RENZO TONIN & ASSOCIATES PTY LTD
ABN 65 002 225 078
Consultants in Acoustics, Vibration and Structural Dynamics
Email: acoustics@rtagroup.com.au Website: www.rtagroup.com.au

technical report

# SITE 4B, SYDNEY OLYMPIC PARK

# CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

TD426-01F02 (REV0) CNVMP

December 2006

Prepared for:
BOVIS LEND LEASE
30 The Bond, 30 Hickson Road
Millers Point NSW 2000

Facsimile: 9237 5051

Attention: MS FLEUR MELLOR

20 YEARS
1982-2002
ACOUSTIC ENGINEERING EXCELLENCE



AAAC Member of the Association of Australian Acoustical Consultants

**Sydney** (Head Office)
Level 1, 418A Elizabeth St
Surry Hills NSW 2010 Australia
PO Box 877 Strawberry Hills NSW 2012
Ph: (02) 8218 0500 Fax: (02) 8218 0501

**Melbourne**
1/66 Curzon St
North Melbourne VIC 3051 Australia
Ph: (03) 9329 5414
Fax: (03) 9329 5627

# TABLE OF CONTENTS

## List of Tables

# 1. INTRODUCTION

Bovis Lend Lease are currently undertaking an Environmental Assessment (EA) for the proposed development at Site 4B, Sydney Olympic Park.

This Construction Noise & Vibration Management Plan (CNVMP) will form part of the EA to establish a management plan to reduce noise and vibration impacts to nearby affected receivers during excavation and construction.

In accordance with relevant guidelines, this document:

- Identifies the potential sources of noise and vibration during the proposed works;
- Specifies the noise and vibration criteria for the proposed works;
- Describes in detail what actions and measures could be implemented to enable these works to comply with the relevant noise and vibration criteria;
- Describes how the effectiveness of these actions and measures would be monitored during the proposed works, clearly indicating who would conduct the monitoring, how often this monitoring would be conducted, how the results of this monitoring would be recorded; and, if any non-compliance is detected;
- Describes procedures to handle complaints.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on the Australian Standard / NZS ISO 9001.

# 2. PROJECT DESCRIPTION

## 2.1 SITE DESCRIPTION

The project involves the construction of a multi-storey commercial complex on Site 4B located in Sydney Olympic Park. Herb Elliot Avenue bounds the site to the north; Olympic Boulevard to the west; the Sydney Olympic Park Authority (SOPA) building to the south and the Peregrine Semiconductor Australia premise to the east. The IBIS Hotel and the Australian Paralympic Committee (APC) buildings are also located to the north across Herb Elliot Avenue. There are no residential areas located within the vicinity of Site 4B.

The nearest and potentially worst affected sensitive receivers were identified during a site inspection. These sensitive receivers are as follows:

- **Receiver R1** **SOPA Building**
  Office / commercial building directly south of the site and sharing a common boundary with the site.

- **Receiver R2** **Peregrine Semiconductor Australia**
  Commercial premises directly east of the site and sharing a common boundary with the site.

- **Receiver R3** **IBIS Hotel**
  Short term accommodation hotel located approximately 77m north of the site across Herb Elliot Avenue

- **Receiver R4** **APC Buildings**
  Residential type buildings used for office / commercial purposes, approximately 37m north of the site across Herb Elliot Avenue

Figure 1 is a locality map showing Site 4B and its surrounding area.

## 2.2 HOURS OF WORK

The expected hours for construction works are as follows:

- Mondays to Fridays – 7am to 6pm
- Saturdays – 8am to 1pm
- Sundays & Public Holidays – No work performed
- Special events days as specified by SOPA – No work performed

It must be noted work may occasionally be conducted outside of the above hours due to unforseen circumstances, eg. requirements of the Police or other authorities, during emergencies, etc. However, owners and occupants of affected properties will be notified at least 48 hours prior to the commencement of the out of hours work.

The duration of the construction works is anticipated to be for 93 weeks.

# 3. EXISTING ACOUSTIC ENVIRONMENT

Long term unattended background noise monitoring was conducted from 11th December to 18th December 2006. The following noise measurement locations were selected for the purpose of this assessment and were considered representative of the sensitive receivers described in Section 2.1 above.

