advanced Sound Level Meter (serial number 2335703) for the airborne noise. Instrument calibration was checked before and after each measurement survey, with the variation in calibrated levels not exceeding the acceptable variation of ±0.5 dBA (AS 1055).

Road traffic noise measurements were undertaken for a period of 15 minutes on the north-east corner of the site. The frequency spectrum obtained during these measurements have been used for the glazing calculations in this assessment. The $L_{Aeq(15minute)}$ obtained was 74 dBA, approximately 15 m setback from Parramatta Road.

Attended noise measurements were also undertaken on the eastern boundary of the site, next to the location of Logger 2. It was found that normal passenger trains do not contribute significantly to the overall L_{Aeq} noise levels in this location. This is also supported by the noise logging graphs from this location showing relatively low levels during the morning and afternoon peak commuting hours and that the overall levels are dominated by a few high-noise events (freight train passbys). It was also noted that the Substation located south of the site was audible at this location. This can also be seen in the logging results; in that the L_{A90} levels only drop marginally during the night-time period.

Similar results were obtained near the southern boundary, next to the location of Logger 4. Passenger train passbys were not significantly higher than the prevailing background noise levels. In this location the ambient level is dominated by the clearly audible substation, emitting approximately 50 dBA to this location. Compare levels can be expected for the entire southern part of the site.

2.3.2 Vibration Measurements

In addition, attended vibration measurements were performed at the locations of Logger 2 and Logger 3 using a Brüel and Kjær Type 4370 accelerometer (1068050) and a Brüel and Kjær Type 2635 charge amplifier (735382). The vibration signal stored on a Brüel and Kjær 2260 Precision Sound Level Meter (serial number 2414604) was recorded on a Rion DA-20 digital data recorder. A calibration signal was recorded in the beginning and at the end of the measurements.

For each train passby, the L_{Amax} and L_{AE} noise levels were recorded, as well as the frequency spectra of each of these parameters. "L_{AE}" refers to the sound exposure level (a measurement integrated over time, reflecting both the noise level and the duration of the event). L_{AE} values may be summed logarithmically and used to calculate the total daily noise exposure due to train noise emissions over the daytime (7.00 am to 10.00 pm) or night-time (10.00 pm to 7.00 am) periods. Maximum Noise Level, abbreviated here as L_{AFmax} is the fast-response (F) maximum A-weighted noise level recorded during each train passby. Train type, speed and directions were all noted for a total of 22 passbys.

Only very low vibration levels were obtained. Trains going around the curve maintain very low speeds and the ground vibrations are therefore low. There are crossovers on both the Northern Line and the Western Line, next to the proposed development area. However, the distances from these to the site boundary are about 50 meters from the Northern Rail Line and in excess of 100 meters from the Western Rail Line.

3 NOISE GOALS

This section outlines the recommended noise goals applicable to the development; with regard to environmental noise emissions, road and rail noise intrusion, rail and road vibration as well as sound separation requirements for dwellings.

3.1 Mechanical Services Noise Emission

The noise emission from any mechanical plant associated with the proposed mixed use development, such as air conditioning condensers and exhaust fans, should be controlled to avoid impacting upon the acoustic amenity of nearby residential premises, including residential premises part of the development itself.

Responsibility for the control of noise emission in New South Wales is vested in Local Government and the Department of Environment, Climate Change and Water (DECCW). The DECCW oversees the Industrial Noise Policy (INP), released by the EPA in January 2000 which provides a framework and process for deriving noise criteria. The INP criteria for industrial noise sources (eg mechanical plant) have two components:

- Controlling the intrusive noise impacts for residents and other sensitive receivers in the short term; and
- Maintaining noise level amenity for particular land uses for residents and sensitive receivers in other land uses.

For assessing intrusiveness, the background noise generally needs to be measured. The intrusiveness criterion essentially means that the equivalent continuous noise level (L_{Aeq}) of the source should not be more than 5 dBA above the measured Rating Background Level (RBL), over any 15 minute period.

In cases where transportation noise (road and rail traffic) dominates the ambient noise environment, the amenity criterion for noise from the industrial noise becomes the $L_{Aeq, period(traffic)}$ minus 10 dB.

The development area has been classified as 'Urban' for the purpose of assessment in accordance with the provisions of the INP. The INP characterises the "Urban" noise environment as an area that:

- Is dominated by "urban hum" or industrial source noise.
- Has through traffic with characteristically heavy and continuous traffic flows during peak periods.
- Is near commercial districts or industrial districts.
- Has any combination of the above.

3.1.1 Project Specific Noise Levels

The project specific noise goals are established on the basis of the area type and the processed results of the unattended noise monitoring.

The project specific noise levels applicable to continuous mechanical noise emissions from the development, which are shown in bold in **Table 3** and **Table 4**, are the lower of the 'Intrusive' and 'Amenity' criteria. For intermittent noise sources, both 'Intrusive' and 'Amenity' criteria may apply independently.

Table 3 Criteria for Mechanical Noise Emissions to Nearby Residences (East of site)

Time of Day	Noise Level dBA re 20 µPa				
	ANL[1] (period)	Measured RBL $L_{A90(15minute)}$[2]	Measured $L_{Aeq(15minute)}$	INP Criteria	
				Intrusive	Amenity
				$L_{Aeq(15minute)}$ Criterion for New Sources	$L_{Aeq(Period)}$ Criterion for New Sources[3]
Day	60	49	66	**54**	56
Evening	50	48	66	**53**	56
Night	45	46	66	**51**	56

Note 1: ANL Acceptable Noise Level for an urban area
Note 2: RBL Rating Background Level taken from the Logger 2 results
Note 3: Assuming existing noise levels unlikely to decrease
Note 4: Project Specific Criteria are shown in bold

These noise goals apply to the residential receivers on Clarence Street east of the development site and also apply to the proposed eastern residential premises, forming part of the development.

In the same way, for receivers west of the site, the noise goals in **Table 4** apply.

Table 4 Criteria for Mechanical Noise Emissions to Nearby Residences (West of site)

Time of Day	Noise Level dBA re 20 µPa				
	ANL[1] (period)	Measured RBL $L_{A90(15minute)}$[2]	Measured $L_{Aeq(15minute)}$	INP Criteria	
				Intrusive	Amenity
				$L_{Aeq(15minute)}$ Criterion for New Sources	$L_{Aeq(Period)}$ Criterion for New Sources[3]
Day	60	53	59	58	**49**
Evening	50	54	61	59	**51**
Night	45	52	58	57	**48**

Note 1: ANL Acceptable Noise Level for an urban area
Note 2: RBL Rating Background Level taken from the Logger 4 results
Note 3: Assuming existing noise levels unlikely to decrease
Note 4: Project Specific Criteria are shown in bold

These criteria will apply to noise emissions from any proposed mechanical plant as measured at the boundary of any residence, including residences within the development itself. For mechanical plant that operates on a 24 hour basis, the night-time criteria of 51 dBA and 48 dBA on the eastern and western side of the site respectively are the limiting criteria.

For potentially affected commercial and industrial receivers, the L_{Aeq} noise criteria are 65 dBA and 70 dBA respectively, applying to when the premises are in use.

3.2 Road and Rail Traffic Noise Intrusion

3.2.1 External Noise Levels

The NSW DECCW's "*Environmental Criteria for Road Traffic Noise*" (ECRTN) (May 1999) recommends criteria for road traffic noise for *"New residential land use developments affected by freeway/arterial traffic noise"*. A summary of the applicable noise goals as recommended by the ECRTN is presented in **Table 5**.

Table 5 Road Traffic Noise Criteria - New Residential Developments

Type of Development	Criteria		
	Day (7 am-10 pm)	Night (10 pm-7 am)	Where Criteria are Already Exceeded
New residential land use developments affected by freeway/arterial traffic noise	$L_{Aeq(15hour)}$ 55 dBA	$L_{Aeq(9hour)}$ 50 dBA	Where feasible and reasonable, existing noise levels should be reduced to meet the noise criteria via judicious design and construction of the development. Locations, internal layouts, building materials and construction should be chosen so as to minimise noise impacts.

3.2.2 Internal Noise Levels

Australian/New Zealand Standard **AS/NZS 2107:2000** - *"Acoustics - Recommended design sound levels and reverberation times for building interiors"* is primarily concerned with establishing internal noise levels for relatively steady noise sources, such as air conditioning plant and continuous road traffic noise. **Table 6** provides a summary of recommended noise levels for residential buildings near "minor and major" roads given in AS/NZS 2107:2000. The guideline lower and upper range of the noise levels are described as "satisfactory" and "maximum" respectively.

Table 6 Recommended Sound Levels and Reverberation Times (AS/NZS 2107:2000)

Type of Occupancy/Activity	Recommended Design Sound Level L_{Aeq} dBA re 20 µPa	
	Satisfactory	Maximum
Houses and apartments near **minor** roads		
Living areas	30 dBA	40 dBA
Sleeping areas	30 dBA	35 dBA
Work areas	35 dBA	40 dBA
Houses and apartments near **major** roads		
Living areas	35 dBA	45 dBA
Sleeping areas	30 dBA	40 dBA
Work areas	35 dBA	45 dBA

The standard describes the 'Satisfactory' design sound level the level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive. The 'Maximum' design sound level is described as the level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

The local Council's own noise regulations should also be considered. The following is stated in Strathfield Council's document PART A of *Strathfield Consolidated Development Control Plan – Part A: Dwelling Houses and Ancillary Structures* (2005):

> *14.3.5 Acoustic Privacy*
>
> *1. Noise-sensitive rooms, such as bedrooms, should be located away from noise sources, including main roads, parking areas, living areas and recreation areas and the like.*
>
> *2. Double glazing, laminated glass, vibration-reducing footings or other materials, should be considered to minimise the effects of noise and/or vibrations.*
>
> *3. Suitable acoustic screen barriers or other noise mitigation measures may be required where physical separation is not able to be achieved.*

Further to this, the NSW Department of Planning's '*Development Near Railway Corridors and Busy Roads'* provides criteria for the internal noise levels due to road and rail noise within single dwelling residential buildings, presented in **Table 7** below.

Table 7 Road and Rail Noise Assessment Criteria

Internal Space	Time period	Internal Noise Level[1] (Windows closed guideline)
Sleeping area	Night (10 pm to 7 am)	35 dBA
Other habitable room	At any time	40 dBA

Note 1: Airborne noise is calculated as Leq (9h) (night) and Leq (15h)(day). Ground-borne noise is calculated as Lmax (slow) for 95% of rail pass-by events.

These noise levels are consistent with AS/NZS 2107:2000 and are therefore adopted as the internal noise goals for the development.

The document also provides criteria for internal noise levels due to road and rail noise contribution with windows or doors open. These state:

> *"If internal noise levels with windows or doors open exceed the criteria by more than 10 dBA, 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".*

3.3 Rail Vibration Criteria

For the assessment of vibration, the NSW Department of Planning guideline refers to guideline criteria set out in *"British Standard BS 6472:1992 Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)"* and DECCW's *"Assessing Vibration – a Technical Guideline".* In order to evaluate intermittent vibration such as that associated with rail activities, this standard provides methodology to assess vibration in terms of "dose". Thus the assessment takes into account such factors as the overall vibration level, the duration of vibration events and number of vibration events in each period (day and night).

Table 8 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7 am – 10 pm)		Night-time (10 pm – 7 am)	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residence	0.2	0.4	0.13	0.26

3.4 Internal Sound Separation Requirements (BCA)

The development will be required to comply with the BCA sound insulation requirements. **Table 9** details the minimum acoustic performance required for all residential projects.

Table 9 BCA 2010 Sound Insulation Requirements

Construction	2010 BCA	
	Laboratory Rating	**Verification**
Walls between sole occupancy units	$R_w + C_{tr}$ not < 50	$D_{nT,w} + C_{tr}$ not < 45
Walls between a bathroom, sanitary compartment, laundry or kitchen in one sole occupancy unit and a habitable room (other than a kitchen) in an adjoining unit	$R_w + C_{tr}$ not < 50 and **Must have a minimum 20 mm cavity between two separate leaves**	$D_{nT,w} + C_{tr}$ not < 45 "Expert Judgment" Comparison to the "Deemed to satisfy" Provisions
Walls between sole occupancy units and a plant room or lift shaft	R_w not < 50 and **Must have a minimum 20 mm cavity between two separate leaves**[1]	$D_{nT,w}$ not < 45
Walls between sole occupancy units and a stairway, public corridor, public lobby or the like, or parts of a different classification	R_w not < 50	$D_{nT,w}$ not < 45
Door assemblies located in a wall between a sole-occupancy unit and a stairway, public corridor, public lobby or the like	R_w not < 30 [2]	$D_{nT,w}$ not < 25
Floors between sole-occupancy units or between a sole-occupancy unit and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification	$R_w + C_{tr}$ not < 50 $L_{n,w} + C_I$ not > 62	$D_{nT,w} + C_{tr}$ not < 45 $L'_{nT,w} + C_I$ not > 62
Soil, waste, water supply and stormwater pipes and ductwork to habitable rooms	$R_w + C_{tr}$ not < 40	n/a
Soil, waste, water supply and stormwater pipes and ductwork to kitchens and other rooms	$R_w + C_{tr}$ not < 25	n/a
Intra-tenancy Walls	There is no statutory requirement for airborne isolation via intra-tenancy walls.	

Note 1: A wall must be of "discontinuous construction" if it separates a sole occupancy unit from a plant room or lift shaft. Clause F5.3(c) defines "discontinuous construction" as a wall having a minimum 20 mm cavity between two separate leaves with no mechanical linkage except at the periphery.

Note 2: Clause FP5.3(b) in the 2010 BCA states that the required insulation of a floor or wall must not be compromised by a door assembly.

Note that the BCA requirements do not cover the acoustic impact of any commercial tenancy operation on residential units within the development itself. An assessment of this should be part of the detailed design stage.

4 NOISE ASSESSMENT

4.1 Mechanical Services Noise Emission

The noise emission of Mechanical plant associated with the development should be controlled so that the operation of such plant does not adversely impact nearby residential properties and other dwellings within the same development. At this stage of the project the location and selection of mechanical plant has not been made. Therefore a full assessment will need to be conducted during the detailed design stage of the project.

It is envisaged that the mechanical plant noise sources will be controllable by common engineering methods that may consist of:

- Judicious location
- Barriers
- Silencers
- Acoustically lined ductwork

The selected mechanical equipment must be reviewed and assessed for conformance with established criteria during the detailed design stage of the project when specific plant selection and location is determined.

4.2 Road and Rail Traffic Noise Intrusion

4.2.1 Airborne Noise

The L_{Aeq} and L_{Amax} noise levels obtained during the unattended noise monitoring are all dominated by the road and rail traffic noise. As such, the noise monitoring results constitute the best basis for the analysis, representing the long-term (one week) results. The locations of the noise loggers are shown in **Figure 2**.

ECRTN Noise Goals Comparison

Review of the existing traffic noise levels detailed in **Table 2** indicates exceedance of the ECRTN external noise criteria presented in **Table 5** for both the day (18 dBA) and night-time (20 dBA) at the most exposed facades facing Parramatta Road and the M4 Motorway.

Application of the ECRTN criteria would then be used to ensure that design of the proposed development, building configuration, materials selection and construction should be chosen to minimise noise impacts. For the proposed development it is not practical to provide effective noise mitigation measures to satisfy the external criteria so consideration should be given to satisfying the internal noise criteria discussed in **Section 3.2.2**.

It is also noted that the noise criteria presented within the ECRTN noise policy document are <u>guidelines</u> and <u>non-mandatory</u>. However, where the external noise levels exceed the guidelines, particular effort is required to ensure the internal acoustic environment becomes satisfactory.

Airborne Noise Modelling and Predictions

An acoustic model of the development has been developed using *SoundPLAN* V6.5. The model includes all known relevant noise sources in the vicinity of the proposed development, being:

- Parramatta Road and M4 Motorway.

- Northern Rail Line and Western Rail Line.
- North Strathfield Goods Loop.
- Substation immediately south of site.
- Columbia Lane and the proposed George Street Extension.

The model includes ground topography, buildings and representative noise sources. At the relatively small distances between the noise sources and receivers, weather effects have little influence on noise propagation and hence neutral meteorological conditions were assumed. The local streets within the development were given an assumed traffic flow of 1000 vehicles per 24-hour period.

The noise model has been calibrated using the results from the four noise loggers and the attended noise measurements. Calculations of the external noise levels throughout the development have been used to predict the internal noise levels at residential receivers. The noise logging results showed small differences in noise levels between daytime and night-time periods. The predicted L_{Aeq} levels are therefore used to represent both daytime and the night-time periods.

Standard window glazing of a building will typically attenuate these noise levels by 20 dBA with windows closed and 10 dBA with windows open (allowing for natural ventilation). The predicted internal noise levels for standard facade glazing are presented in **Table 10** for the windows open and windows closed scenarios at each building façade (northern, eastern, southern and western). Predicted values that comply with their corresponding criteria are indicated in bold.

Table 10 Predicted Internal Road Traffic Noise Levels – Windows Open/Closed

Location	Type of Occupancy	Windows Open					Windows Closed				
		Internal Noise Criteria (Leq dBA)	Predicted Internal Noise Level (Leq dBA)				Internal Noise Criteria (Leq dBA)	Predicted Internal Noise Level (Leq dBA)			
			N	E	S	W		N	E	S	W
Tower B	Living Areas (day)	50	64	64	**50**	58	40	54	54	**40**	48
	Sleeping Areas (night)	45	64	64	50	58	35	54	54	40	48
Tower C	Living Areas (day)	50	-	60	-	**46**	40	-	50	-	**36**
	Sleeping Areas (night)	45	-	60	-	46	35	-	50	-	36
Tower D	Living Areas (day)	50	56	56	**48**	52	40	46	46	**38**	42
	Sleeping Areas (night)	45	56	56	48	52	35	46	46	38	42
Tower G	Living Areas (day)	50	64	64	54	60	40	54	54	44	50
	Sleeping Areas (night)	45	64	64	54	60	35	54	54	44	50
Tower H	Living Areas (day)	50	64	58	-	56	40	54	48	-	46
	Sleeping Areas (night)	45	-	58	-	56	35	-	48	-	46
Tower J	Living Areas (day)	50	60	58	**48**	54	40	50	48	**38**	44
	Sleeping Areas (night)	45	60	58	48	54	35	50	48	38	44
Tower O	Living Areas (day)	50	56	54	54	54	40	46	44	44	44
	Sleeping Areas (night)	45	56	54	54	54	35	46	44	44	44
Tower Q	Living Areas (day)	50	56	54	**50**	54	40	46	44	**40**	44
	Sleeping Areas (night)	45	56	54	50	54	35	46	44	40	44
Tower R	Living Areas (day)	50	54	54	52	52	40	44	44	42	42
	Sleeping Areas (night)	45	54	54	52	52	35	44	44	42	42
Tower U	Living Areas (day)	50	52	-	**48**	52	40	42	-	**38**	42
	Sleeping Areas (night)	45	52	-	48	52	35	42	-	38	42

Location	Type of Occupancy	Windows Open					Windows Closed				
		Internal Noise Criteria (Leq dBA)	Predicted Internal Noise Level (Leq dBA)				Internal Noise Criteria (Leq dBA)	Predicted Internal Noise Level (Leq dBA)			
			N	E	S	W		N	E	S	W
Tower V	Living Areas (day)	50	-	52	**50**	**46**	40	-	42	**40**	36
	Sleeping Areas (night)	45	-	52	50	46	35	-	42	40	36

NOTE: There are additional glazing requirements for some buildings provided in Section 5.2 (substation)

The predicted internal noise levels shown in **Table 10** indicate that with windows open, the internal noise criteria will generally be exceeded at all proposed residential facades. It is also apparent that standard 4 mm glazing would not be sufficient to meet the internal noise requirements in all locations.

The exceedances of the internal noise criteria are detailed in **Table 11** below.

Table 11 Predicted Internal Noise Level Exceedances (4 mm glazing)

Location	Type of Occupancy	Predicted Exceedance at Facade (dBA)			
		N	E	S	W
Tower B	Living Areas (day)	14	14	nil	8
	Sleeping Areas (night)	19	19	5	13
Tower C	Living Areas (day)	-	10	-	nil
	Sleeping Areas (night)	-	15	-	1
Tower D	Living Areas (day)	6	6	nil	2
	Sleeping Areas (night)	11	11	3	7
Tower G	Living Areas (day)	14	14	4	10
	Sleeping Areas (night)	19	19	9	15
Tower H	Living Areas (day)	14	8	-	6
	Sleeping Areas (night)	19	13	-	11
Tower J	Living Areas (day)	10	8	nil	4
	Sleeping Areas (night)	15	13	3	9
Tower O	Living Areas (day)	6	4	4	4
	Sleeping Areas (night)	11	9	9	9
Tower Q	Living Areas (day)	6	4	nil	4
	Sleeping Areas (night)	11	9	5	9
Tower R	Living Areas (day)	4	4	2	2
	Sleeping Areas (night)	9	9	7	7
Tower U	Living Areas (day)	2	-	nil	2
	Sleeping Areas (night)	7	-	3	7
Tower V	Living Areas (day)	-	2	nil	nil
	Sleeping Areas (night)	-	7	5	1

NOTE: There are additional glazing requirements for some buildings provided in Section 5.2 (substation)

As can be seen from the results in **Table 11**, significant exceedances are predicted in many locations. We therefore recommend the following:

- Windows and doors in the facade of living and sleeping spaces of residences will need to be closed to meet internal noise levels. Where this occurs care will need to be taken to ensure that the BCA fresh air requirements can be met with windows closed. In some instances forced ventilation may be required. Design input on this issue should be sought from an appropriately qualified mechanical consultant.
- Improved glazing will be required for many windows and doors, indicatively:
  - Single glazing (6.38 mm laminated glass), where exceedances are up to 4 dBA.
  - Single glazing (10.38 mm laminated glass), where exceedances are between 5 dBA and 6 dBA.
  - Single glazing (12.76 mm laminated glass), where exceedances are between 7 dBA and 8 dBA.
  - Acoustical double glazing (10 mm mono / 100 mm air / 6 mm mono) with sound absorbent in reveal, where exceedances are between 9 dBA and 15 dBA.
  - For excesses greater than 15 dBA the following options should be considered:
    - Reduce window area – reducing the window area by 50 % will reduce traffic noise levels, and glazing requirements, by 3 dBA, OR
    - Install winter gardens (solution for windows to balconies only) OR
    - Increase air cavity in acoustical double glazing from 100 mm to 200 mm (10 mm mono / 200 mm air / 6 mm mono) with sound absorbent in reveal.