- **Location M1** Located on the northern side of the SOPA property, approximately 5m south of the common boundary with Site 4B and 4m north of the SOPA building. The noise environment at this location was dominated by mechanical plant noise associated with a neighbouring property and construction noise not associated with the site. The background noise levels at this location are considered to be representative of Receivers R1 and R2.

- **Location M2** Located on the western side of the SOPA property, approximately 17m west of the SOPA building and 30m east of Olympic Boulevard. The noise environmental at this location was dominated by occasional traffic noise on Olympic Boulevard and nearby construction noise not associated with the site. The background noise levels at this location are considered to be representative of Receivers R3 and R4.

## 3.1 NOISE MONITORING RESULTS

The results of the background noise measurement are presented in Table 3.1. This background levels are considered representative of the background noise levels for the areas noted above and hence suitable for use in this CNVMP.

**Table 3.1 – Results of $L_{90}$ Background Noise Monitoring, dB(A)**

| Location | $L_{90}$ Background Noise Levels | | |
|---|---|---|---|
| | Day | Evening | Night |
| Location M1 | 56 | 56 | 56 |
| Location M2 | 48 | 46 | 46 |

*Note: 1. Day is defined as 7am to 6pm, Monday to Saturday and 8am to 6pm Sundays & Public Holidays.*
*2. Evening is defined as 6pm to 10pm, Monday to Sunday & Public Holidays.*
*3. Night is defined as 10pm to 7am, Monday to Saturday and 100pm to 8am Sundays & Public Holidays.*

Based on the hours of construction work presented in Section 2.2, only the day period will be assessed herein.

# 4. NOISE MANAGEMENT PLAN

## 4.1 PURPOSE

This section provides an assessment of construction noise emissions from the site and recommends noise mitigation measures and management measures that can be used to minimise noise impacts at receivers surrounding the site.

## 4.2 PROPOSED CONSTRUCTION NOISE SOURCES

The construction of the proposed commercial building at Site 4B will be conducted in two main stages. Stage 1 relates to civil works involving excavation and site establishment, while Stage 2 involves the construction of the proposed commercial building.

Plant and equipment likely to be used during construction are provided in Table 4.1 below.

**Table 4.1 – Typical Construction Equipment & Sound Power Levels, dB(A)**

| Plant Item | Plant Description | Sound Power Levels dB(A) |
|---|---|---|
| ***Stage 1 – Civil Works*** | | |
| 1 | Rock Breaker | 120 |
| 2 | Jack Hammers | 113 |
| 3 | Bulldozer | 112 |
| 4 | Excavator | 110 |
| 5 | Dump Trucks | 108 |
| 6 | Power Generator | 103 |
| 7 | Silenced Air Compressor | 98 |
| ***Stage 2 – Building Construction*** | | |
| 8 | Drilling / Boring Rig (for piles) | 114 |
| 9 | Mobile Crane | 113 |
| 10 | Concrete Truck | 109 |
| 11 | Concrete Pump | 105 |
| 12 | Welders | 105 |
| 13 | Power Generator | 103 |
| 14 | Silenced Air Compressor | 98 |

The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table D2 of Australian Standard 2436 - 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", information from past projects and information held in our library files.

## 4.3 NOISE CRITERIA

The Department of Environment and Conservation (DEC) guidelines used to assess noise generated from construction sites for residential receivers are as follows:

### 4.3.1 Level Restrictions

**i) *Construction period of 4 weeks and under*.**

The $L_{10}$ level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by **more than 20 dB(A)**.

**ii) *Construction period greater than 4 weeks and not exceeding 26 weeks*.**

The $L_{10}$ level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by **more than 10 dB(A)**.

**iii) *Construction period greater than 26 weeks*.**

The criterion for a long-term operational noise would apply, and that is the $L_{10}$ level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by **more than 5 dB(A)**.

It is noted that the above criteria apply specifically to residential premises. For assessment purposes and for a conservative assessment, the IBIS Hotel (Receiver R3) has been considered to be a residential premise.

For the commercial receivers (R1, R2 and R4), the NSW DEC's guidelines state that commercial premises can generally accept 5-10dB(A) more noise than residential premises before the noise becomes annoying to the occupants, this could also apply to construction noise.

Since the duration of construction is expected to be approximately 93 weeks, the $L_{A10}$ level of construction noise should not exceed the $L_{A90}$ background noise level by more than 5dB(A) (for residential premises) plus a conservative 5dB(A) adjustment (for commercial premises). This equates to:

- **Residential = $L_{A10,\ 15min} \leq L_{A90}$ + 5 dB(A)**
- **Commercial = $L_{A10,\ 15min} \leq L_{A90}$ + 5 + 5 dB(A)**

Therefore, based on the measured $L_{A90}$ background noise levels, the applicable construction noise criteria for residential and commercial receivers surrounding the site are presented below.

**Table 4.2 – Summary of Construction Noise Criteria for Critical Receivers**

| Receiver Location | Construction Noise Criteria, dB(A) |
|---|---|
| Receiver R1 – SOPA Building (commercial) | 56 + 5 = 61 |
| Receiver R2 – Peregrine (commercial) | 56 + 5 = 61 |
| Receiver R3 – IBIS Hotel (residential) | 48 + 5 = 53 |
| Receiver R4 – APC Buildings (commercial) | 48 + 5 = 53 |

### 4.3.2 Time Restrictions

- Monday to Friday, 7am to 6pm.
- Saturday, 7am to 1pm if inaudible on residential premises, otherwise 8am to 1pm.

- No construction work to take place on Sundays or Public Holidays.

The hours of work presented in Section 2.2 are in accordance with the above time restrictions and therefore comply.

However, where it is necessary for construction works to be undertaken outside the preferred construction hours, the $L_{10}$ noise levels emitted by the works is normally restricted to a margin not greater than 5dB(A) above the background noise level for that period. Where this is the case, the criteria presented in the following table will be applicable.

**Table 4.3 – Summary of Construction Noise Criteria for Out of Hours Work**

| Receiver Location | Construction Noise Criteria, dB(A) |
|---|---|
| Receiver R1 – SOPA Building (commercial) | 56 + 5 = 61 |
| Receiver R2 – Peregrine (commercial) | 56 + 5 = 61 |
| Receiver R3 – IBIS Hotel (residential) | 46 + 5 = 51 |
| Receiver R4 – APC Buildings (commercial) | 46 + 5 = 51 |

*Note: Criteria based on background noise levels during the night time period*

## 4.4 NOISE MANAGEMENT MEASURES

### 4.4.1 Estimated Noise Levels

The estimated noise levels at the nearest affected receiver locations were calculated and are shown in Table 4.4 below. It must be noted that the predicted noise levels presented are based on all the plant and equipment operating concurrently for the corresponding stage of construction. Therefore these noise levels are for 'worst-case' scenarios.

**Table 4.4 – Estimated Construction Noise Levels at Nearest Affected Receivers**

| Receiver | Criteria, dB(A) | | Estimated $L_{A10(15min)}$ Noise Level, dB(A) | |
|---|---|---|---|---|
| | Daytime | Out of Hours | Stage 1 | Stage 2 |
| Receiver R1 – SOPA Building (commercial) | *61* | *61* | 94 | 90 |
| Receiver R2 – Peregrine (commercial) | *61* | *61* | 94 | 90 |
| Receiver R3 – IBIS Hotel (residential) | *53* | *51* | 76 | 72 |
| Receiver R4 – APC Buildings (commercial) | *53* | *51* | 82 | 78 |

The calculations above are based on works generally occurring in the areas closest to the corresponding nearby critical receivers and assume all equipment for each stage of works are operating concurrently. Calculations take into consideration attenuation due to distance between the receiver and the construction activity only and does not consider shielding provided by intervening structures. It is assumed that no noise mitigation treatment has been applied to plant and equipment on site.

Noise emission from construction activities will potentially exceed the set noise criteria for all locations during both stages of works. The plant and equipment significantly contributing to the elevated noise levels during the construction works include:

- Rock breaker;
- Drilling rig (for piles);
- Jack hammers;
- Bulldozer; and
- Excavator

Noise management measures, as outlined below, should be undertaken to minimise noise impact during construction activities.