Glazed balconies, or 'Winter Gardens', are an efficient double glazing alternative provided the windows can be closed and seal properly. Winter gardens can therefore be used in lieu of acoustical double glazing, keeping in mind that the ventilation requirements still should be achieved.

Specific glazing requirements depend on a large number of factors, for example window and room sizes and extent of balconies, and must therefore be determined during the detailed design stage of the project. Glazing design can be "optimised" taking into account the varying noise exposures of each facade as opposed to the conservative approached used in this assessment.

For those parts of buildings exposed to high noise levels (ie. where acoustical double glazing is required), all facade elements will need to be acoustically upgraded, including the façade walls and any make up air vents that may be required. Advice on appropriate upgrades can be provided during the detailed design phase of the project, as the architectural information becomes available.

4.2.2 Ground-borne Noise Assessment

Vibration from the wheel-rail interaction can propagate through the ground, via a building's structure and cause floor, walls and ceilings to faintly vibrate. These vibrations radiate noise which may be audible inside a room. This type of noise is often referred to as *ground-borne noise* or *regenerated noise*. It has most often a dominant low-frequency component and therefore a 'rumbling' character.

Background noise levels and other ambient noise are important factors in determining whether ground-borne noise will affect amenity. A high background noise generally masks other noises. Issues with ground-borne noise is most common where buildings are constructed over or adjacent to land over tunnels.

Rail vibration measurements were undertaken near the eastern and southern boundaries of the development where proposed residential buildings are the closest to the existing railway. The measured vibration data has been analysed to determine the **highest** maximum vibration levels (on a one-third octave band basis) experienced throughout the measurements. These vibration levels are summarised in **Table 12**.

For convenience, units of dB re 1E-9 m/s have been used in this report for expressing the magnitude of vibration emissions. A level of 100 dB corresponds to a vibration level of 0.1 mm/s and a level of 120 dB corresponds to a vibration level of 1.0 mm/s.

Table 12 Highest Maximum Ground Surface Vibration Levels

Train Type	Frequency (Hz) - Vibration Level (dB)													Overall Level (dB)
	20	25	31.5	40	50	63	80	100	125	160	200	250	315	
Passenger	88	81	81	76	77	67	57	53	50	48	48	45	45	96

The vibration transmitted into buildings depends on the "coupling loss" between the ground and the building footings, and also on the extent of amplification in building elements such as suspended floors. Coupling loss refers to the reduction in vibration levels at the building foundations with respect to the ground vibration. The amount of coupling loss depends greatly on the manner in which a building is constructed.

In the case of slab-on-ground constructions or buildings with basements, the surface area of the slab is large and the slab is in contact with the underlying soil. For such constructions, there would be little or no coupling loss (ie reduction in vibration levels between the ground and building foundations). Such a construction has been assumed for the proposed development in order to give a conservative estimate of the ground-borne railway noise.

The level of ground-borne noise within residential buildings adjacent to the railway results from the vibration of the walls, floors and ceilings, and also the acoustical properties of the room.

In order to predict the level of ground-borne noise within the proposed development, the correction factors in **Table 13** have been applied.

Table 13 Corrections for Ground-borne Noise

Correction Type	Frequency (Hz) - Correction (dB)												
	20	25	32	40	50	63	80	100	125	160	200	250	315
Nominal Conversion to Noise	-27	-27	-27	-27	-27	-27	-27	-27	-27	-27	-27	-27	-27
A-Weighting	-51	-45	-39	-35	-30	-26	-23	-19	-16	-13	-11	-9	-7

On the basis of the typical maximum vibration levels in **Table 12** and the corrections in **Table 13** for typical residential building constructions, **Table 14** provides a summary of the predicted $L_{max(slow)}$ ground-borne noise levels for a train passby. The overall noise levels have been calculated by logarithmically adding the A-weighed noise levels in each one third octave frequency band.

Table 14 Summary of Predicted A-weighted Ground-borne Noise Levels

Noise Levels	Frequency (Hz) – Noise Levels (dBA)													
	20	25	32	40	50	63	80	100	125	160	200	250	315	dBA
Lmax(slow)	10	9	15	14	20	14	7	7	7	8	10	9	11	**25**

Note The predicted ground-borne noise levels are for the lower floor. The predicted ground-borne noise levels for the upper storeys are expected to progressively decrease.

The predicted 25 dBA ground-borne noise level complies with the criteria of 35 dBA for bedrooms (night-time) and 40 dBA for other habitable rooms (at all times).

It is noted that this would be considered a very conservative approach. Significant amount of reduction would be expected from the building footings and from the ground floor to the residential storeys.

4.3 Rail Vibration Assessment

In order to calculate the vibration dose, the number of passenger and freight train passbys were determined as described in **Section 2.3.2**. The ground vibration levels were sufficiently low to immediately rule out any exceedances of the assessment criteria. On the basis of the measured levels, constant train passbys (ie approximately 6 trains per minute) would be required to exceed both daytime and night-time vibration criteria.

It is also noted that the measured levels were in all cases significantly lower than accepted vibration perception threshold of 103 dB.

No further rail vibration analysis is therefore considered required at this stage.

4.4 Internal Sound Separation Requirements (BCA)

The Building Code of Australia (BCA) sound separation requirements for airborne sound insulation and impact noise isolation constitute the minimum requirements to be complied with for dwellings.

There are large numbers of well tested and proven designs available and suitable for residential buildings.

It is reiterated that these requirements are ‘minimum requirements’ and do not necessarily provide a design quality that will meet the expectations of future occupants. This is particularly the case with respect to impact noise control via tenancy floor / ceilings. BCA requirements in this area are low and complaints can be expected if a higher quality is not targeted.

5 DISCUSSION

5.1 Freight Train Noise

Northern Sydney Freight Corridor

The proposed Northern Sydney Freight Corridor (NSFC) development has the potential to increase the number of freight trains through the area. SLR Consulting has recently carried out the Environmental Noise and Vibration assessment of the NSFC project. Although our detailed studies are yet to be released in the public domain, we can advise that the noise impacts of the project will be limited to a maximum increase in noise level of between 1 dBA to 2 dBA. Such an increase will not change the outcomes of this assessment and its conclusions.

The potential impact of the NSFC can be revisited at the detailed design stage to confirm the above and when more information regarding the development itself is available.

Maximum Noise Events

The maximum noise events associated with freight trains operating the North Strathfield Goods Loop have been found to be significant; in the order of 90 dBA to 100 dBA at the locations of proposed residential development. Although not a formal requirement, it is appropriate to look at the potential for sleep disturbance in the proposed residential developments.

Unlike L_{Aeq} levels and annoyance reactions, the relationship between maximum noise levels and sleep disturbance is not currently well defined. The ECRTN recognises that there is an absolute level that noise events must reach before the onset of sleep disturbance. Again, it was acknowledged that the scientific literature had still not reached a consensus, however the ECRTN concluded the following:

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

With the results from the noise survey undertaken and the proposed indicative glazing schedule, it would appear that the conditions in (1) would be satisfied under the current operation of freight trains. The conditions in (2) would not be met at all locations.

Facades directly exposed to the noise from the rail will need to be acoustically upgraded and designed to meet BCA ventilation requirements with windows closed if the more stringent criteria is to be met. Example solutions of appropriate glazing upgrades include acoustical double glazing (ie. 10 mm glass, 100 mm airgap, 6 mm glass) or where appropriate 12.76 mm thick laminated glass.

5.2 Substation

The noise emissions from the substation are, as all similar electric noise sources, highly tonal. The noise from the substation is easily identifiable even at fairly low levels and would be likely to be found subjectively intrusive for many people. The elevated nature of the receivers in the towers proposed on the southern part of the site would make it impossible to screen the noise sources by means of any feasible noise barrier.

Facades directly exposed to the noise from the substation will need to be acoustically upgraded and designed to meet BCA ventilation requirements with windows closed. Example solutions of appropriate glazing upgrades include acoustical double glazing (ie. 10 mm glass, 100 mm airgap, 6 mm glass) or where appropriate 12.76 mm thick laminated glass.

6 CONCLUSION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by PD Mayoh Pty Ltd to prepare an Acoustic Assessment for the proposed development of the Columbia Precinct on 2-20 Parramatta Road and 11-13 Columbia Lane, Homebush.

The assessment has examined the following areas of acoustic significance:

- Road and rail traffic noise intrusion to external and internal areas.
- Rail vibration.
- Noise emission from mechanical plant.
- Internal Sound Insulation Requirements (BCA 2010).

Attended noise and vibration measurements have been carried out on site. In addition, four noise loggers were deployed to capture the ambient noise environment at the site. The results of the noise surveys have been used to calibrate an acoustic model of the proposed development. Ambient noise logging and the acoustic modelling have been used to determine:

- In-principle measures that will be required to control rail and road traffic noise intrusion to residential areas.
- Appropriate industrial noise emission criteria.

Based upon the findings of this assessment, the proposed development site is suitable for residential land uses on the basis of acoustics.

7 CLOSURE

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

This report is for the exclusive use of P D Mayoh Pty Ltd Architects. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

SLR Consulting disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work

Acoustic Terminology

1 Sound Level or Noise Level

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound.

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

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

2 “A” Weighted Sound Pressure Level

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

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

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

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

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

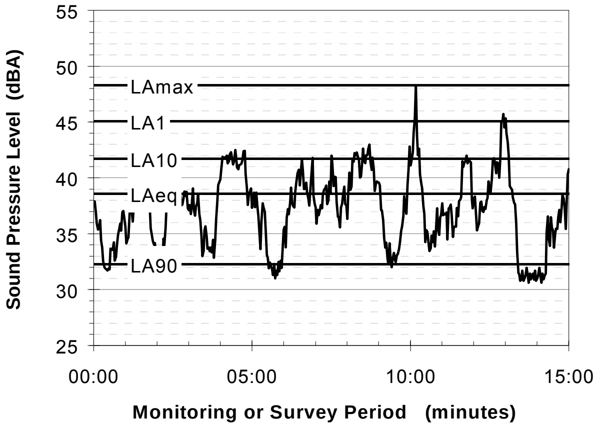
3 Sound Power Level

The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

- L_{A1} The noise level exceeded for 1% of the 15 minute interval.
- L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.
- L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.
- L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the “repeatable minimum” L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or “average” levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than “broad band” noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

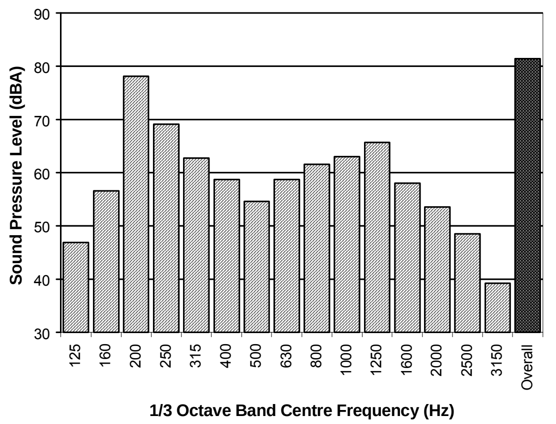
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

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

9 Human Perception of Vibration

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

10 Over-Pressure

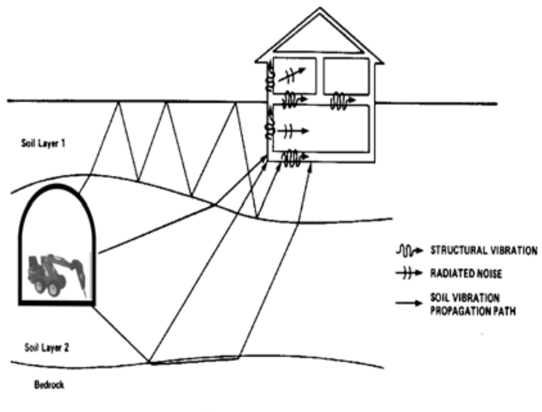
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

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

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

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



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

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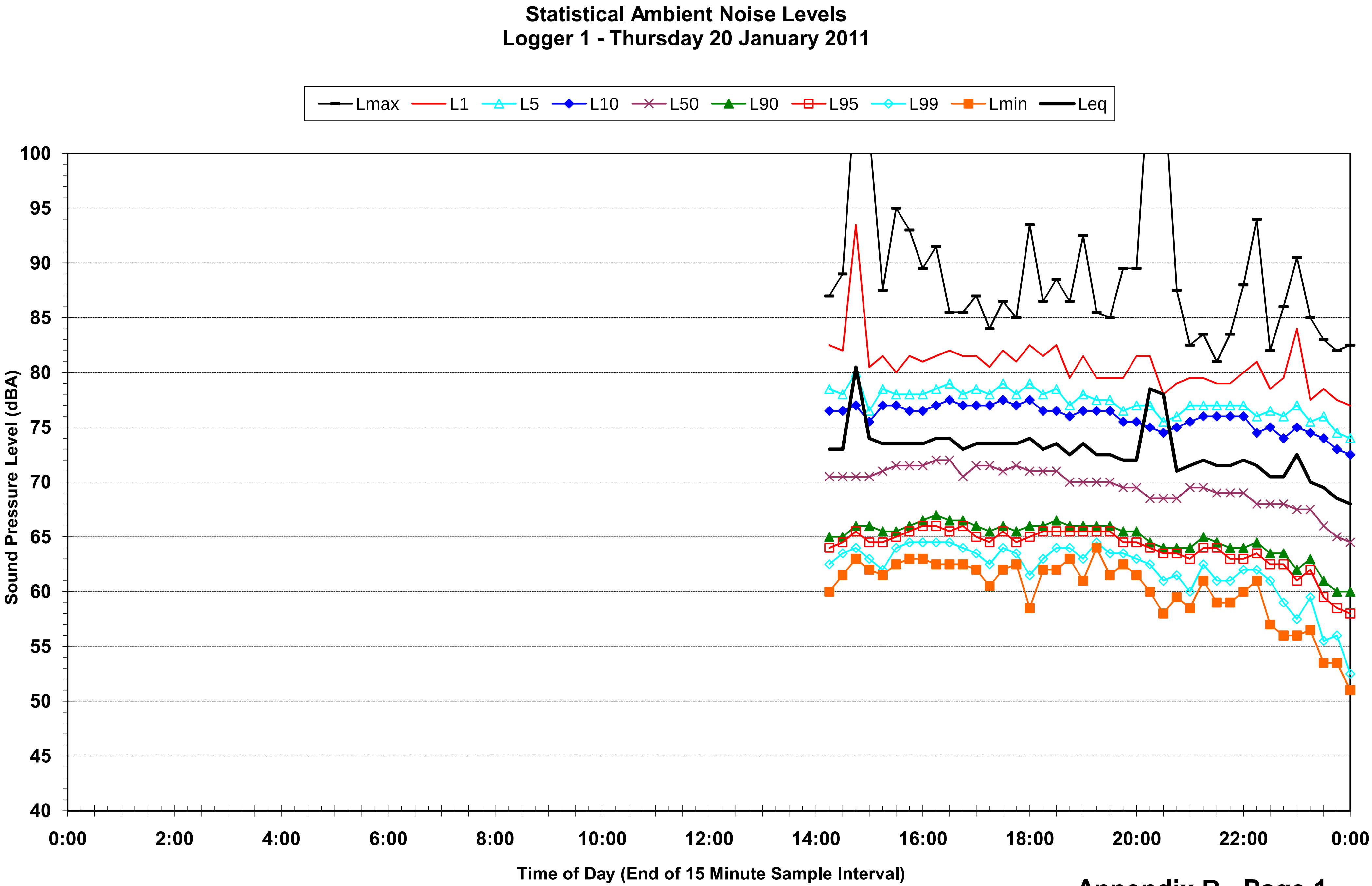
Unattended Noise Monitoring Graphs



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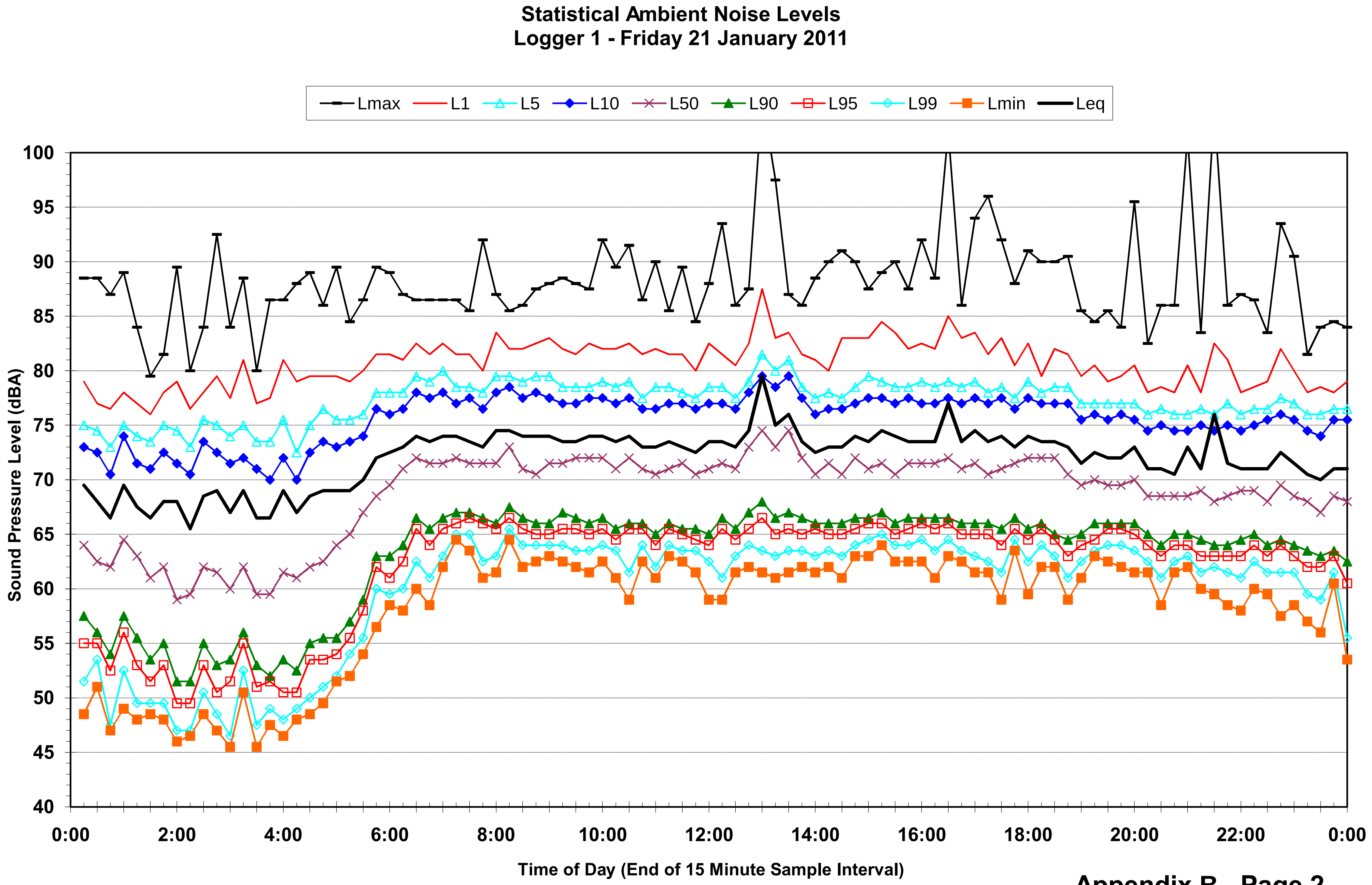
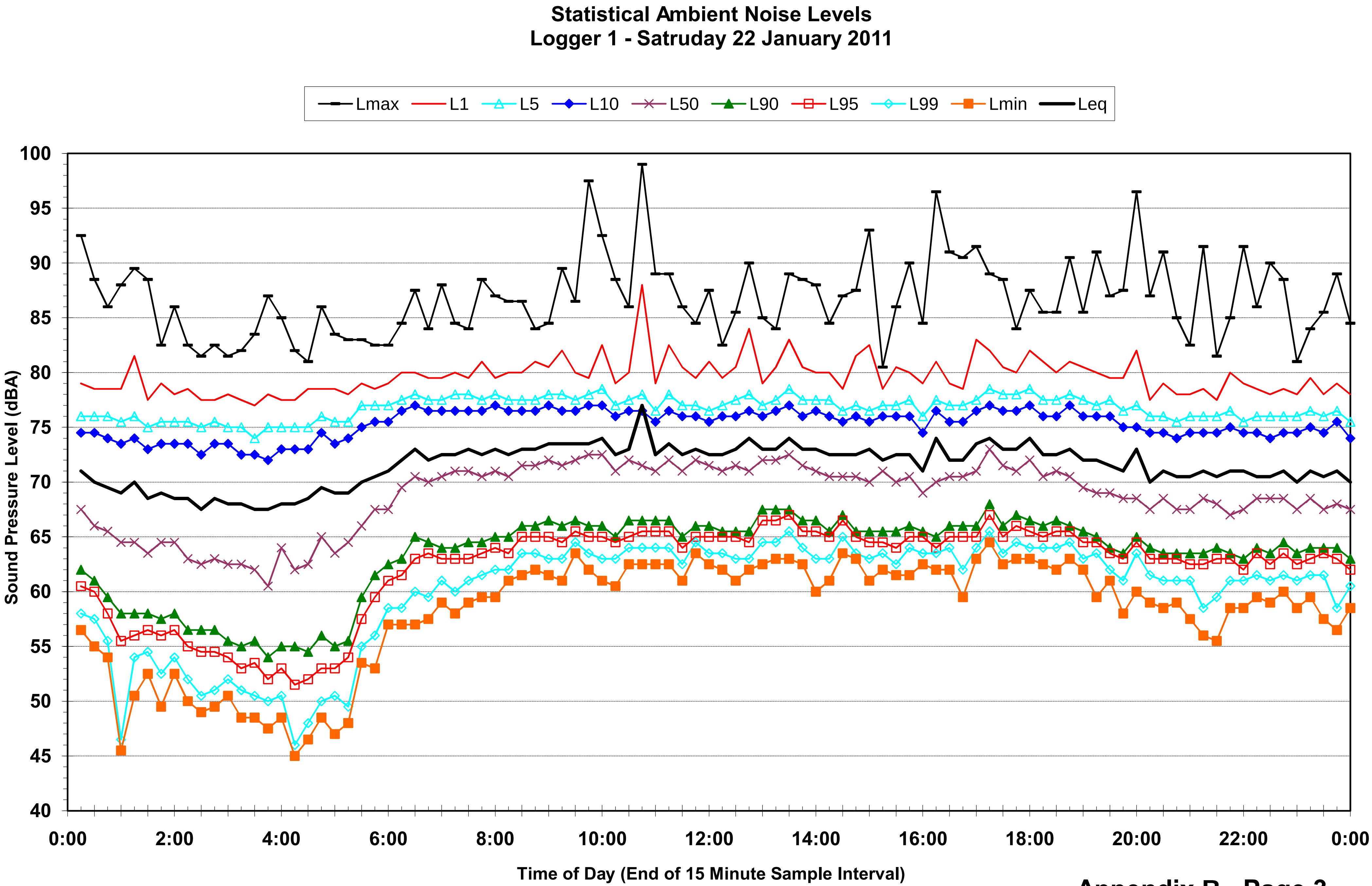
Statistical Noise Levels

Heggies Report 10150



Statistical Ambient Noise Levels
Logger 1 - Friday 21 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)



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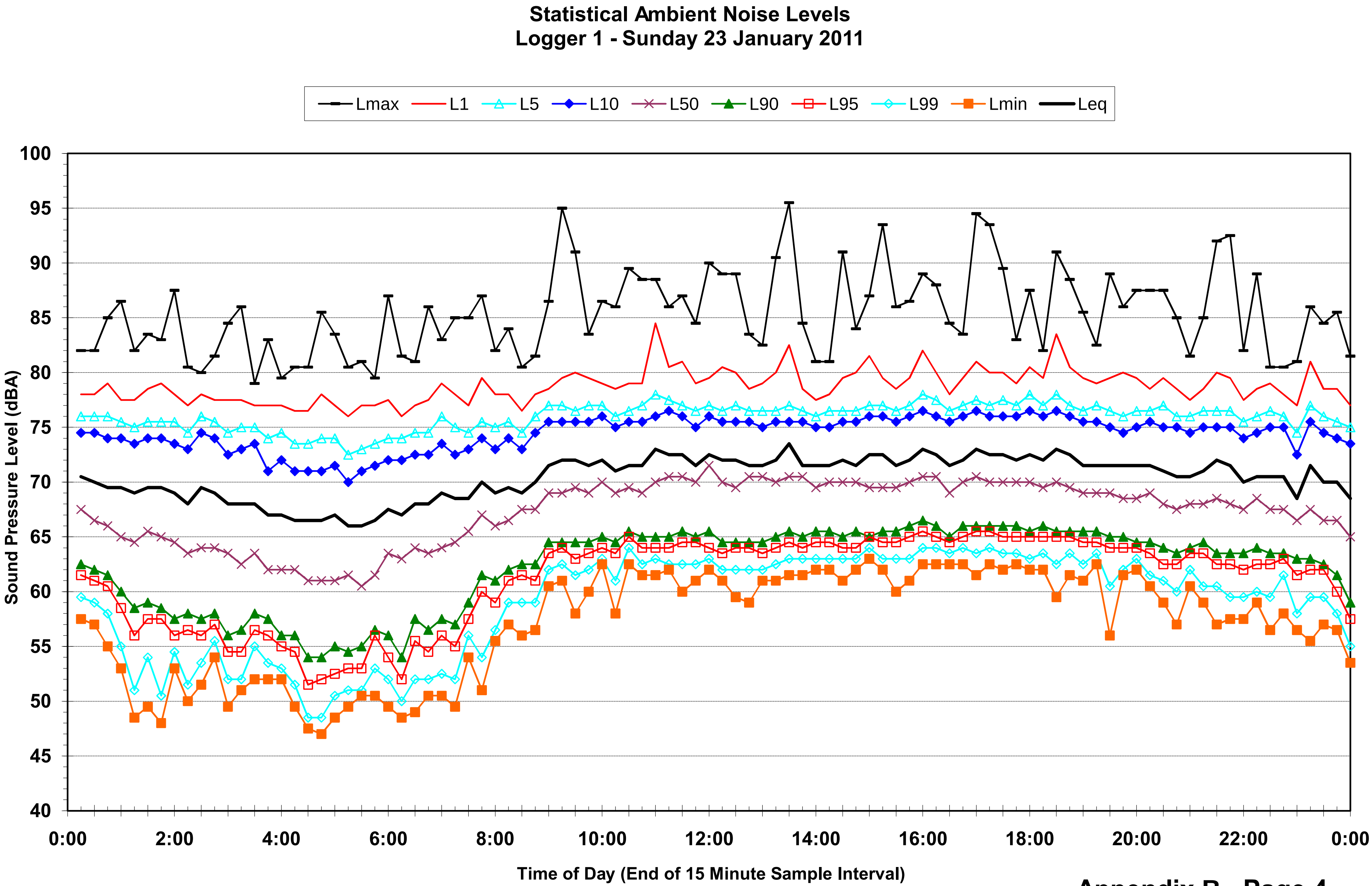
Statistical Noise Levels

Heggies Report 10150


Statistical Ambient Noise Levels
Logger 1 - Sunday 23 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
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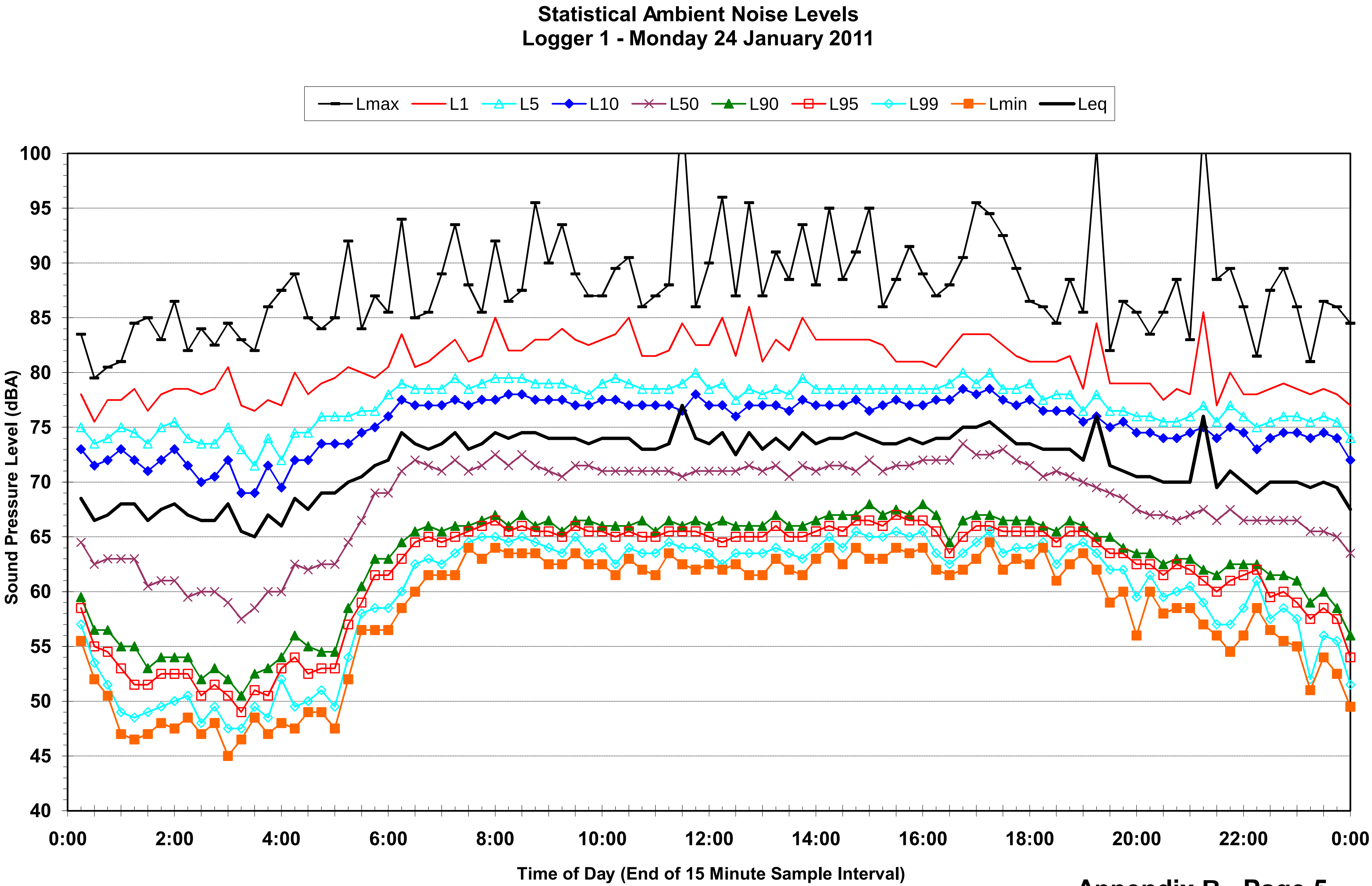
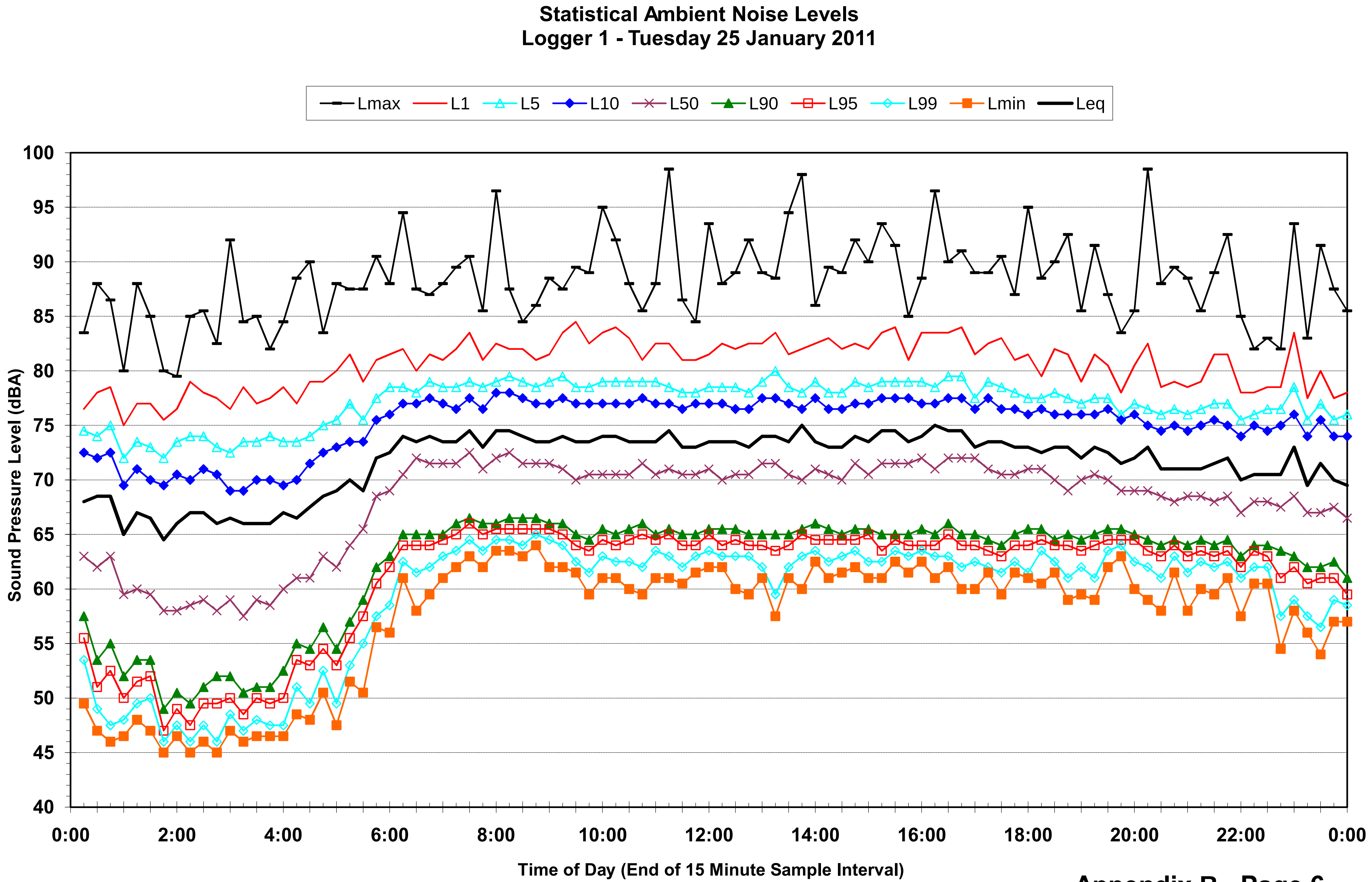
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Logger 1 - Monday 24 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
100
95
90
85
80
75
70
65
60
55
50
45
40
Sound Pressure Level (dBA)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)



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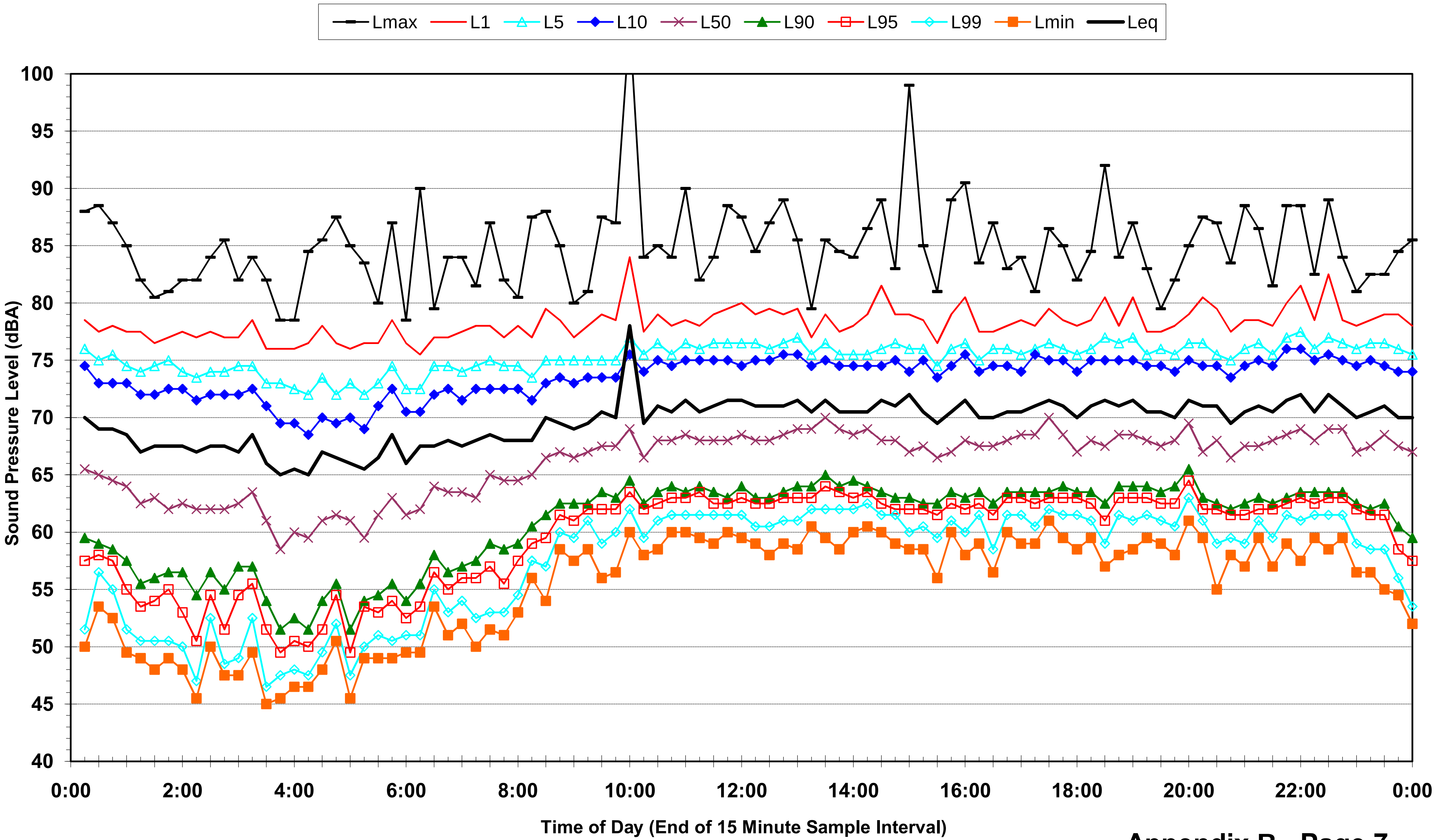
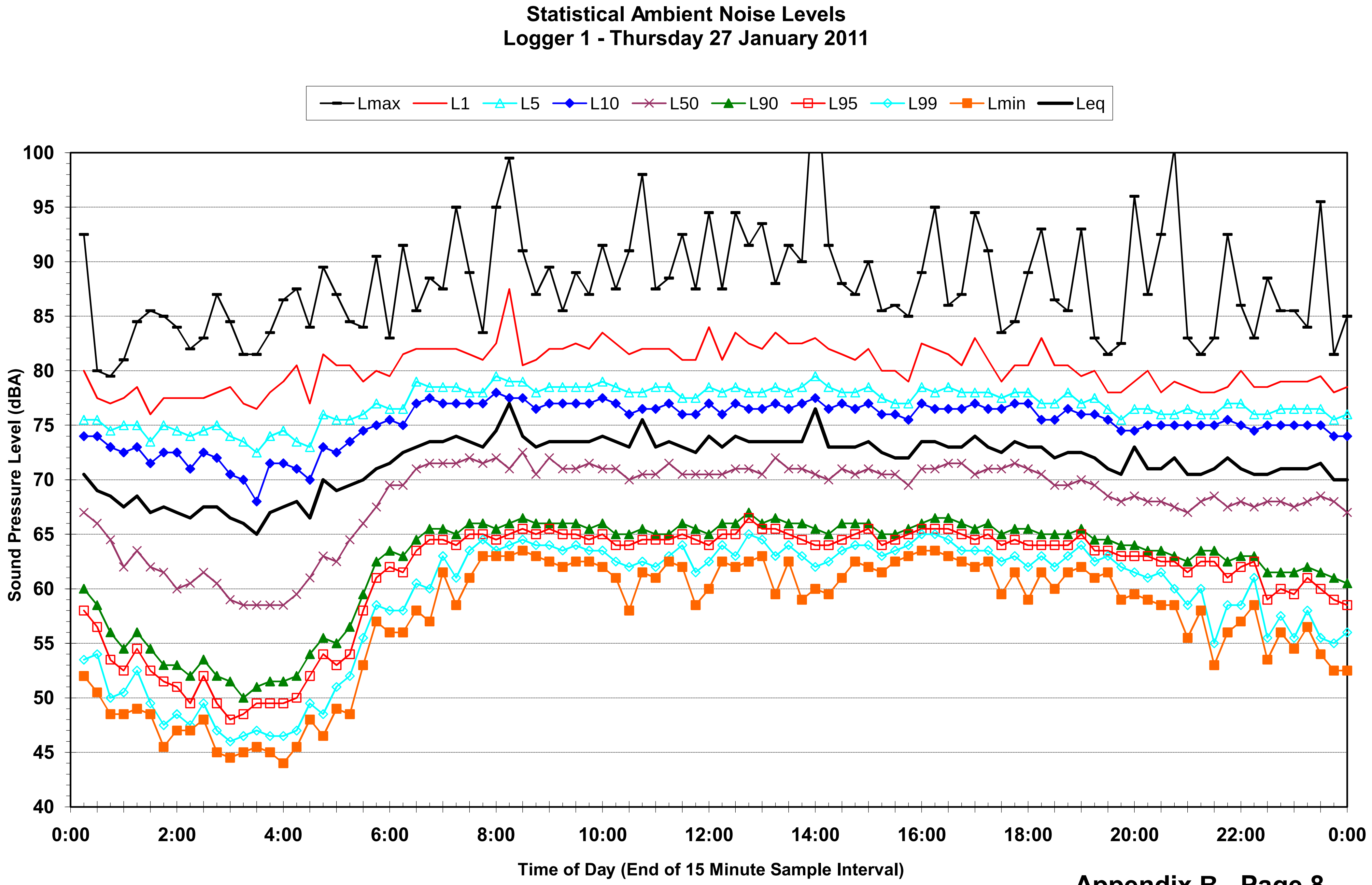
Statistical Noise Levels