### 4.4.2 General Engineering Noise Controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites* are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-1981, Appendix E, Table E1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table E2 in Appendix E presents typical examples of noise reductions achievable after treatment of various noise sources. Table E3 in Appendix E presents the relative effectiveness of various forms of noise control treatment.

Table 4.5 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

**Table 4.5 – Relative Effectiveness of Various Forms of Noise Control, dB(A)**

| Noise Control Method | Practical Examples | Typical noise reduction possible in practice | | Maximum noise reduction possible in practice | |
|---|---|---|---|---|---|
| | | AS 2436 | Renzo Tonin & Assoc. | AS 2436 | Renzo Tonin & Assoc. |
| Screening | Acoustic barriers such as earth mounds, temporary or permanent noise barriers | 7 to 10 | **5 to 10** | 15 | **15** |
| Acoustic Enclosures | Engine casing lagged with acoustic insulation and plywood | 15 to 30 | **10 to 20** | 50 | **30** |
| Engine Silencing | Residential class mufflers | 5 to 10 | **5 to 10** | 20 | **20** |
| Substitution by alternative process | Use electric motors in preference to diesel or petrol | 15 to 25 | **15 to 25** | 60 | **40** |

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

To ensure efficient noise attenuation performances are achieved using any of the methods listed above, it is recommended acoustic engineers work closely with the construction contractors and carry out noise testing of works.



### 4.4.3 Specific Engineering Noise Controls

Physical noise treatment options specific to the site are summarised below. Note that the ability to implement these measures is subject to site practicality.

1. ***Noise Control Kits*** — Where possible, 'noise control kits' could be fitted to plant engines to reduce noise level emissions. Such 'noise control kits' comprise:
   - high performance 'residential-grade' exhaust mufflers,
   - additional engine cowling / enclosure lined inside with sound absorbent industrial-grade foam, and
   - air intake and discharge silencers / louvres.

2. ***Partial Acoustic Enclosures*** — Where noise exceedances occur, moveable, partial acoustic enclosures shall be constructed around noisy plant and equipment, for example the air compressors. A partial enclosure can be constructed from 10mm plywood, located on site as close as practical to the plant. The inner face of the plywood enclosure should be lined with 50mm acoustic insulation (eg. Tontine AcoustiSorb2 or TBL 32/50, hydrophobic mineral wool, or equivalent).

   Acoustic enclosures should be checked by a suitable acoustic engineer once it is constructed.

3. ***Hoarding*** — Where noise emissions from stationary equipment or from compounds (not transient activities) generate complaints from neighbouring occupancies, erect temporary hoarding between the source and receiver. The hoarding should be constructed from any durable material with sufficient mass to prevent direct noise transmission eg. steel, aluminium, fibrous-cement, timber, polycarbonate, or any combination of such materials, provided they withstand the weather elements.

   Furthermore, penetrations through the building facade should be boarded over prior to carrying out further noisy works inside the building to reduce noise emission from the building outwards to neighbours, especially when internal works occur during the night time period.

   Hoarding should be checked by a suitable acoustic engineer once erected.

4. ***Truck Movement*** — Potential noise impact from truck movement will be limited by managing the movement of trucks on site. The number of trucks on site will be kept to the minimum required.

### 4.4.4 Noise Management Measures

The following environmental noise management measures shall be provided to minimise adverse noise impacts to nearby receivers.

1. ***Time Management*** — Where noise level exceedances cannot be avoided or where physical noise control measures are not reasonable or feasible, then consideration should be given to implementing time restrictions and/or providing periods of repose for occupants. That is, daily periods of respite from noisy activities should also be scheduled for building occupants during business hours.

   Some items of plant may exceed noise limits even after noise treatment is

applied. To reduce the overall noise impact, the use of noisy plant should be restricted to within certain time periods, to be negotiated with Council and the residents.

For example, between 10am and 3pm (with one-hour break for lunch between 12pm and 1pm), noisy activities could occur with no noise level restrictions over a limited time period. Residents would be notified of the potential noise impact during this time period so that they can organise their day around the noisy period.