Heggies Report 10150

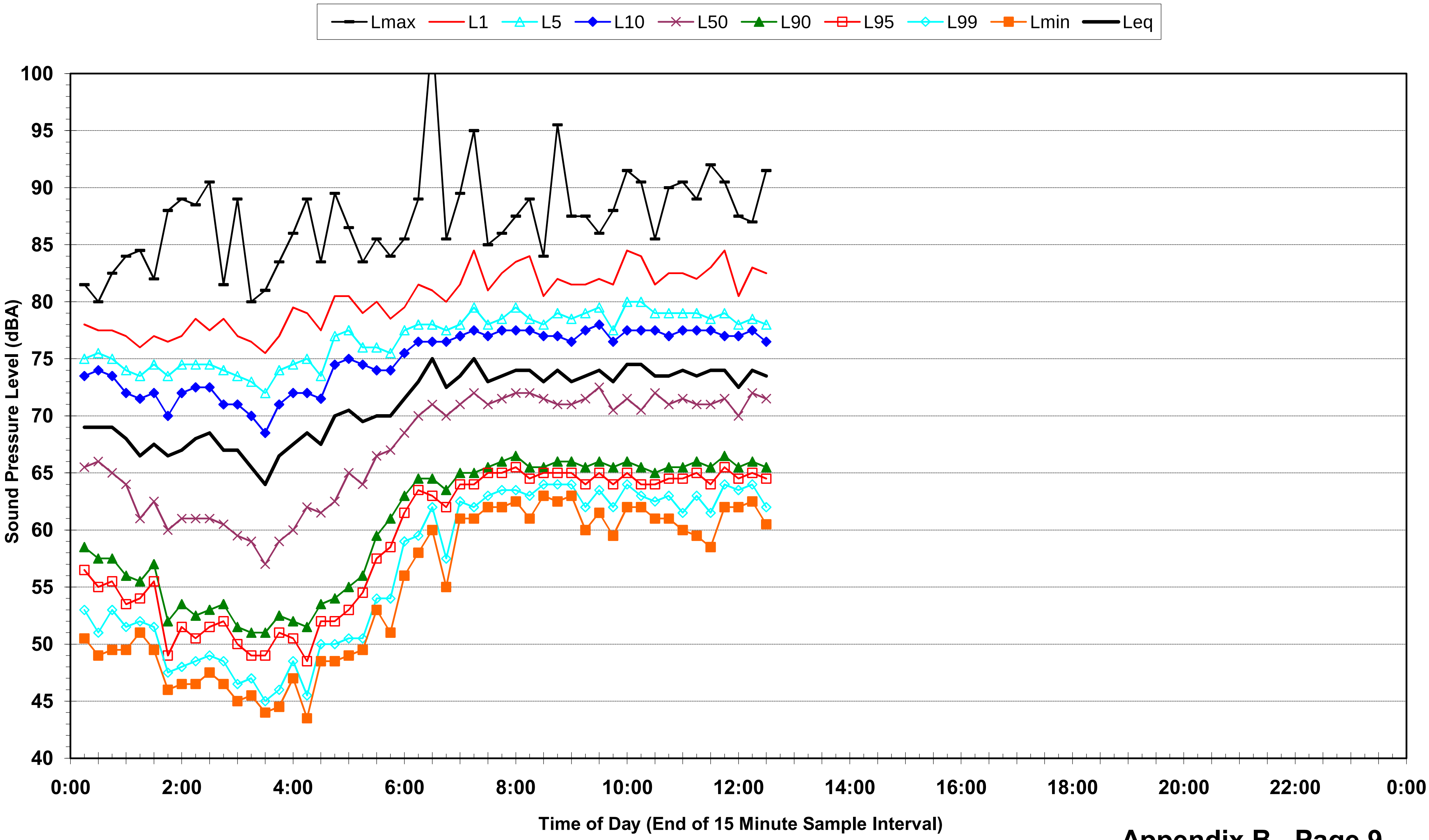
Statistical Ambient Noise Levels
Logger 1 - Wednesday 26 January 2011



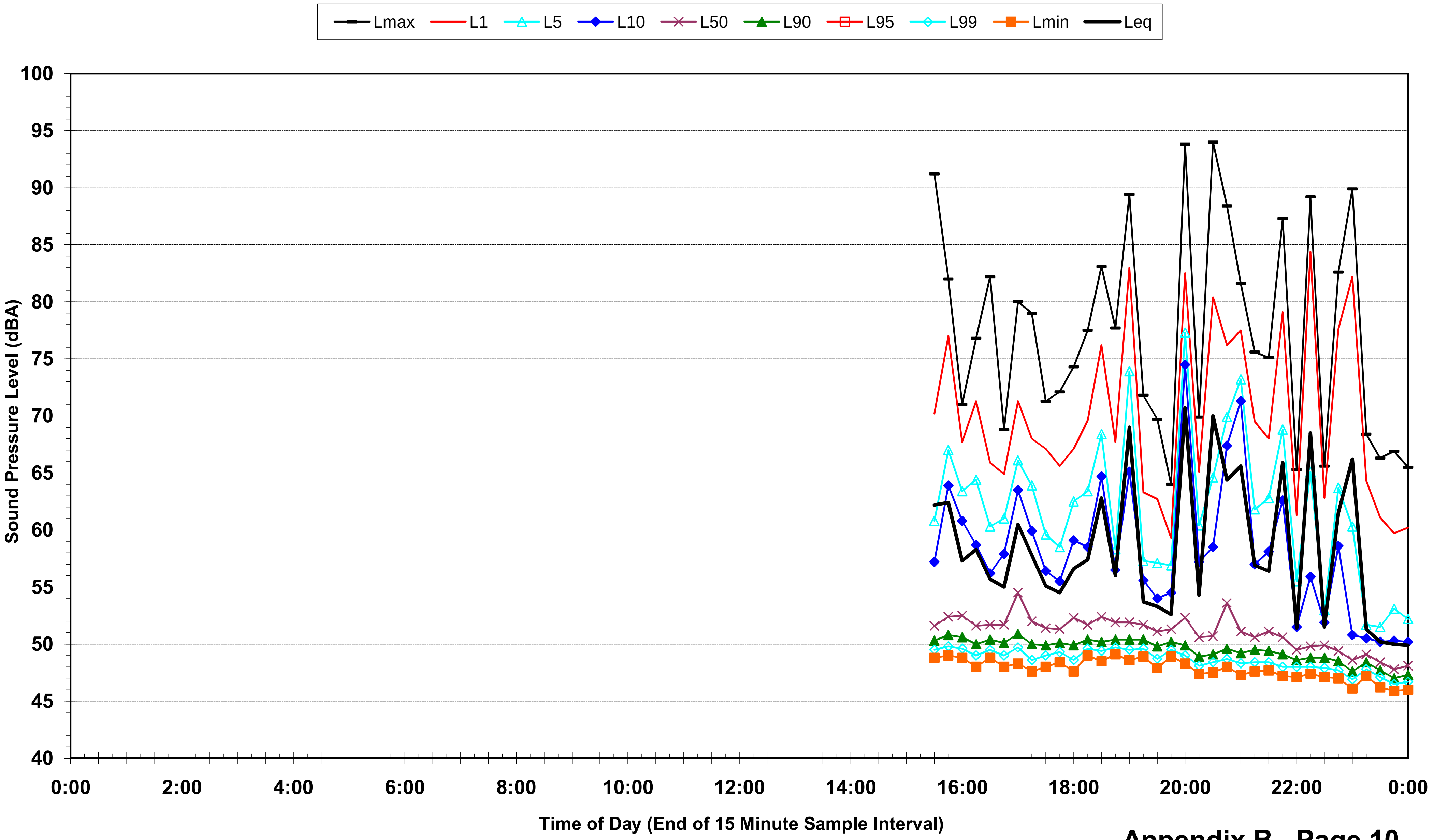


Statistical Ambient Noise Levels
Logger 1 - Thursday 27 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

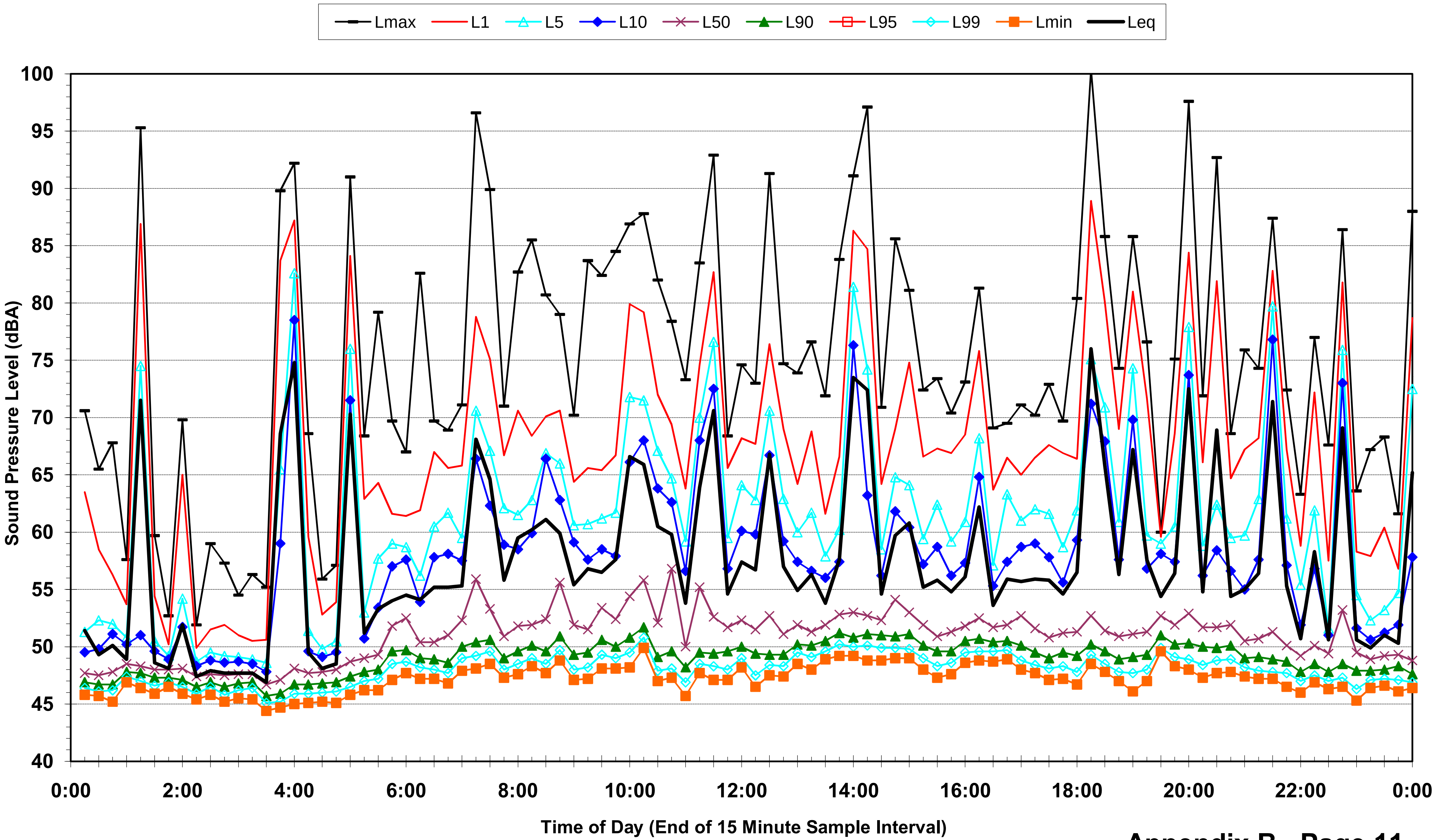
Statistical Ambient Noise Levels
Logger 1 - Friday 28 January 2010

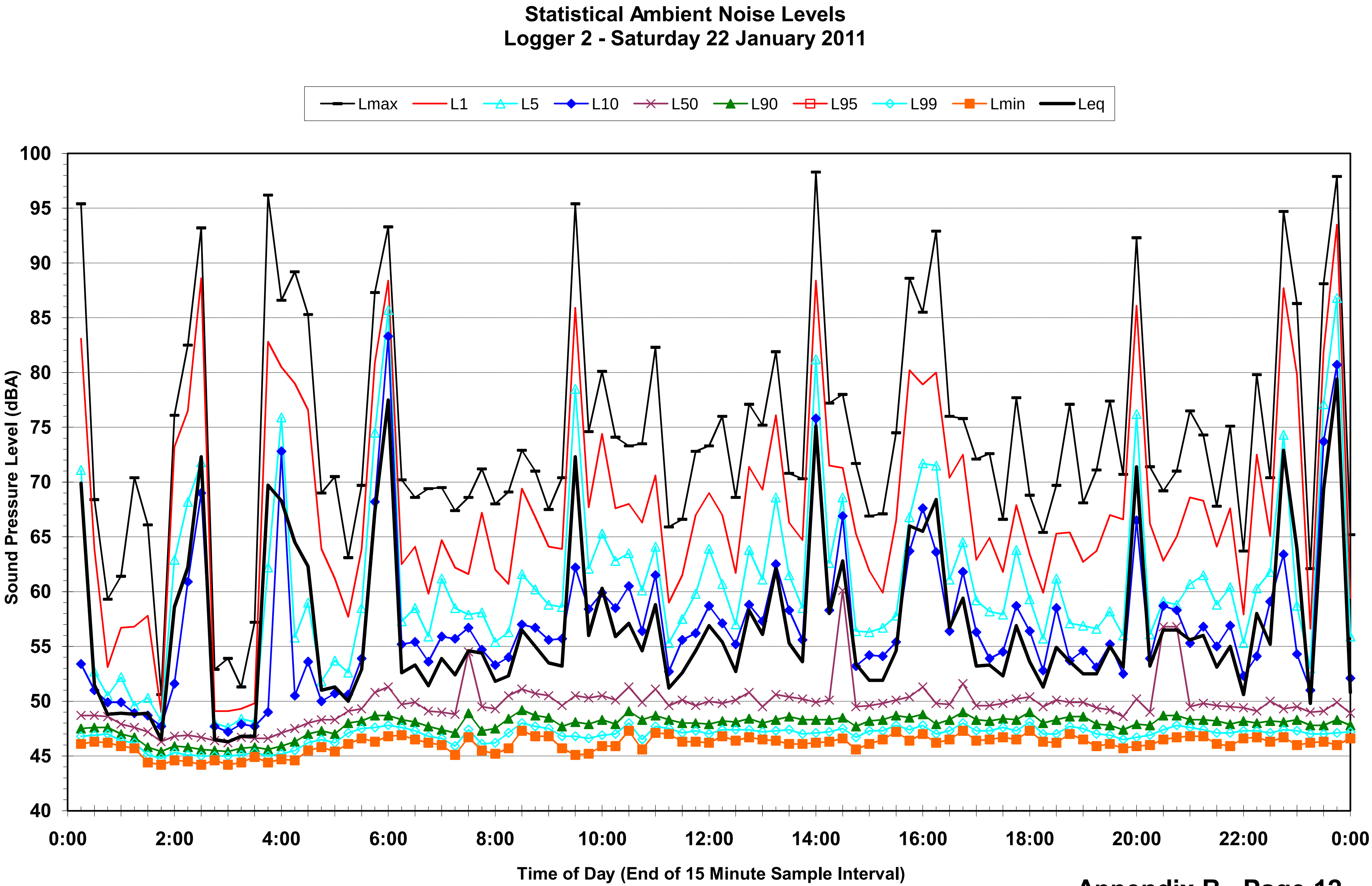


Statistical Ambient Noise Levels
Logger 2 - Thursday 20 January 2011



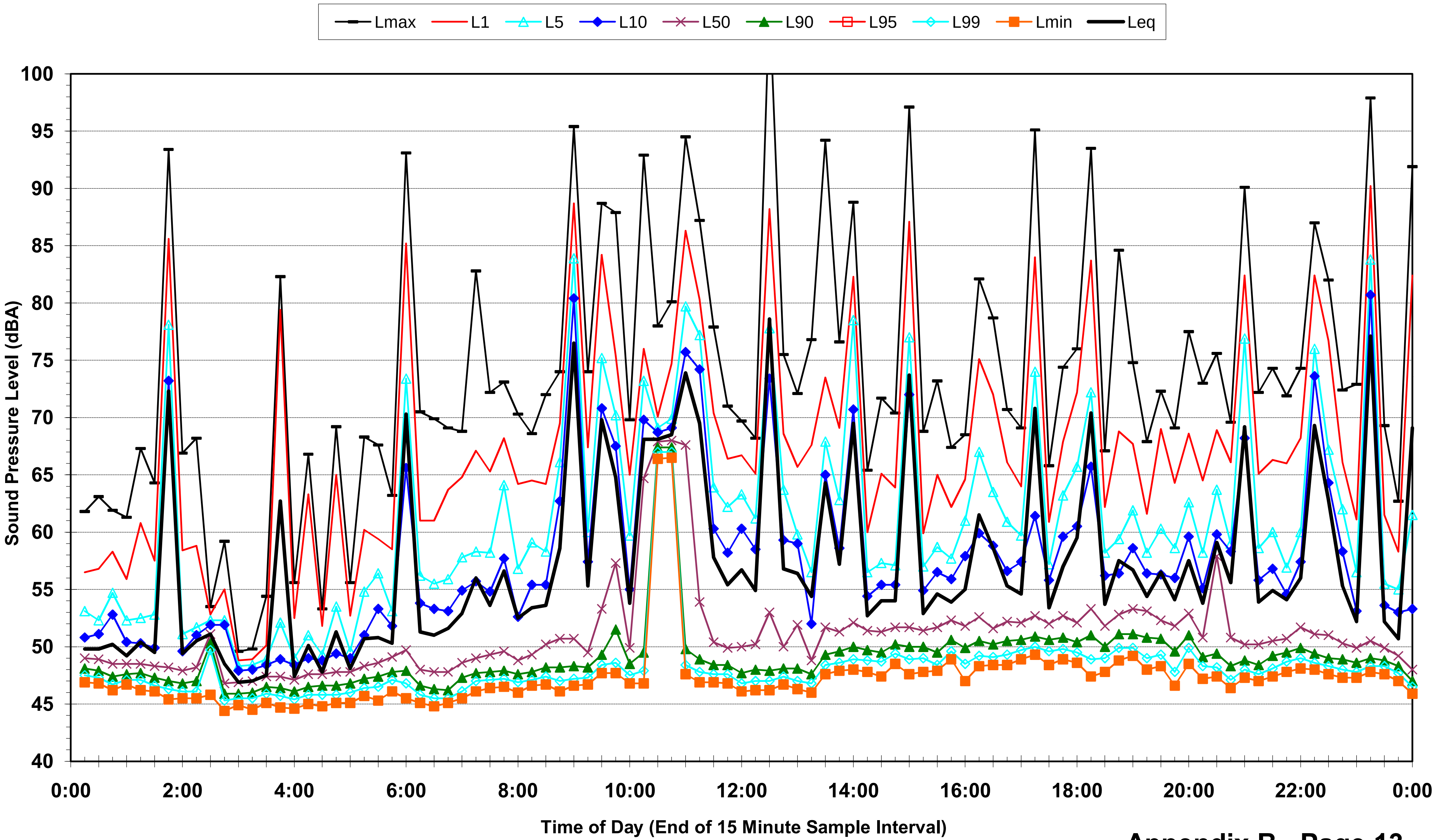
Statistical Ambient Noise Levels
Logger 2 - Friday 21 January 2011





Statistical Ambient Noise Levels
Logger 2 - Saturday 22 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Logger 2 - Sunday 23 January 2011



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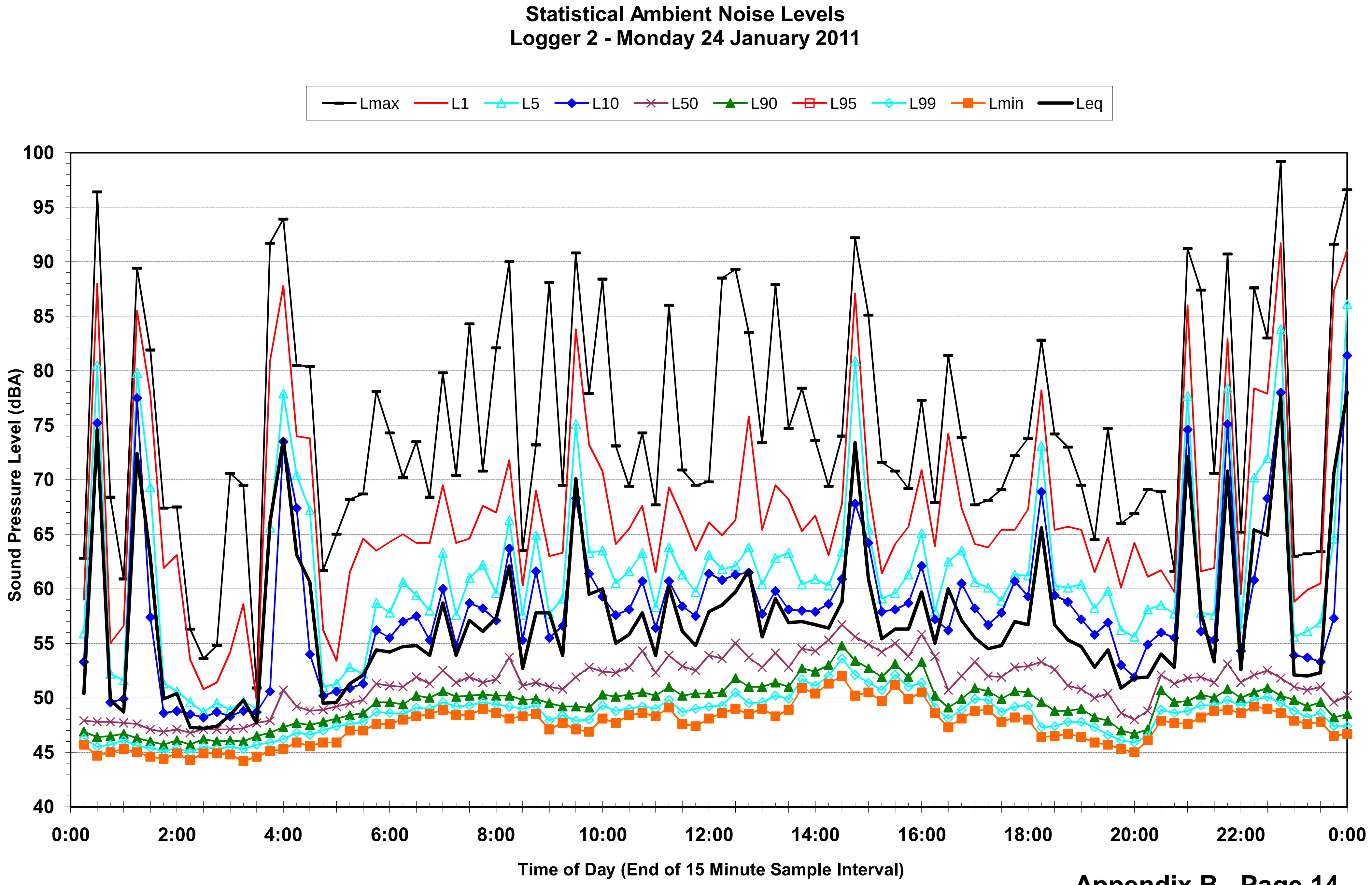
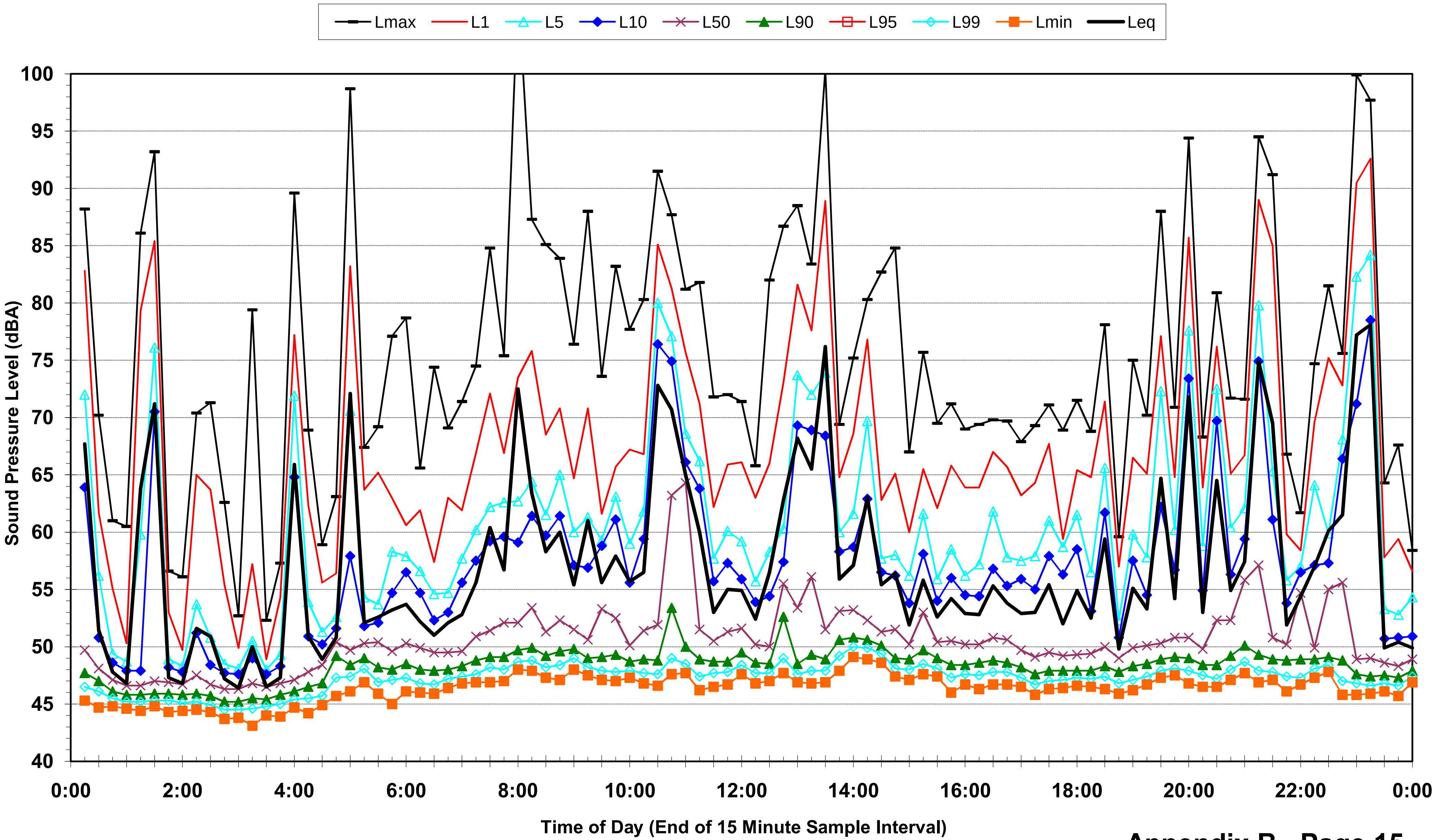
Statistical Noise Levels

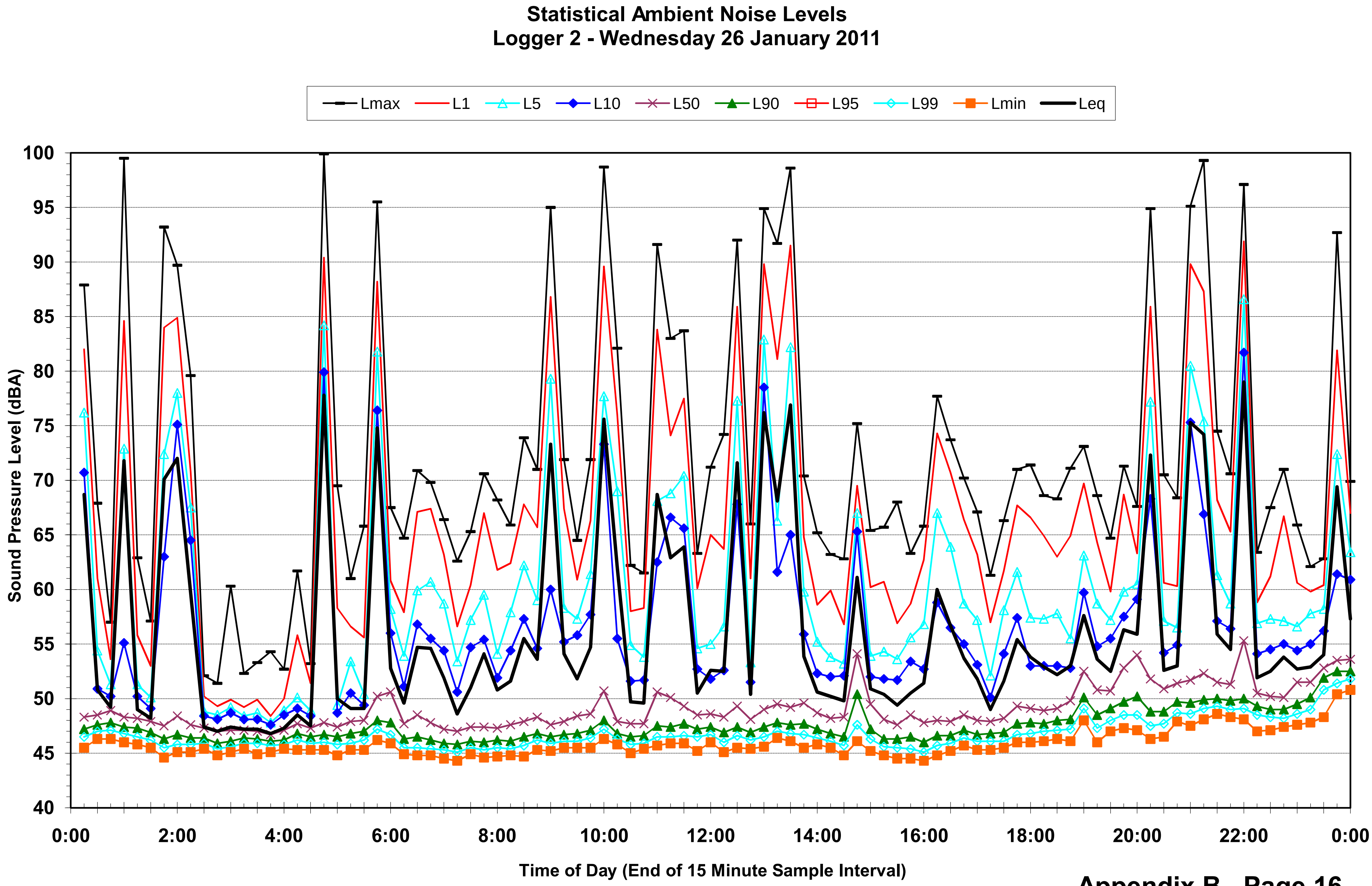
Heggies Report 10150



Statistical Ambient Noise Levels
Logger 2 - Monday 24 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

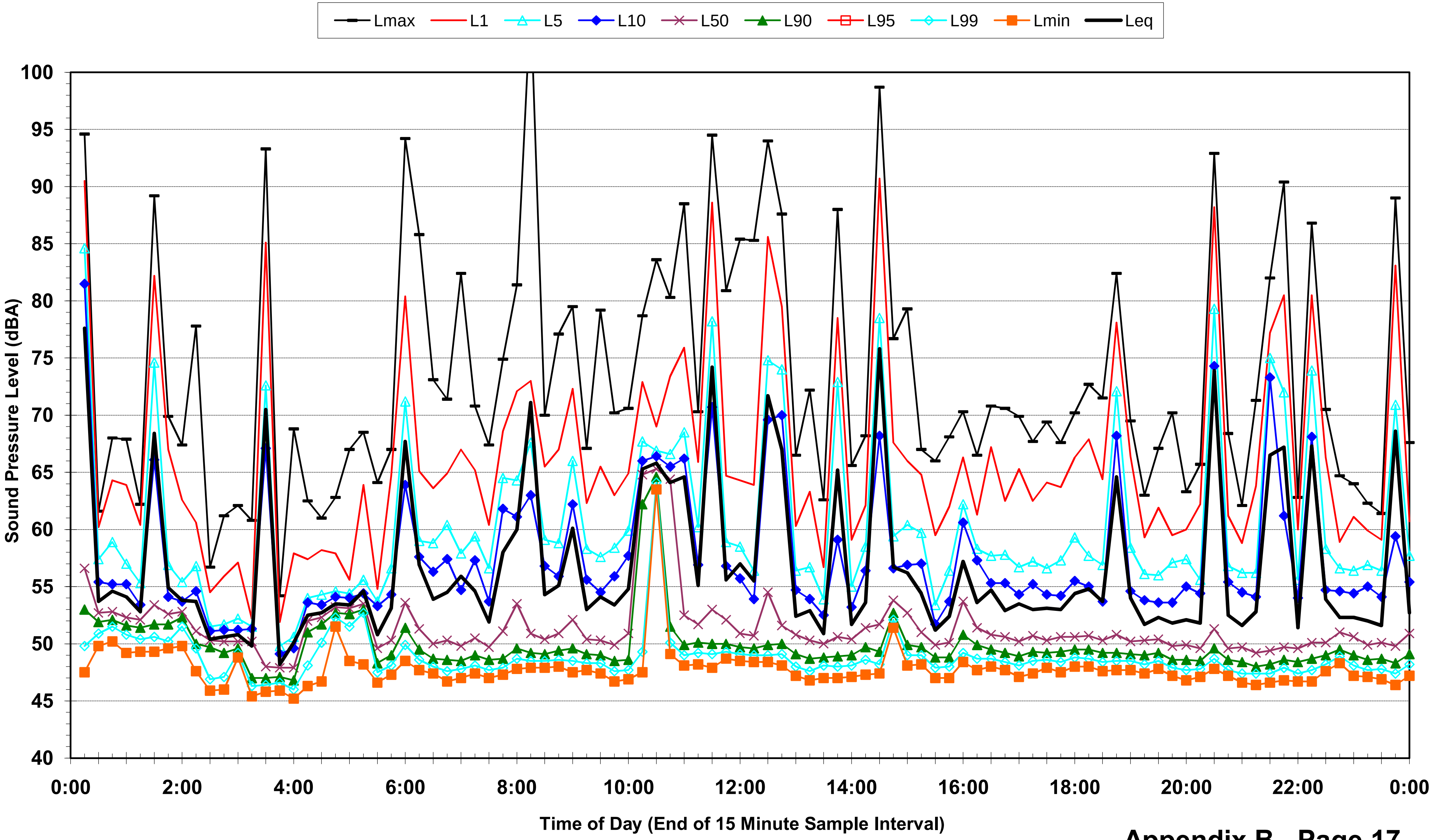
Statistical Ambient Noise Levels
Logger 2 - Tuesday 25 January 2011

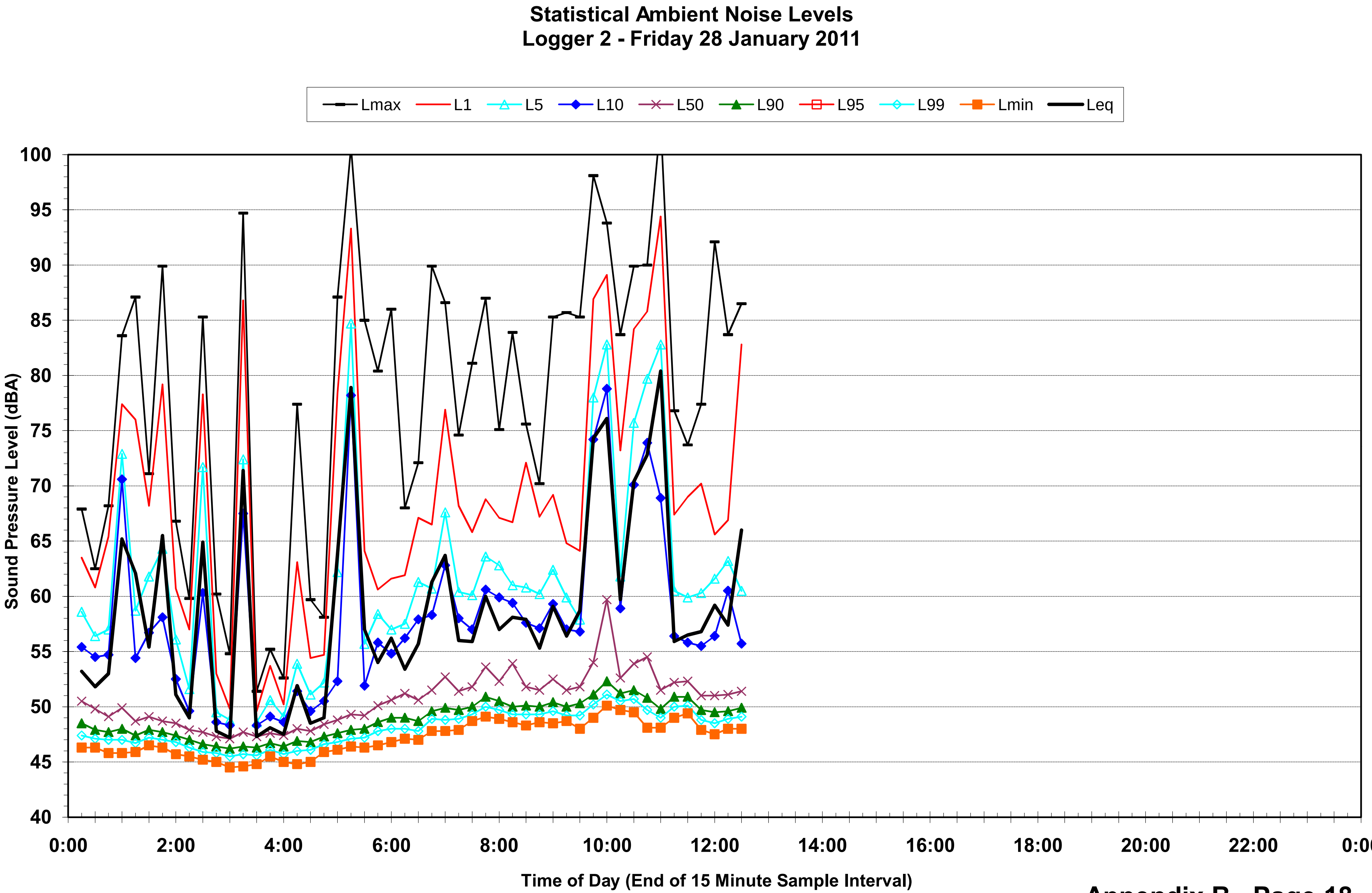




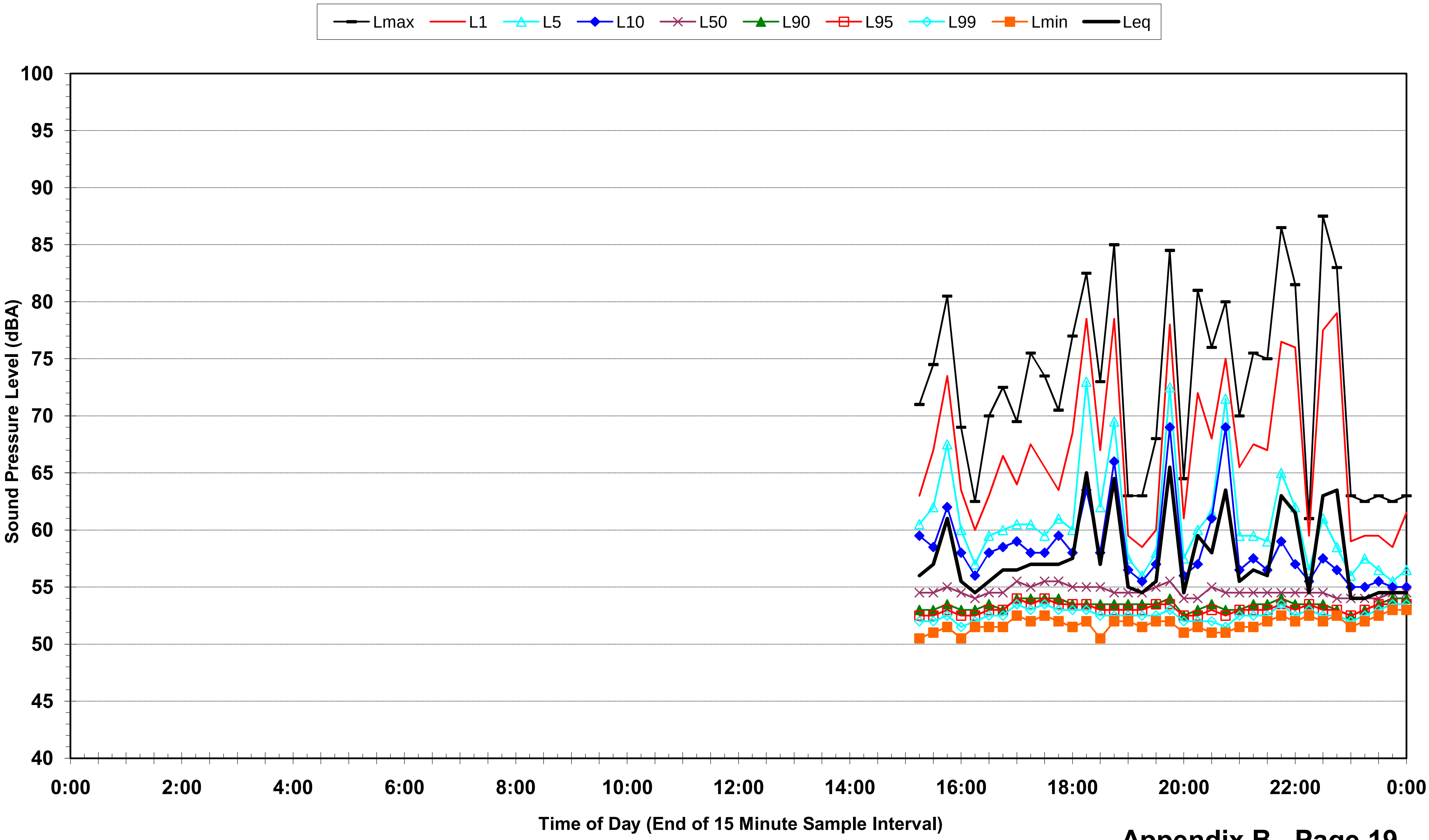
Statistical Ambient Noise Levels
Logger 2 - Wednesday 26 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Logger 2 - Thursday 27 January 2011