Allowing the construction activities to proceed, despite the noise exceedance may be the preferred method in order to complete the works expeditiously.

***2. General***

- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods should be switched off.
- Good relations with people living and working in the vicinity of the construction site should be established at the beginning of the works and be maintained throughout the works, as this is of paramount importance.
- Keep people informed of progress.
- Take complaints seriously and deal with them expeditiously. The person selected to liaise with the building occupants should be adequately trained and experienced in such matters.

***3. Regular Periodic Noise Monitoring***

Noise monitoring should be undertaken at the commencement of works and regular periods at all affected receiver locations identified in this study to provide feedback to management on any noise exceedances, so necessary actions can be taken. Noise monitoring should be undertaken in accordance with Appendix C.

***4. Complaints Handling Procedure***

A complaint handling procedure should be put in place to deal with noise complaints that may arise from demolition activities. A contact number for complaints to be made on should be established for residents to inform the site of unsatisfactorily high noise levels. This number should be displayed clearly on signage at the site perimeter. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits. See Appendix D for an example of a complaint handling procedure and form.

# 5. VIBRATION MANAGEMENT PLAN

## 5.1 VIBRATION SOURCES

Typical vibration levels from construction plant equipment most likely to cause significant vibration are summarised below. The information was sourced from a variety of reference materials available in the Renzo Tonin & Associates library.

**Table 5.1 – Typical Ground Vibration Generated by Construction Plant**

| Activity | Typical ground vibration |
|---|---|
| Bored piling | 4mm/s to 5mm/s at a distance of approximately 5m, and 1.5mm/s at 10m. At distances greater than 25m, vibration are usually below 0.6mm/s, and at 50m or more vibration are usually below 0.1mm/s |
| Bulldozers | Typical ground vibration from bulldozers range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s. |
| Hydraulic rock breakers | Typical ground vibration from rock breakers ranges from 4.50mm/s at 5m to 1.30mm/s at 10m, 0.4mm/s at 20m and 0.10mm/s at 50m |
| Truck traffic | Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration in the range 0.01-0.2mm/s at the footings of buildings located 10-20m from a roadway. In general ground vibration from trucks is usually imperceptible in nearby buildings. |

Therefore, vibration management strategies implemented on site shall consider these items of plant and construction activities involving these items of plant.

## 5.2 VIBRATION CRITERIA

### 5.2.1 Objectives

The management objective for the site is to limit vibration from construction activities so as to avoid building damage and human discomfort associated with the construction works for Site 4B at Sydney Olympic Park.

It is noted that buildings in the vicinity of Site 4B are mainly occupied by office areas. However, residential type spaces where sleeping areas are provided are located within the IBIS Hotel (Receiver R3) and should be considered for the assessment of human annoyance due to vibration.

Commercial type buildings surround Site 4B. However, there is residential type buildings associated with the Australian Paralympic Committee site (Receiver R4) and should be considered for the assessment of structural damage due to vibration.

The following criteria are considered applicable when assessing vibration emission levels from the construction works.

### 5.2.2 Vibration Criteria

The effects of ground vibration on buildings near construction sites may be broadly defined by the following three categories:

1. Disturbance to building occupants - Vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,

2. Effects on building contents - Vibration where the building contents may be affected, and,
3. Effects on building structures - Vibration in which the integrity of the building or structure itself may be prejudiced.

In general, vibration criteria for human disturbance (1) are more stringent than vibration criteria for effects on building contents (2) and building structural damage (3). Hence, compliance with the more stringent limits dictated by Category 1, would ensure that compliance is also achieved for the other two categories.

**Category 1 – Disturbance to Buildings Occupants**

For disturbance to human occupants of buildings, we refer to the DEC's *'Assessing Vibration; a technical guideline'*, published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*.

Vibration sources are defined as C*ontinuous, Impulsive or Intermittent.* Section 2 of the technical guideline defines each type of vibration as follows:

> ***'Continuous*** *vibration continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).*
>
> ***Impulsive*** *vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.*
>
> ***Intermittent*** *vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude'.*

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

Preferred and maximum values for continuous and impulsive vibration are defined in table 2.2 of the guideline and are reproduced below.