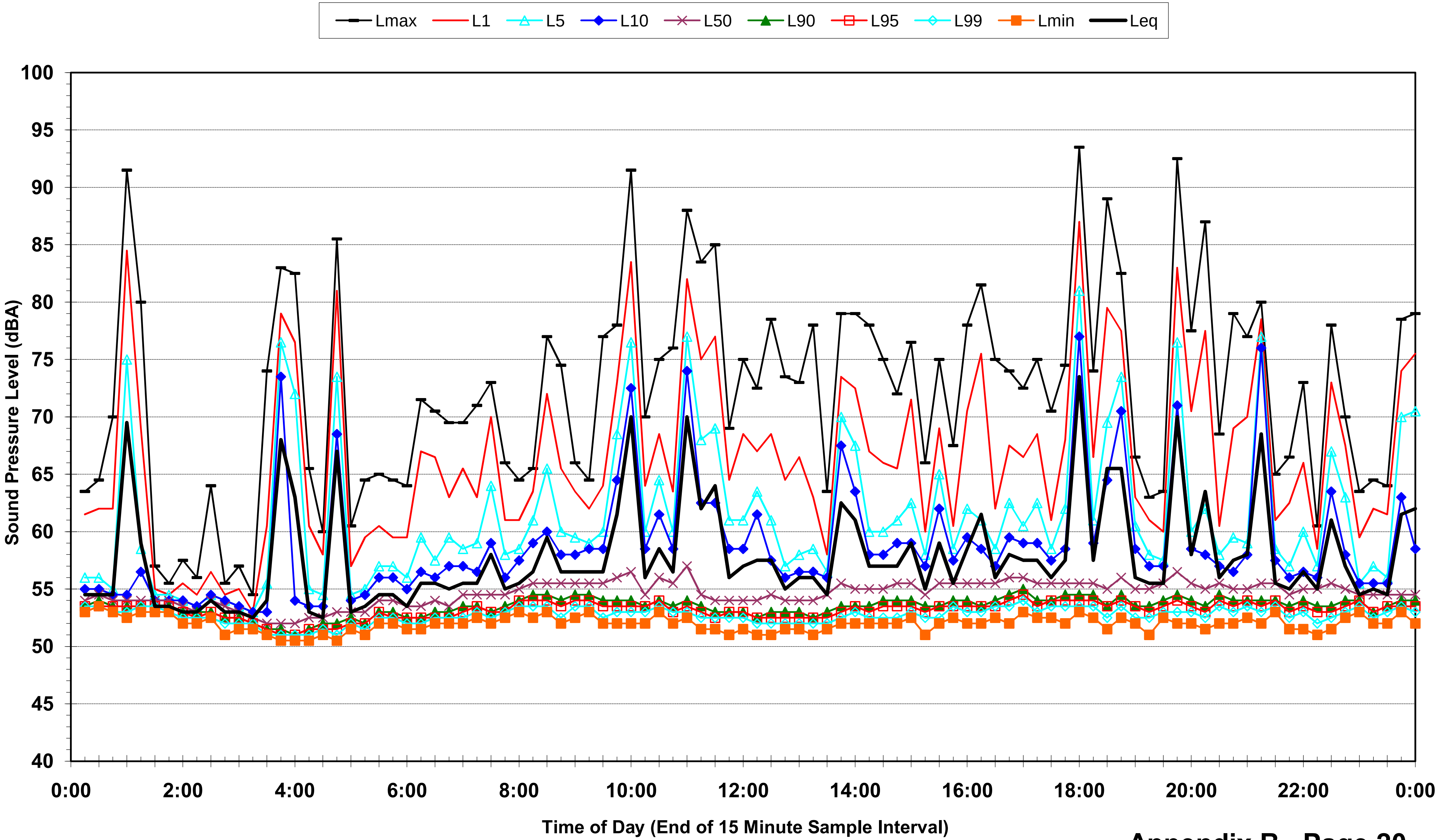


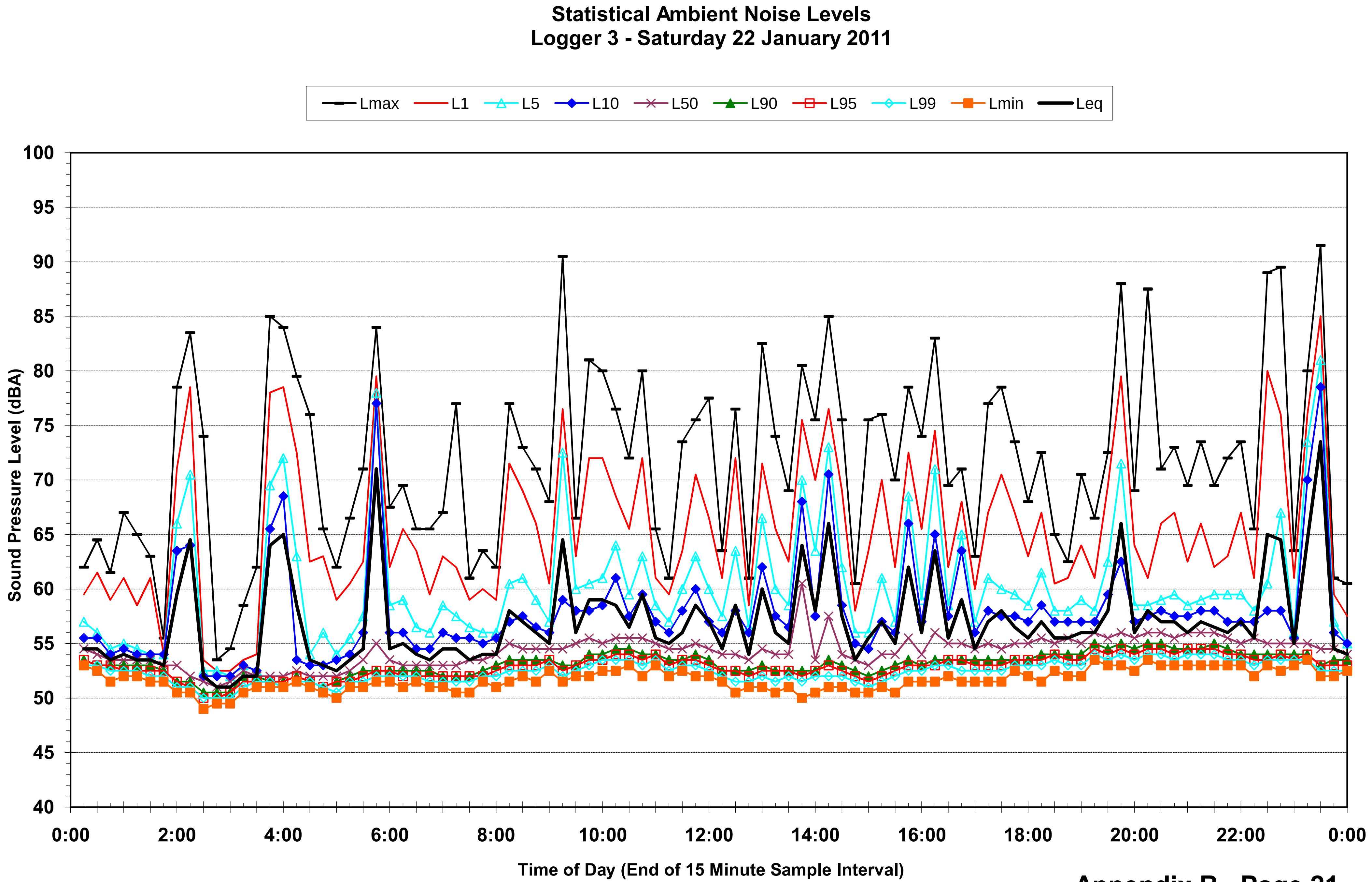

Statistical Ambient Noise Levels
Logger 2 - Friday 28 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Logger 3 - Thursday 20 January 2011



Statistical Ambient Noise Levels
Logger 3 - Friday 21 January 2011





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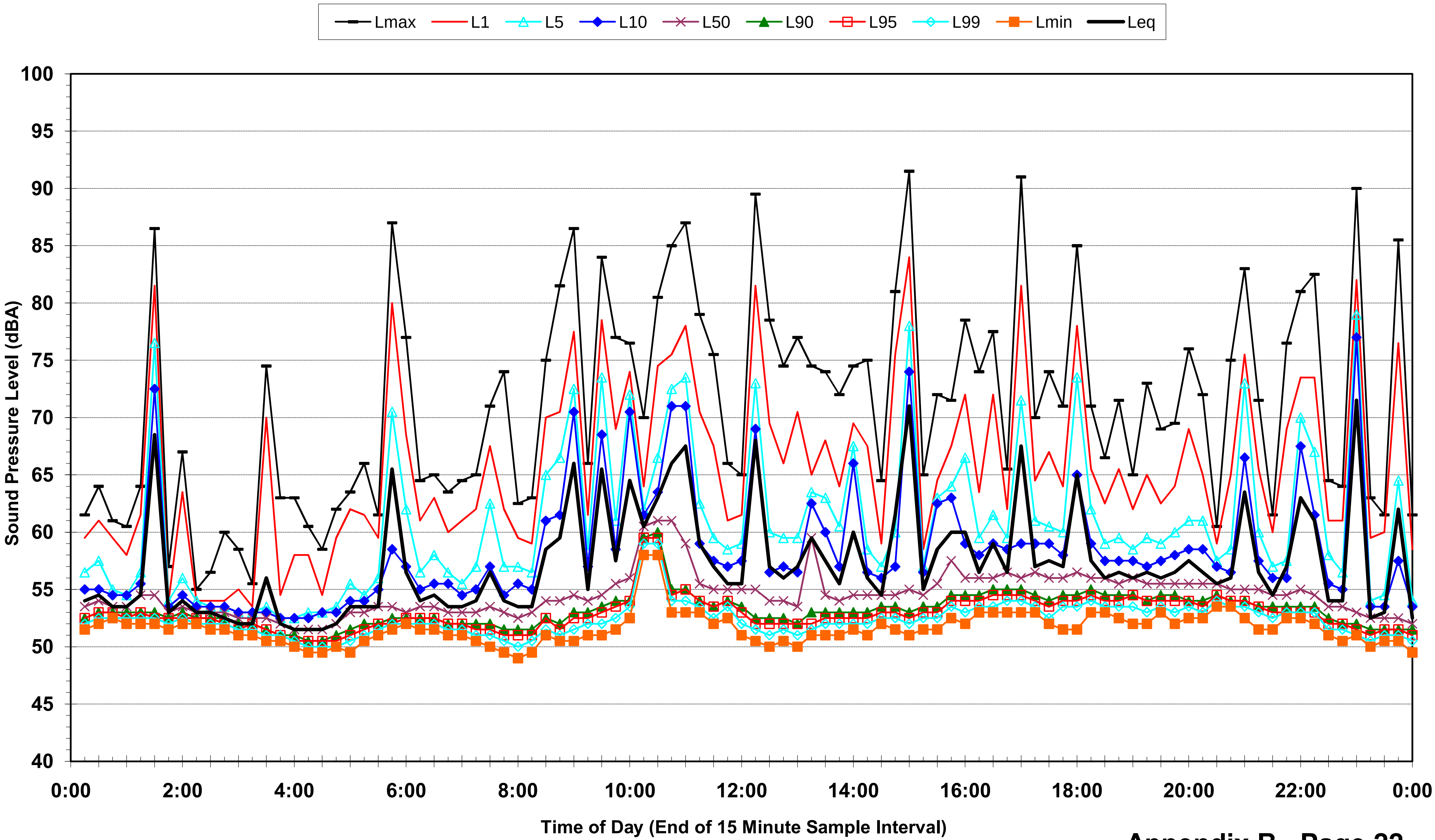
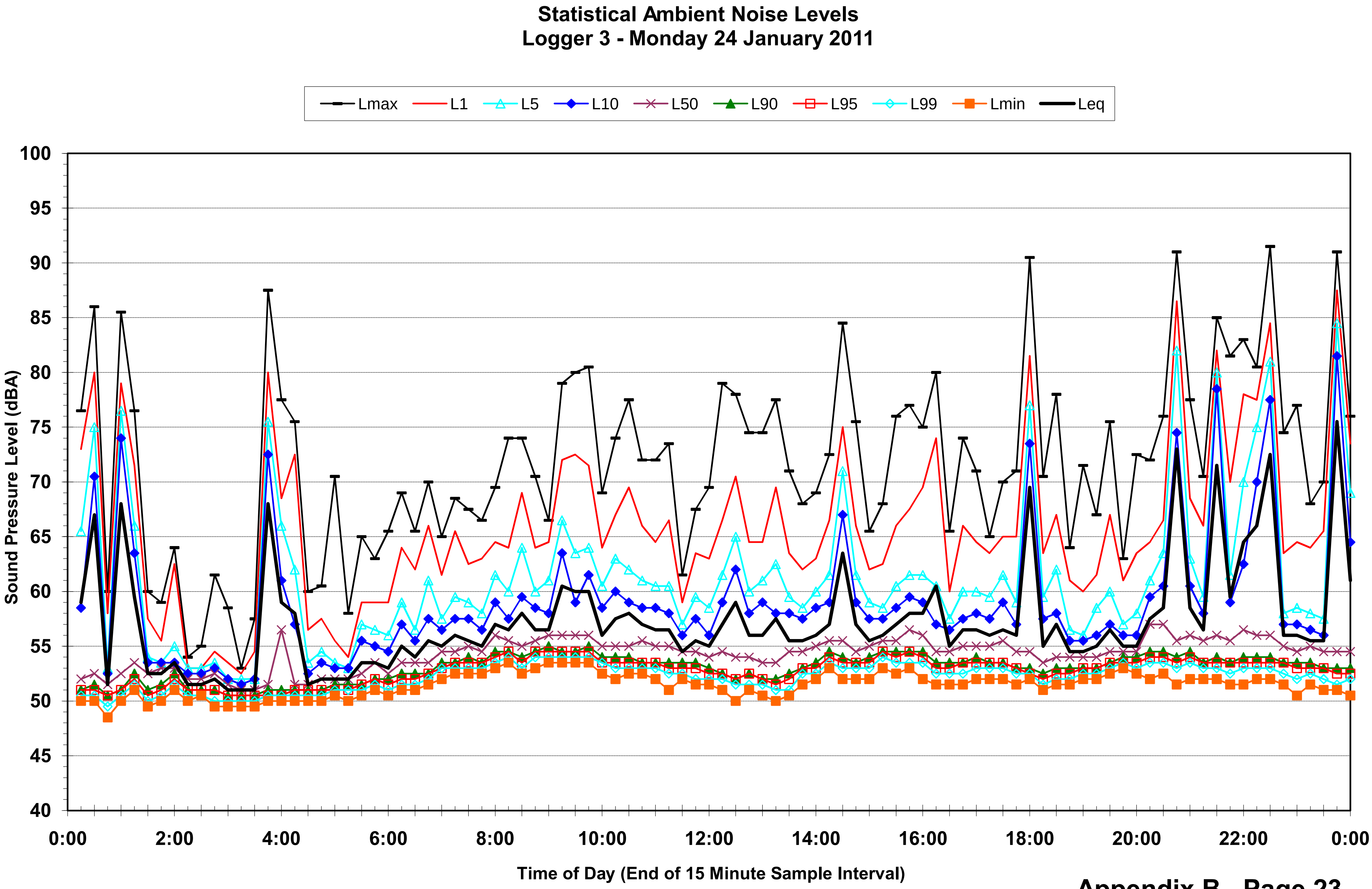
Statistical Noise Levels

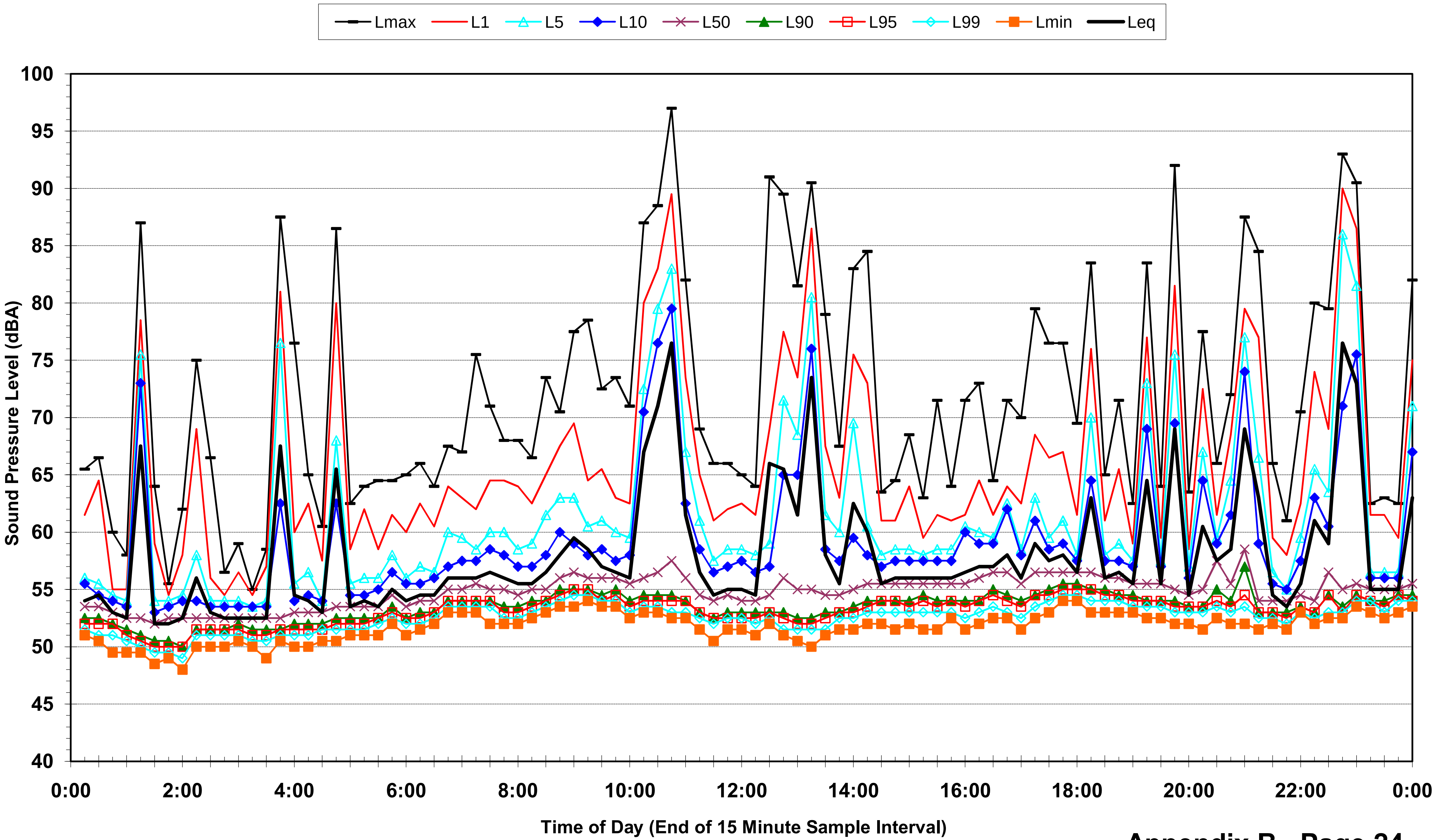
Heggies Report 10150

Statistical Ambient Noise Levels
Logger 3 - Sunday 23 January 2011




Statistical Ambient Noise Levels
Logger 3 - Monday 24 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
Logger 3 - Tuesday 25 January 2011



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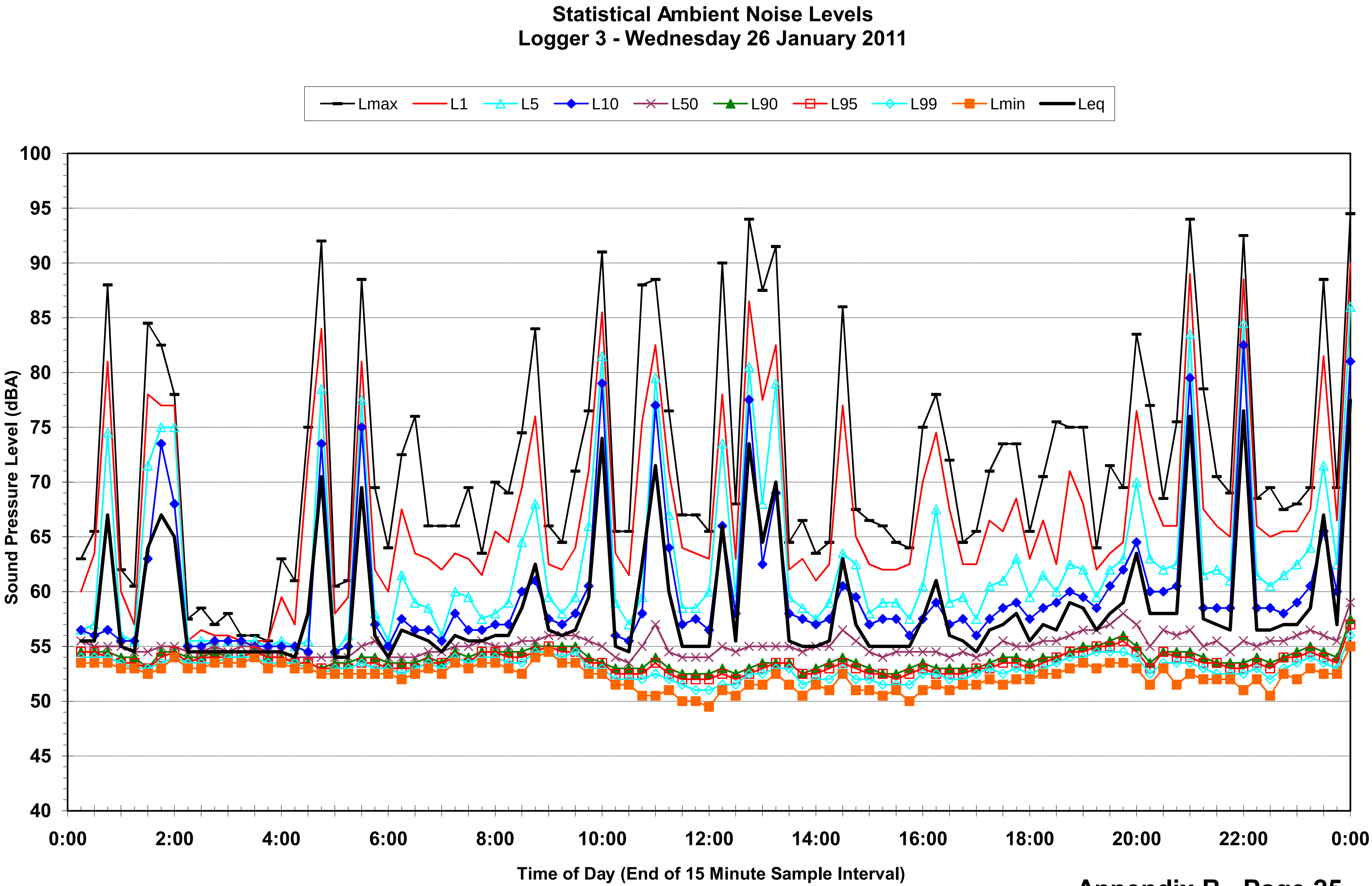
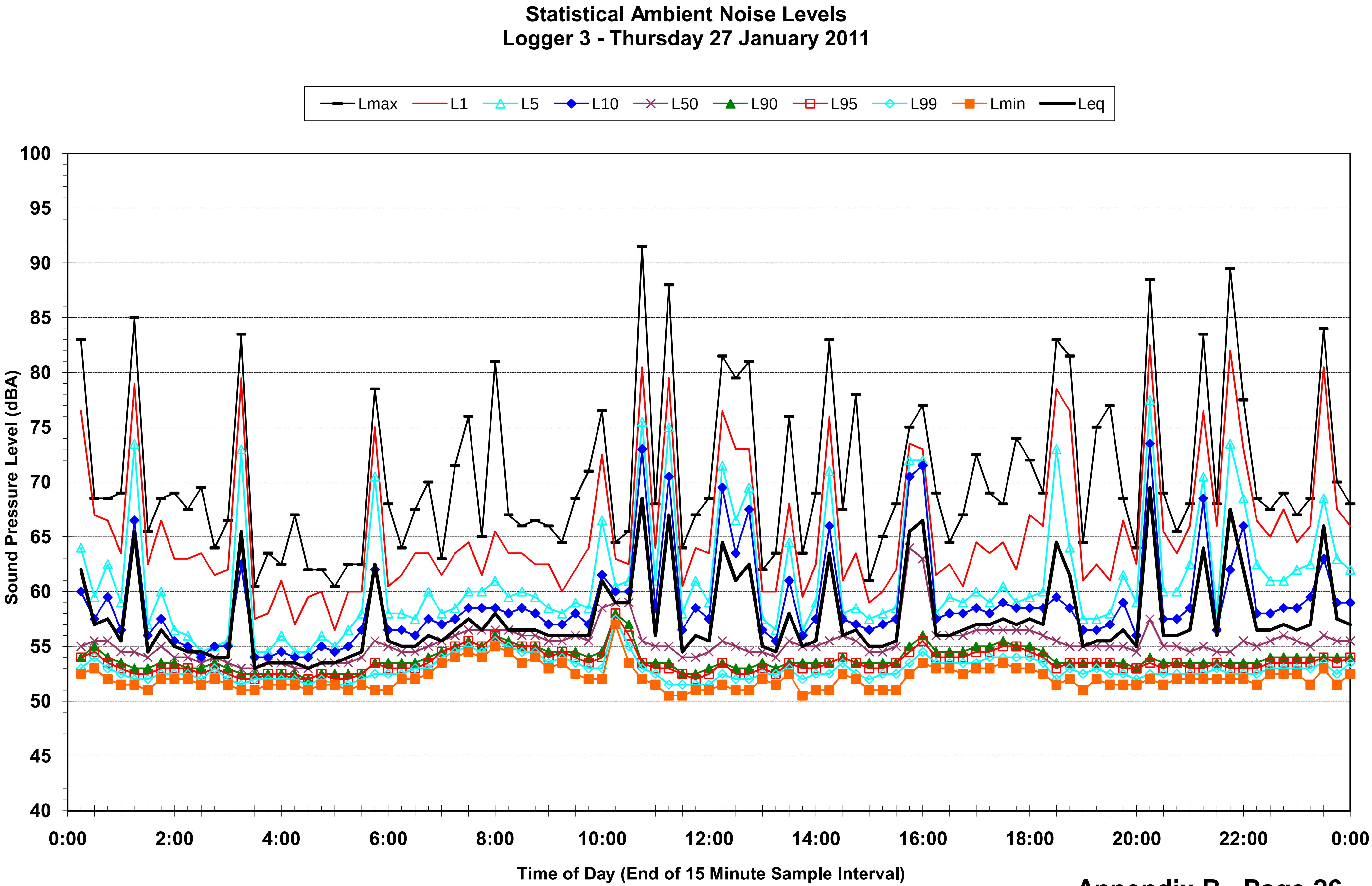
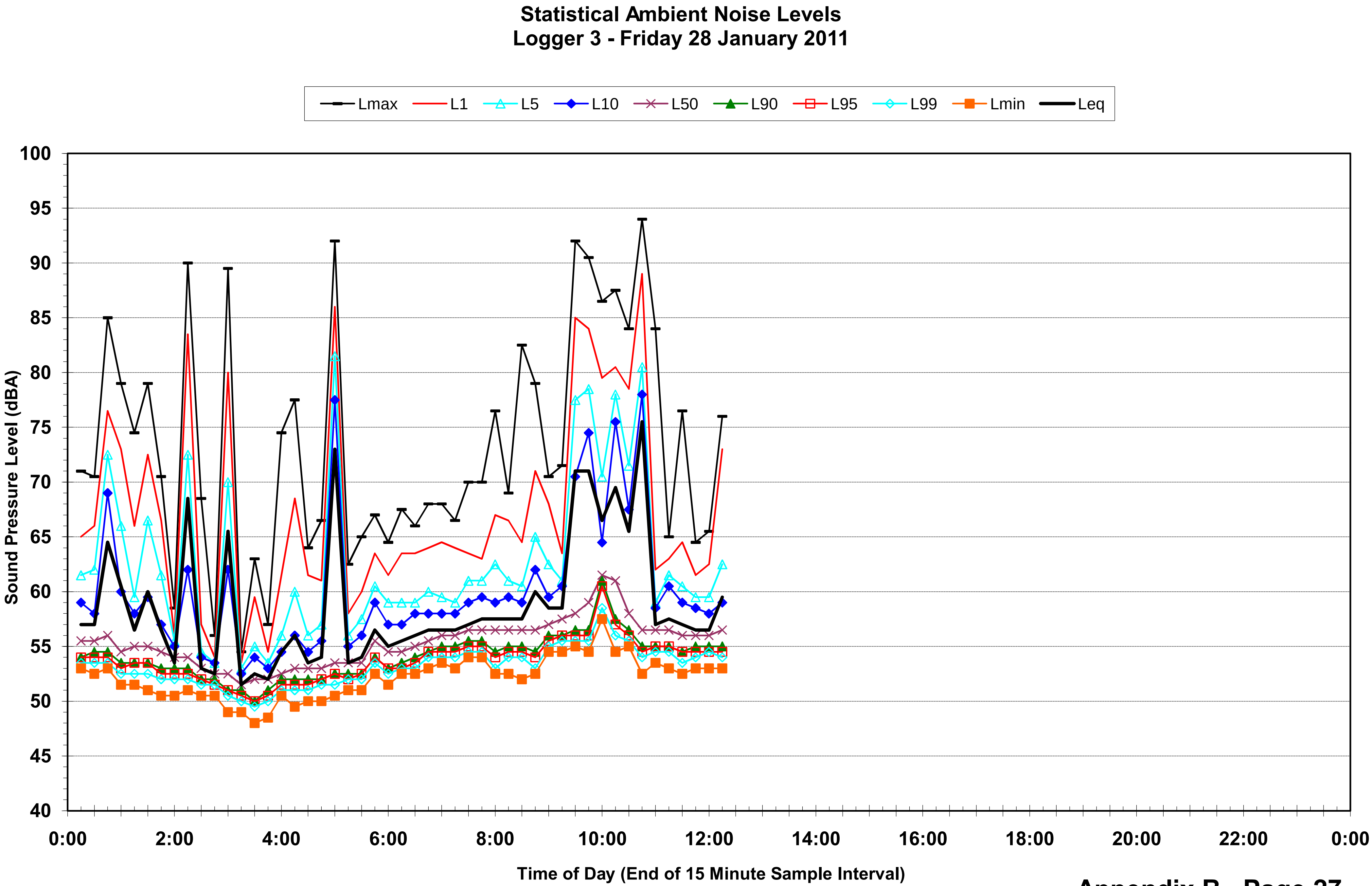
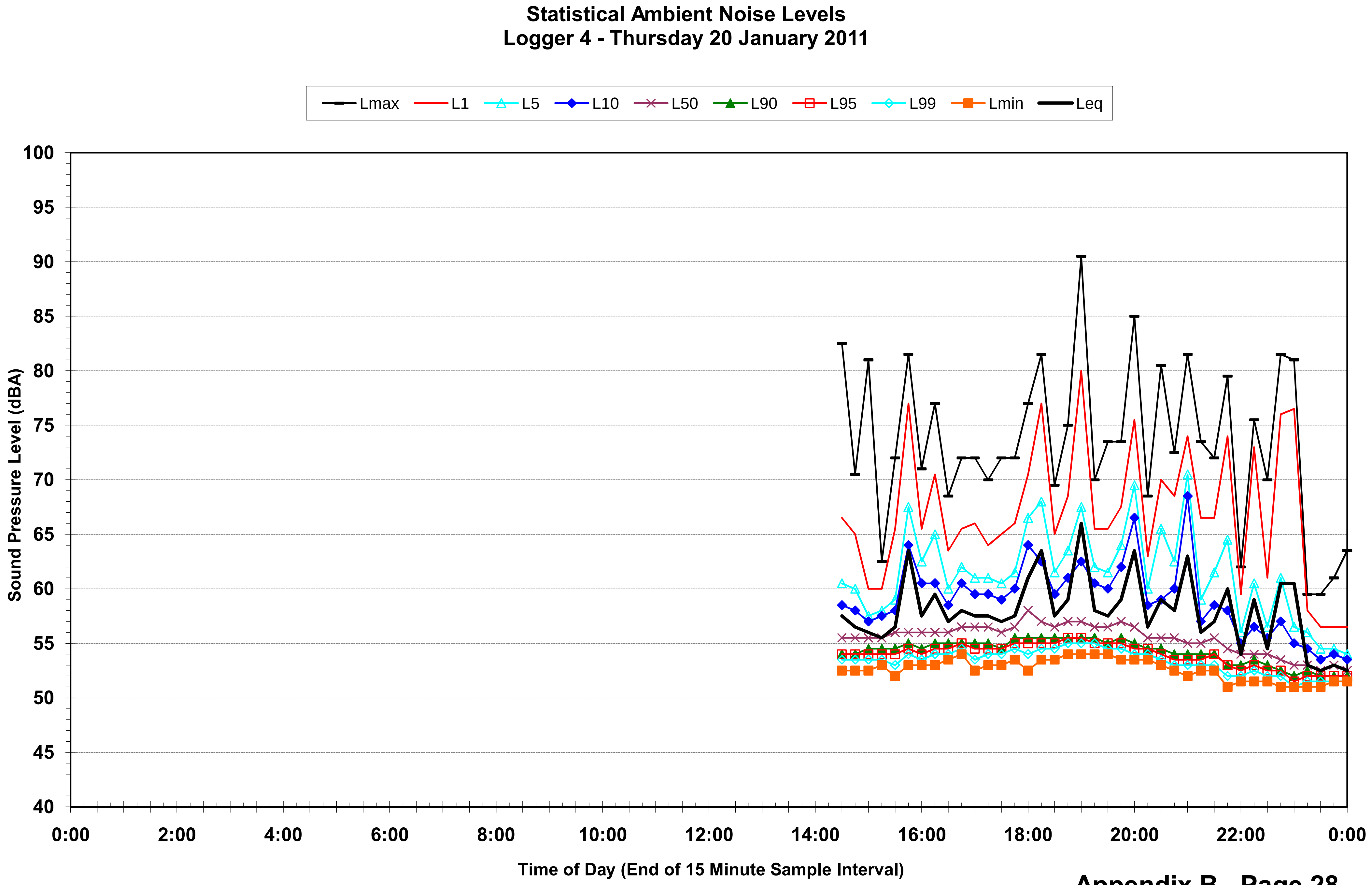
Statistical Noise Levels

Heggies Report 10150

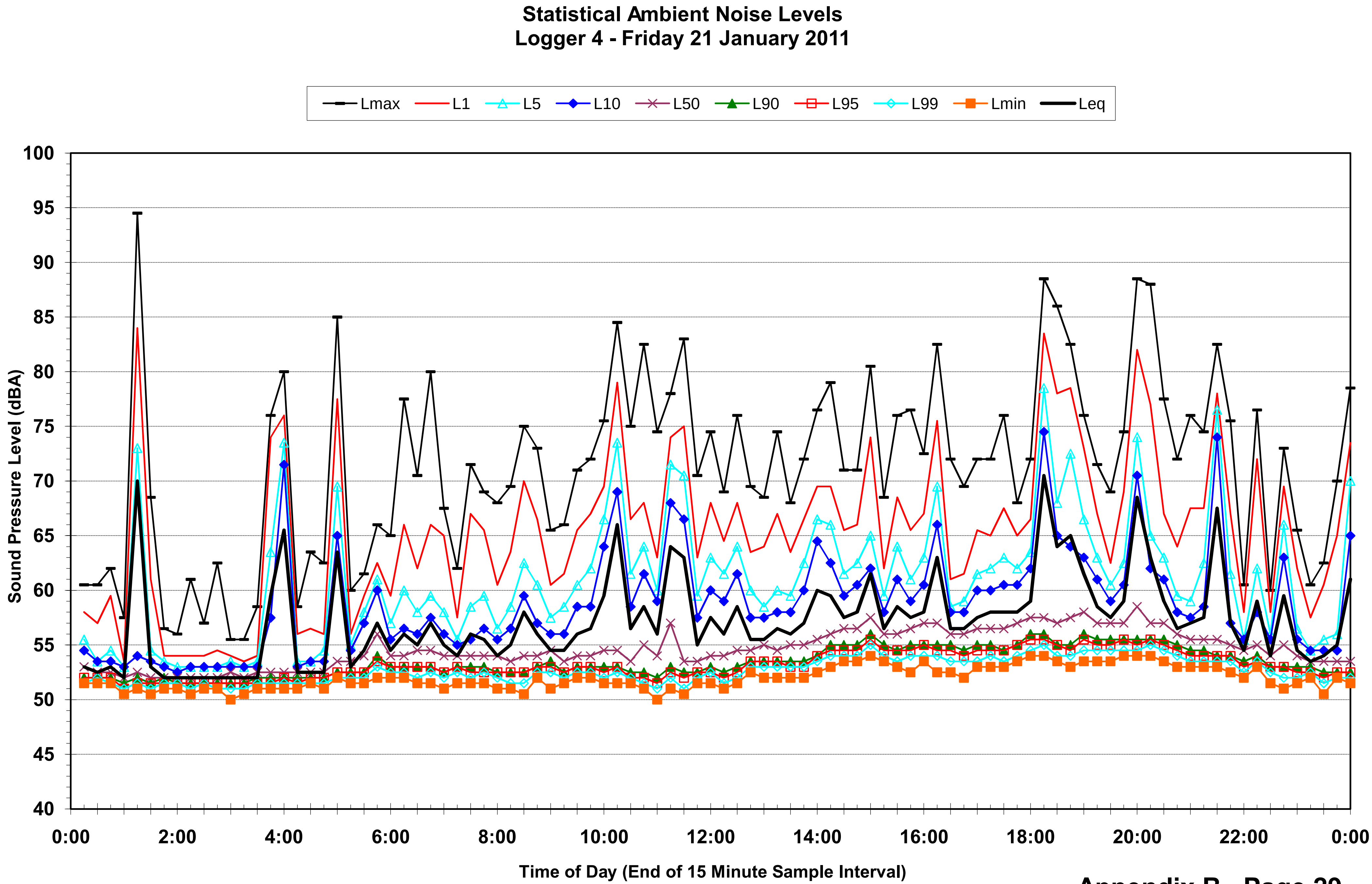

Statistical Ambient Noise Levels
Logger 3 - Wednesday 26 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Logger 3 - Thursday 27 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)

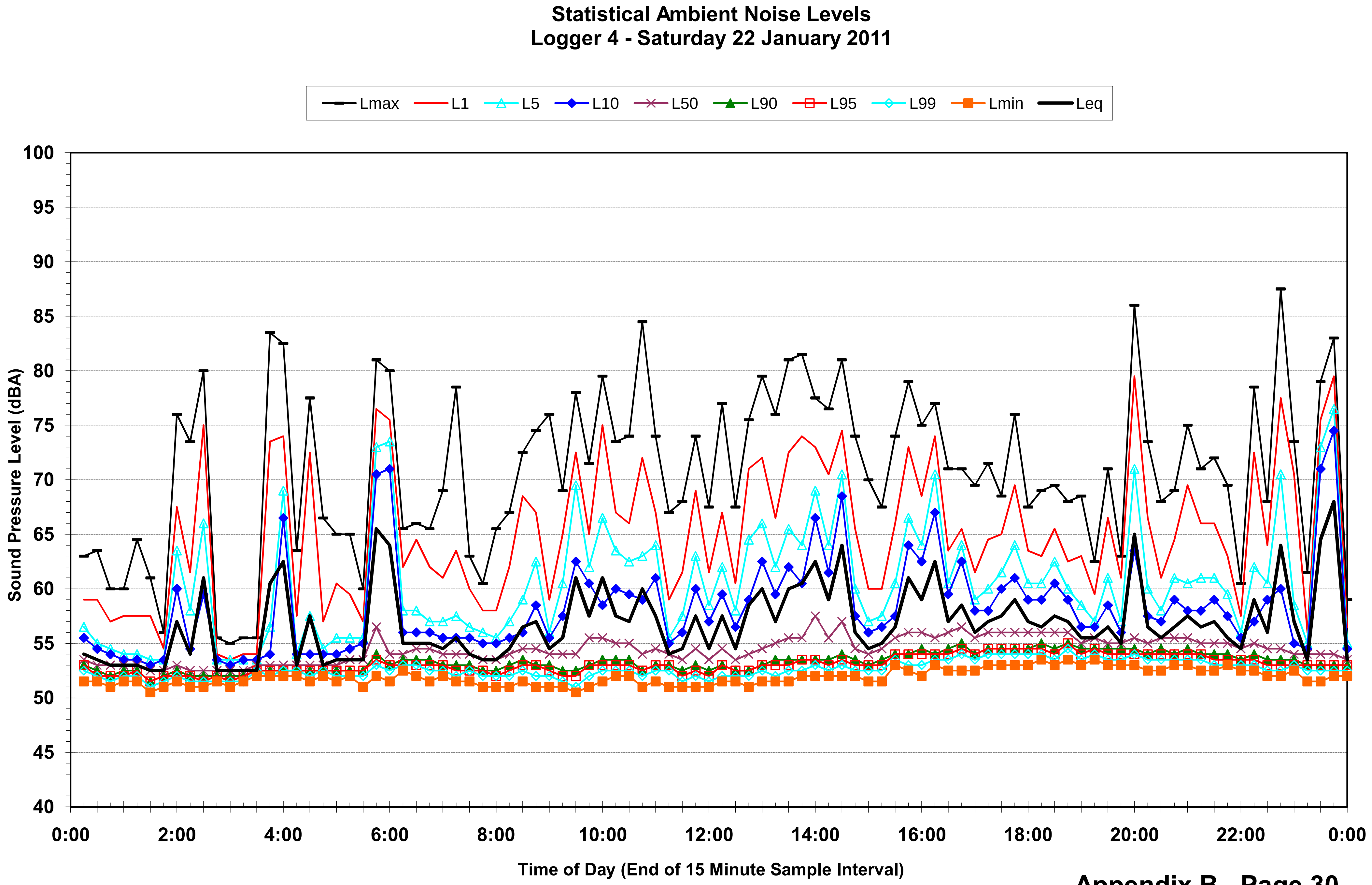

Statistical Ambient Noise Levels
Logger 3 - Friday 28 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
Logger 4 - Thursday 20 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
Logger 4 - Friday 21 January 2011
Lmax
L1
L5
L10
L50
L90
L95
L99
Lmin
Leq
Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
55
50
45
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time of Day (End of 15 Minute Sample Interval)