**Table 5.2 – Preferred and Maximum Weighted rms Values for Continuous and Impulsive Vibration Acceleration (m/s$^2$) 1-80Hz**

| Location | Assessment period[1] | Preferred values | | Maximum values | |
|---|---|---|---|---|---|
| | | z axis | x & y axis | z axis | x & y axis |
| **Continuous vibration** | | | | | |
| Critical areas[2] | Day- or night-time | 0.005 | 0.0036 | 0.010 | 0.0072 |
| Residences | Daytime | 0.010 | 0.0071 | 0.020 | 0.014 |
| | Night-time | 0.007 | 0.005 | 0.014 | 0.010 |

| Location | Assessment period[1] | Preferred values | | Maximum values | |
|---|---|---|---|---|---|
| | | z axis | x & y axis | z axis | x & y axis |
| **Continuous vibration** | | | | | |
| Offices, schools, educational institutions and places of worship | Day- or night-time | 0.020 | 0.014 | 0.040 | 0.028 |
| | | 0.04 | 0.029 | 0.080 | 0.058 |
| Workshops | Day- or night-time | 0.04 | 0.029 | 0.080 | 0.058 |
| **Impulsive vibration** | | | | | |
| Critical areas[2] | Day- or night-time | 0.005 | 0.0036 | 0.010 | 0.0072 |
| Residences | Daytime | 0.30 | 0.21 | 0.60 | 0.42 |
| | Night-time | 0.10 | 0.071 | 0.20 | 0.14 |
| Offices, schools, educational institutions and places of worship | Day- or night-time | 0.64 | 0.46 | 1.28 | 0.92 |
| Workshops | Day- or night-time | 0.64 | 0.46 | 1.28 | 0.92 |

*Notes:* 1. *Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am*

2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992*

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 2.4 of the guideline and are reproduced below.

**Table 5.3 – Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)**

| Location | Daytime [1] | | Night-time [1] | |
|---|---|---|---|---|
| | Preferred values | Maximum values | Preferred values | Maximum values |
| Critical areas[2] | 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 |

*Notes:* 1. *Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am*

2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992*

Based on Table 5.2 and Table 5.3 above, occupants of residential areas, Receiver R3, will be assessed against the criteria for residences. For the occupants of office areas, namely Receivers R1, R2 and R4, the criteria for offices will need to be assessed against.

**Category 2 – Effects on building contents**

The typical frequency range of construction induced ground vibration is approximately 8 Hz to 100 Hz. Over this range the threshold of visible movement of building contents such as plants, pictures, blinds etc is approximately 0.5 mm/s. At vibration levels higher than 0.9 mm/s, audible rattling of loose objects such as crockery can be expected.

**Category 3 – Structural Damage to Buildings**

Currently there exists no Australian Standard for assessment of structural building damage caused by vibrational energy. Therefore, reference is made to both the British and German standards below which are relevant to the assessment of structural damage.

British Standard

British Standard 7385: Part 2 "Evaluation and measurement of vibration in buildings", can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

BS7385 recommends that the peak particle velocity is used to quantify vibration and specifies damage criteria for frequencies within the range 4Hz to 250Hz, which is the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The levels from the standard are given below in Table 5.4.

**Table 5.4 – BS 7385 Structural Damage Criteria**

| Group | Type of Structure | Peak component particle velocity, mm/s | | |
|---|---|---|---|---|
| | | 4Hz to 15Hz | 15Hz to 40Hz | 40Hz and above |
| 1 | Reinforced or framed structures Industrial and heavy commercial buildings | 50 | | |
| 2 | Un-reinforced or light framed structures Residential or light commercial type buildings | 15 to 20 | 20 to 50 | 50 |

The peak vibration limits set for minimal risk of 'cosmetic' damage are: 15mm/s for un-reinforced or light framed structures, for example residential or light commercial buildings (Line 2; increasing as the frequency content of the vibration increases) and 50mm/s for reinforced or framed structures, for example industrial and heavy commercial buildings (Line 1; constant across all frequencies). 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

These values relate to transient vibrations and to low rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%.