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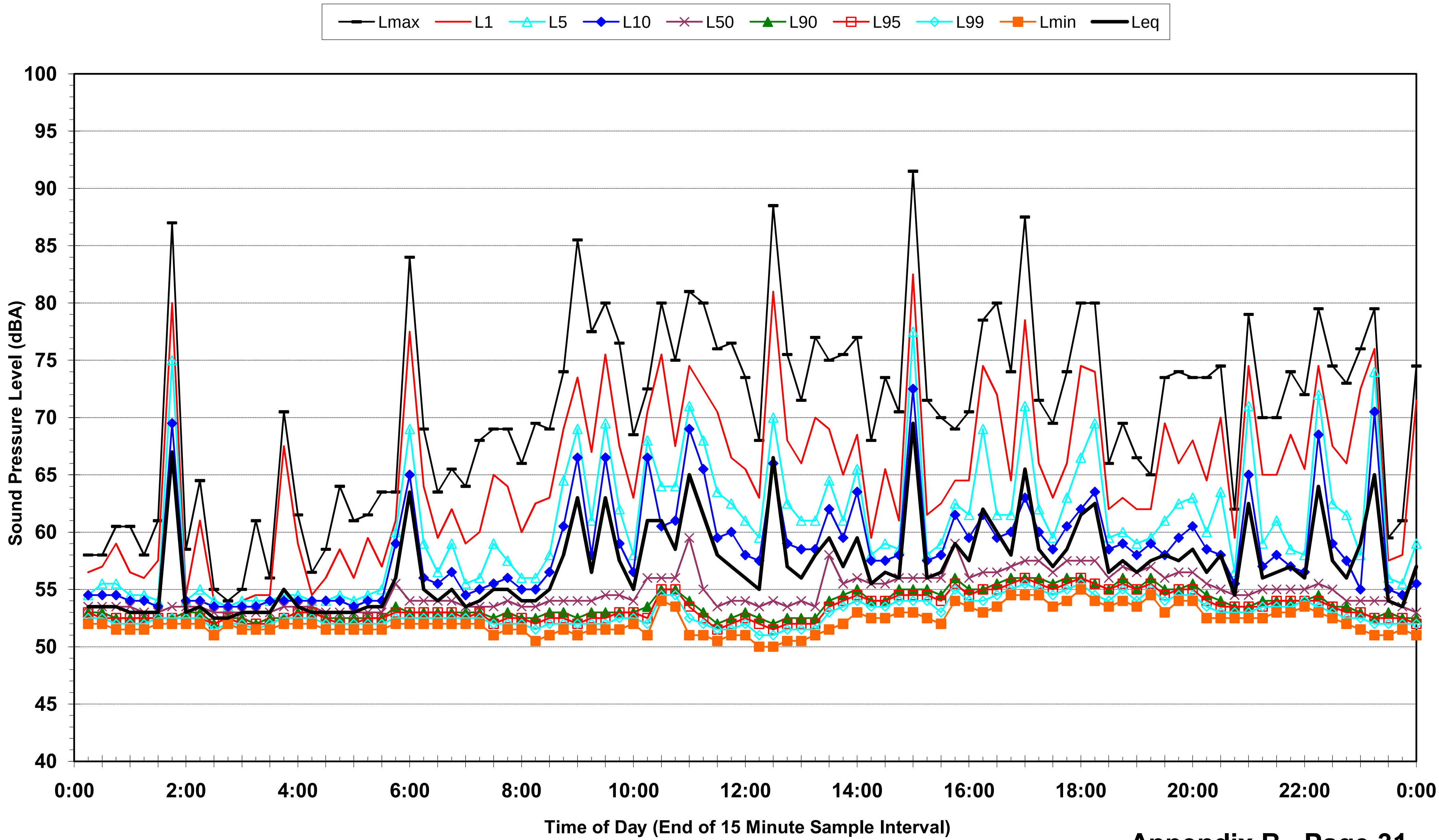
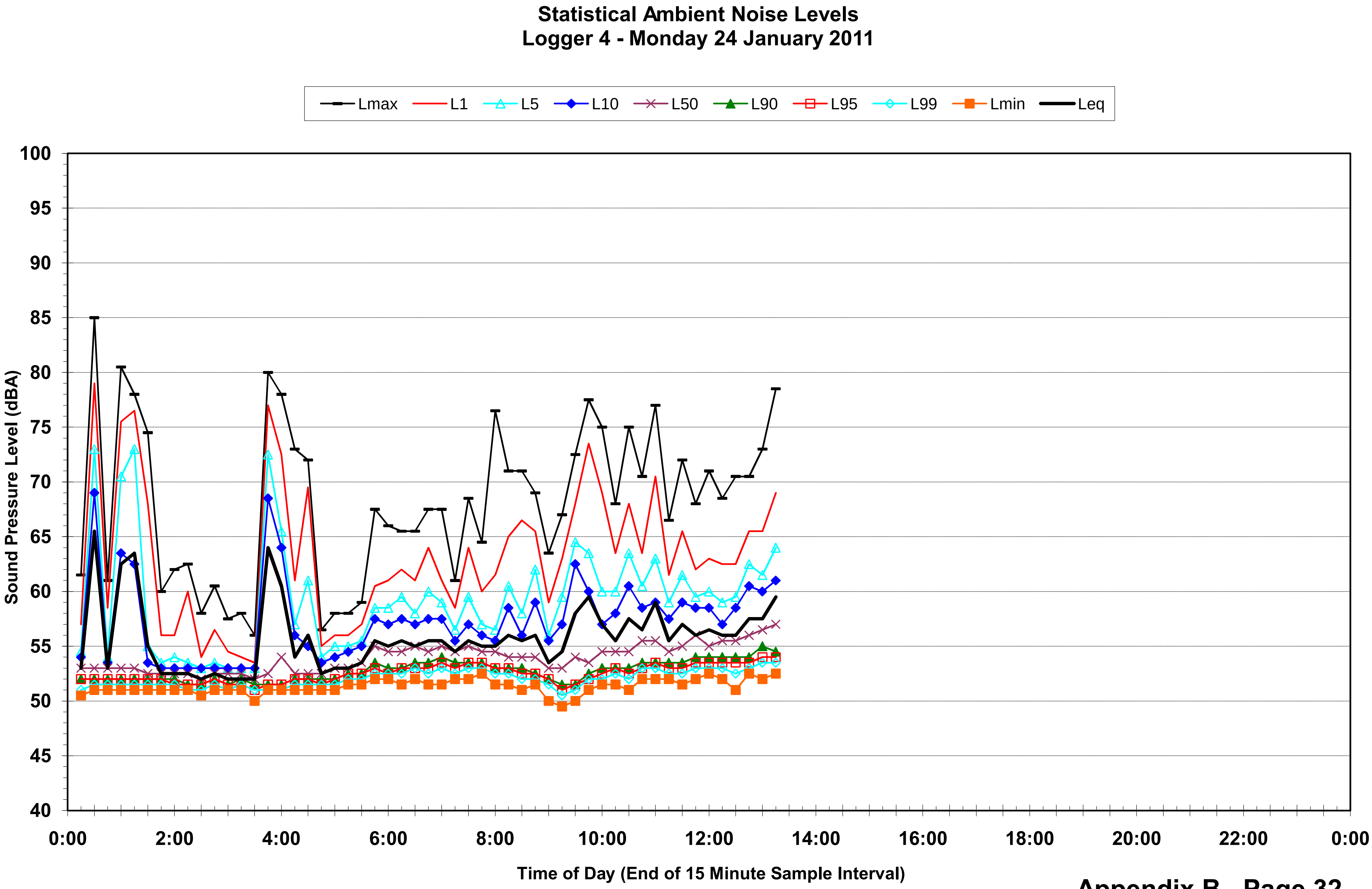
Statistical Ambient Noise Levels
Logger 4 - Sunday 23 January 2011





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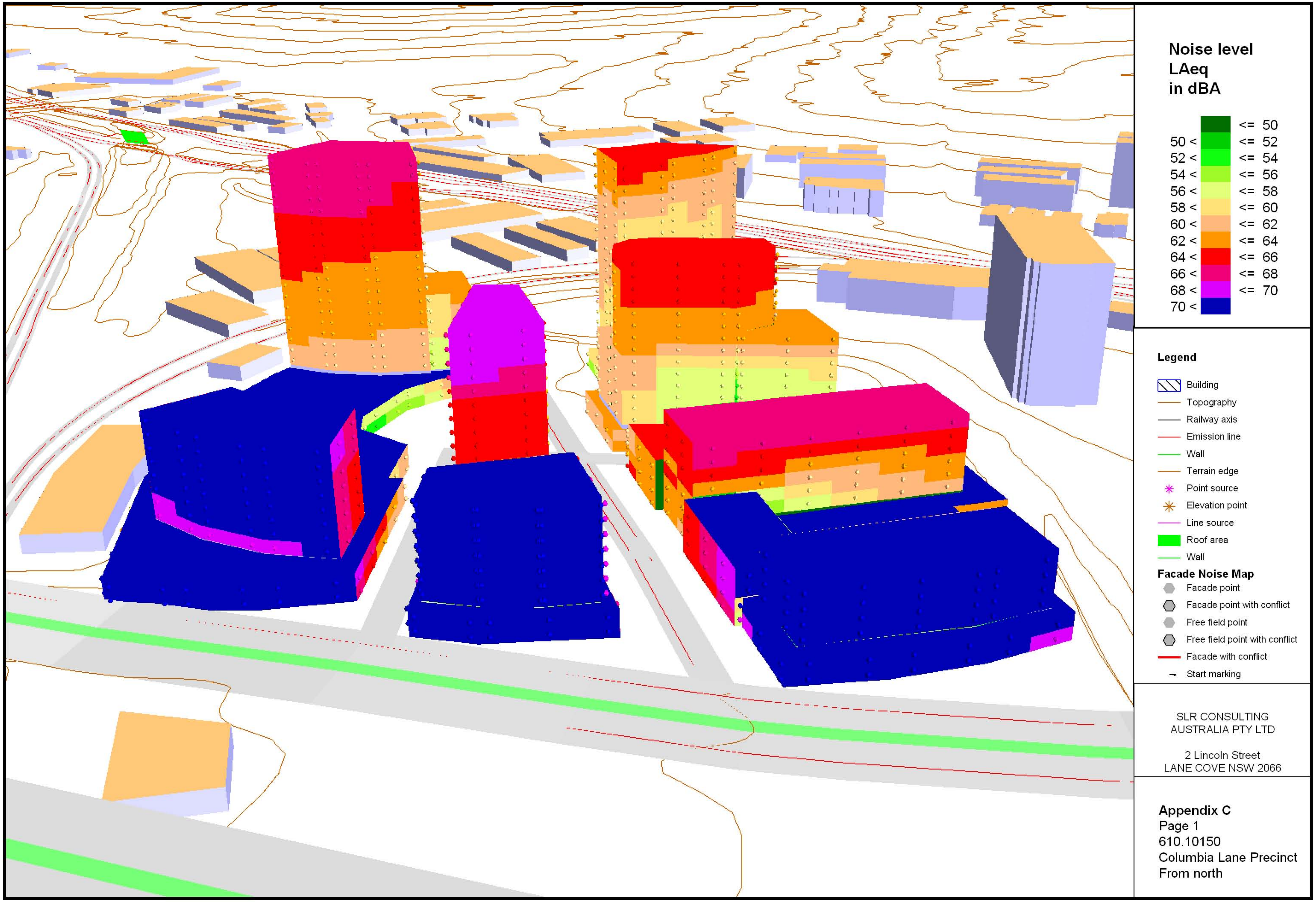
Statistical Noise Levels

Heggies Report 10150

Facade Noise Maps



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LANE COVE NSW 2066

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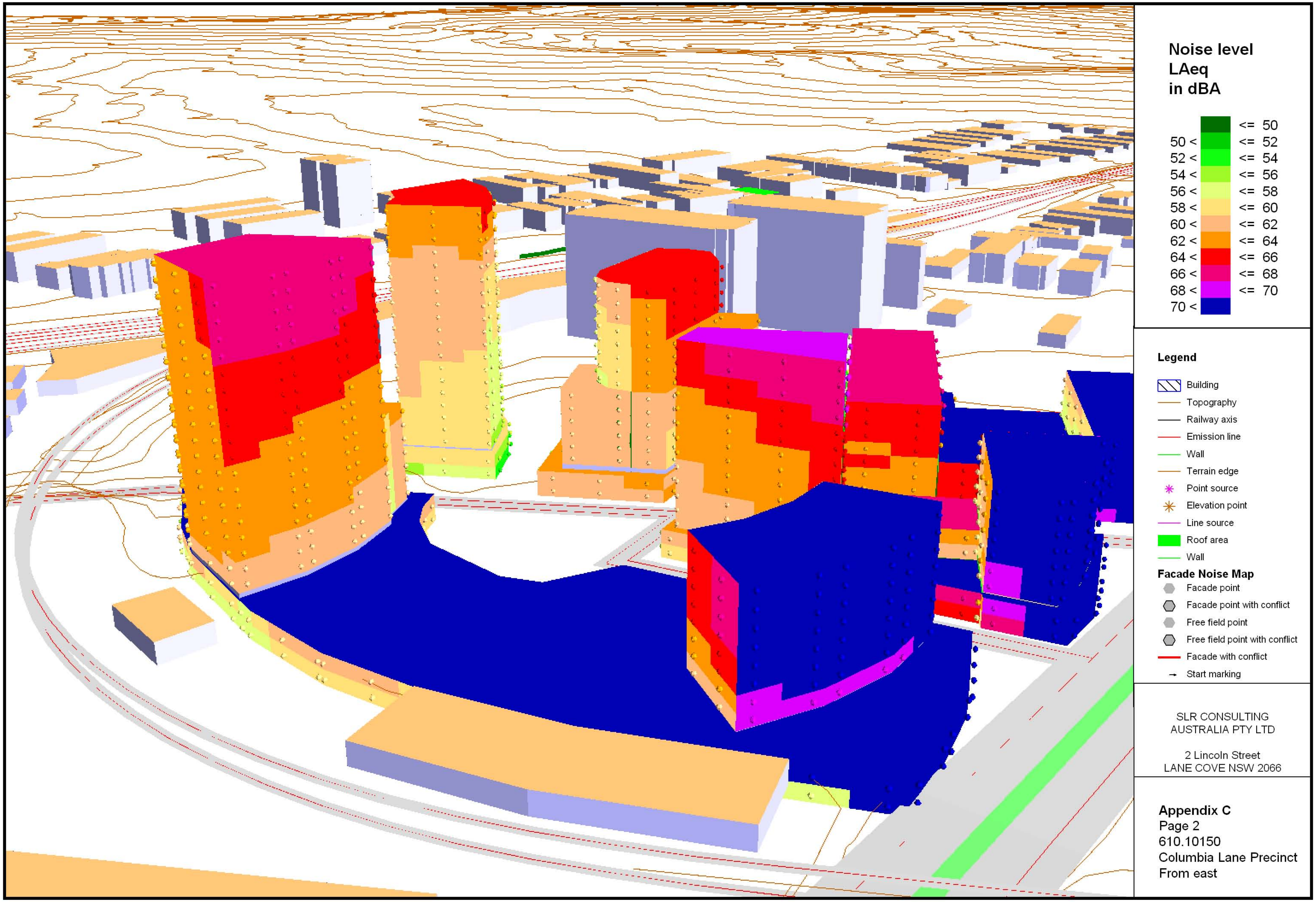
610.10150
Columbia Lane Precinct
From north


Noise level
LAeq
in dBA
<= 50
50 < <= 52
52 < <= 54
54 < <= 56
56 < <= 58
58 < <= 60
60 < <= 62
62 < <= 64
64 < <= 66
66 < <= 68
68 < <= 70
70 <
Legend
Building
Topography
Railway axis
Emission line
Wall
Terrain edge
Point source
Elevation point
Line source
Roof area
Wall
Facade Noise Map
Facade point
Facade point with conflict
Free field point
Free field point with conflict
Facade with conflict
Start marking
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LANE COVE NSW 2066
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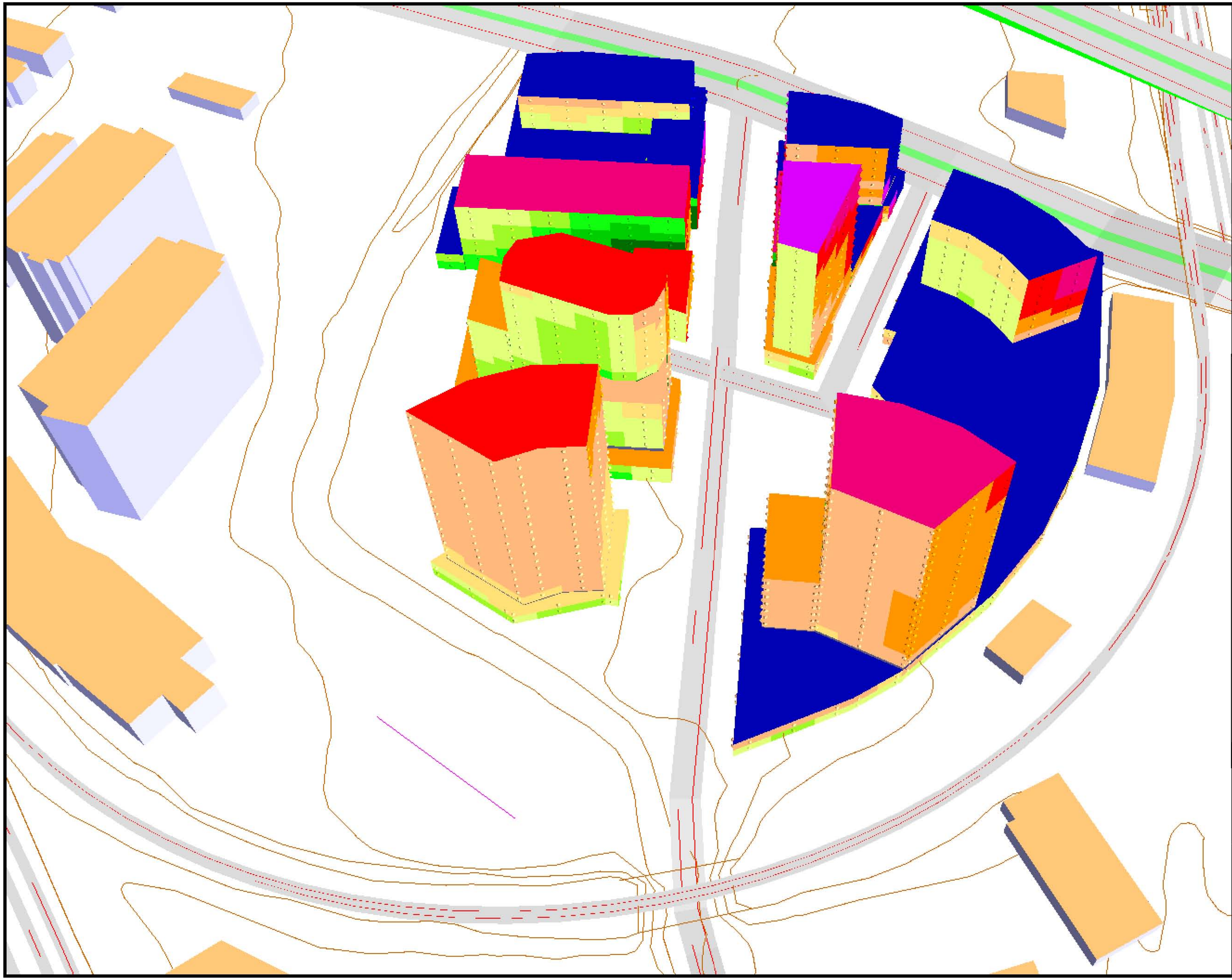
Page 2
610.10150
Columbia Lane Precinct
From east



Legend

- Building
- Topography
- Railway axis
- Emission line
- Wall
- Terrain edge
- Point source
- Elevation point
- Line source
- Roof area
- Wall

Facade Noise Map

- Facade point
- Facade point with conflict
- Free field point
- Free field point with conflict
- Facade with conflict
- Start marking

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LANE COVE NSW 2066

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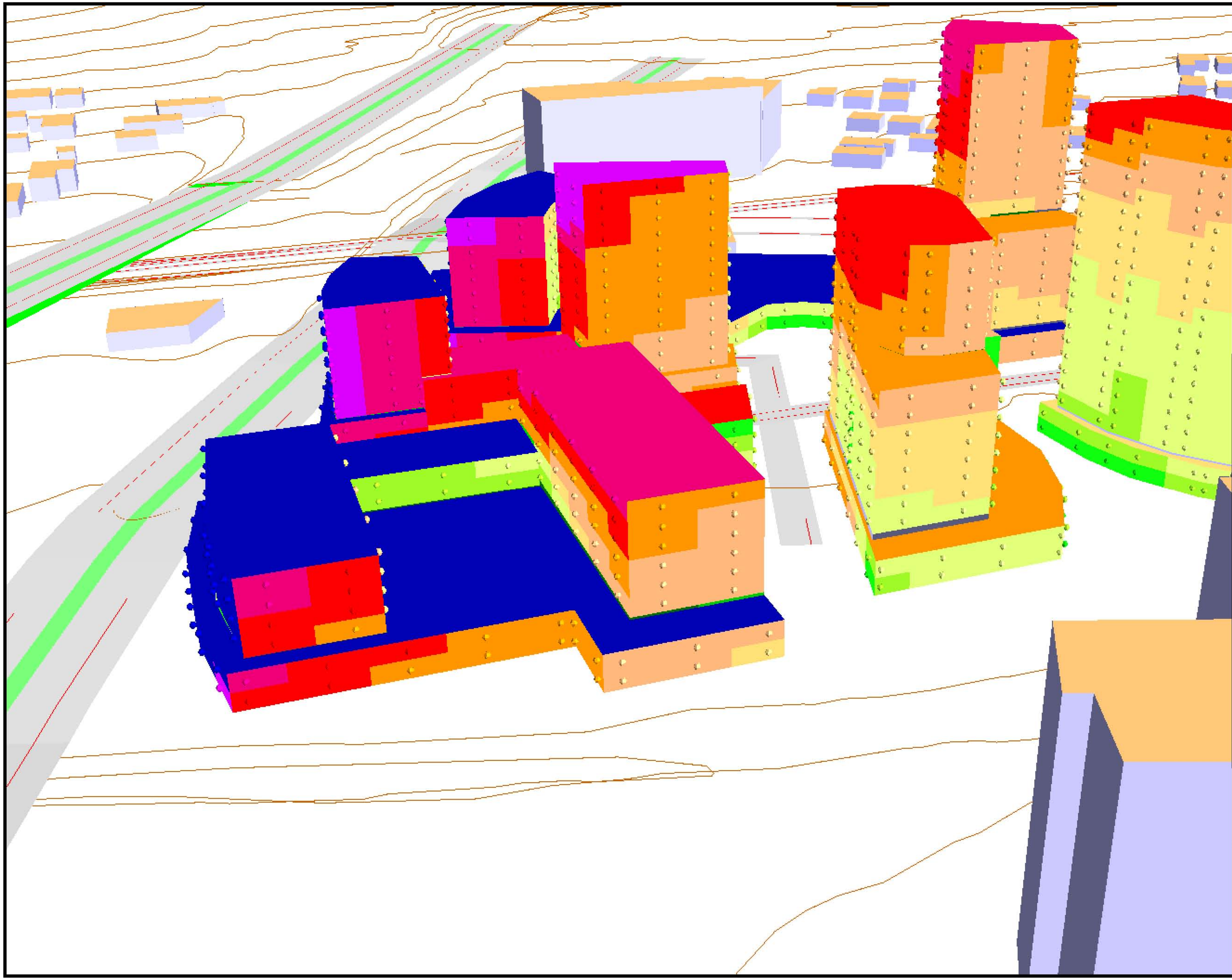
610.10150
Columbia Lane Precinct
From south



Noise level LAeq in dBA

	<= 50
50 <	<= 52
52 <	<= 54
54 <	<= 56
56 <	<= 58
58 <	<= 60
60 <	<= 62
62 <	<= 64
64 <	<= 66
66 <	<= 68
68 <	<= 70
70 <	

Legend

Building
Topography
Railway axis
Emission line
Wall
Terrain edge
Point source
Elevation point
Line source
Roof area
Wall

Facade Noise Map

Facade point
Facade point with conflict
Free field point
Free field point with conflict
Facade with conflict
Start marking

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LANE COVE NSW 2066

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610.10150
Columbia Lane Precinct
From west