The levels set by this standard are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular types of buildings. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls.

This standard states that it considers sources of vibration including blasting, demolition, piling, ground treatments, compaction, construction equipment, tunnelling, road and rail traffic and industrial machinery.

As stated in the standard, it sets guide values for building vibration based on the lowest levels above which damage has been credibly demonstrated. That is, it gives guidance on the levels of vibration above which building structures could be damaged.

German Standard

The German standard DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures", also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum 'safe limit' of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (eg historical with preservation orders etc), it is 3mm/s. These limits increase as the frequency content of the vibration increases. These values are presented in Table 5.5 below and are generally recognised to be conservative.

**Table 5.5 – DIN 4150-3 Structural Damage Criteria**

| Group | Type of Structure | Vibration Velocity, mm/s | | | |
|---|---|---|---|---|---|
| | | At Foundation at Frequency of | | | Plane of Floor Uppermost Storey |
| | | Less than 10Hz | 10Hz to 50Hz | 50Hz to 100Hz | All Frequencies |
| 1 | Buildings used for commercial purposes, industrial buildings and buildings of similar design | 20 | 20 to 40 | 40 to 50 | 40 |
| 2 | Dwellings and buildings of similar design and/or use | 5 | 5 to 15 | 15 to 20 | 15 |
| 3 | Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order) | 3 | 3 to 8 | 8 to 10 | 8 |

Based on Table 5.4 and Table 5.5, the residential type buildings of Receiver R4 will be assessed against structures classified as Group 2 in the tables. For the commercial type buildings, being Receivers R1, R2 and R3, assessment of structural damage will be against Group 1 type structures.

Furthermore, it is noted that the Sydney Olympic Park railway tunnel runs below and adjacent to Site 4B. Therefore, assessment of structural damage to the tunnel should be conducted. There are no specific criteria for tunnels; however, for assessment purposes and due to the reinforced construction of the tunnel, it is considered as a Group 1 type structure as presented in the above tables.

## 5.3 BUFFER DISTANCES FOR VIBRATION CONTROL

The relationship between vibration and the probability of causing human annoyance or damage to structures, is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of a vibration, all play an important role in both the annoyance caused and the strains induced in structures.

As the pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific, below are some indicative minimum 'buffer' distances determined for some common construction plant with data available from recent projects, which assist to avoid human discomfort in terms of perceptible (or tactile) vibration during daytime construction hours:

**Table 5.6 – Recommended Minimum Buffer Distances for Construction Plant**

| Plant Item | Recommended Minimum Buffer Distance (m) |
|---|---|
| Bored piling[1] | 10 |
| Bulldozers | 5 |
| Rockbreaker – small | 5 |
| Rockbreaker – medium | 7 |
| Rockbreaker – large | 15 |
| Truck movements | 10 |

*Note: 1. Based on bore drilling vibration data*

Site specific buffer distances should be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on site.

Furthermore, periodic monitoring is to be conducted, at all critical or sensitive areas, and the vibration levels are to be tested for compliance with the set vibration limits. This monitoring shall be undertaken in accordance with the vibration monitoring methods described in Appendix D of this report.

## 5.4 VIBRATION MANAGEMENT MEASURES

Further to buffer distances, to ensure vibration impacts are minimised during the construction period, the following vibration management control measures are provided:

1. The proper implementation of a vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with occupants and property owners is recommended and should be aimed at providing a communication path directly to the contractor.

2. A management procedure will be implemented to deal with vibration complaints. Each complaint will be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences. An example of a vibration complaint management procedure and complaint form is presented in Appendix E of this report.

3. Carry out vibration testing of actual equipment on site to determine acceptable buffer distances to commercial and residential occupancies.

4. Carry out additional vibration monitoring as specified in Appendix D when construction activities are at the nearest point to the nominated occupancies. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach/exceed the recommended limits in nearby occupancies.

5. Carry out periodic monitoring at all critical or sensitive areas and the vibration levels are to be tested for compliance with the set vibration limits. This monitoring shall be undertaken in accordance with the noise and vibration monitoring program described in Appendix D.

6. Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller rock breakers, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

7. Before, during and after the demolition and construction stages we recommend preparation of a dilapidation report on the state of the existing buildings sharing the property boundary with the site as well as the Sydney Olympic Park railway tunnel.

# 6. COMPLAINTS MANAGEMENT

Noise and vibration levels generated by construction activities associated with the construction of the Site 4B development at Sydney Olympic Park, should aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

The building contractor is responsible for implementing this Noise and Vibration Management Plan and ensuring that all reasonable measures are implemented such as the provision of a Noise / Vibration Complaints Program, to minimise the generation of excessive noise and vibration levels from the site to nearby sensitive areas.

Owners and occupants of nearby affected properties shall be informed by direct mail of a direct 24-hour telephone line where any noise and / or vibration complaints related to the operation of the construction activities will be recorded. Additionally, owners and occupants will be notified of any periods of noisy construction activities at least 24 hours prior to their commencement.

All noise and vibration complaints shall be investigated by the site in accordance with the Noise / Vibration Complaint Management Procedure identified in Appendix E of this report.

# 7. CONCLUSION

A noise and vibration management plan for the construction of the Site 4B development at Sydney Olympic Park has been prepared. Specifically, this management plan aims to minimise noise and vibration impact during the construction works through a combination of physical noise and vibration controls and noise and vibration management measures, to aid in achieving compliance with relevant Australian and International Standards.

In-principle recommendations are provided to limit noise and vibration impacts to acceptable levels. For vibration impacts, buffer distances have been provided as guidance to minimise impacts at nearby sensitive receivers.

Procedures to manage complaints are also provided in Section 6 and Appendix E to ensure complaints are dealt with accordingly.



## APPENDIX A – GLOSSARY OF CONSTRUCTION NOISE TERMS

The following is a brief description of the technical terms used to describe construction noise to assist in understanding the technical issues presented.

*Acoustic Barrier* — Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc used to reduce noise, without eliminating it.

*Air-borne noise* — This refers to noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise and receiver.

*Ambient Noise* — The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.

*Assessment Period* — The period in a day over which assessments are made.

*Assessment Point* — A point at which noise measurements are taken or estimated.

*Audible Range* — The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.

*Background Noise* — Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the $\mathbf{L_{90}}$ noise level (see below).

*Barrier* — See “acoustic barrier”, a solid object used to attenuate sound.

*Decibels [dB]* — The level of noise is measured objectively using a Sound Level Meter. This instrument has been specifically developed to mimic the operation of the human ear.

The human ear responds to minute pressure variations in the air. These pressure variations can be likened to the ripples on the surface of water but of course cannot be seen.

The pressure variations in the air cause the eardrum to vibrate and this is heard as sound in the brain. The stronger the pressure variations, the louder the sound is heard.

The range of pressure variations associated with everyday living may span over a range of a million to one. On the top range may be the sound of a jet engine and on the bottom of the range may be the sound of a pin dropping.

Instead of expressing pressure in units ranging from a million to one, it is found convenient to condense this range to a scale 0 to

120 and give it the units of decibels. The following are examples of the decibel readings of every day sounds:

0 dB the faintest sound we can hear
30 dB a quiet library or in a quiet location in the country
45 dB typical office space; ambience in the city at night
60 dB Martin Place at lunch time
70 dB the sound of a car passing on the street
80 dB loud music played at home
90 dB the sound of a truck passing on the street
100 dB the sound of a rock band
115 dB limit of sound permitted in industry
120 dB deafening.

*dB(A); A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched in is denoted as dB(A). Practically all noise is measured using the A filter.

*Diffraction* The distortion around solid obstacles of waves travelling past.

*Fluctuating Noise* Noise that varies continuously and to an appreciable extent over the period of observation.

*Frequency* Of a periodic quantity: the time rate of repetition. The reciprocal of the period. Frequency is measured in Hertz (Hz).

*Loudness* A 3dB increase represents a doubling of the sound pressure, however an increase of about 10dB is required before the sound will subjectively appear to be twice as loud. That is, a sound of 85dB is twice as loud as a sound of 75dB which is twice as loud as a sound of 65dB and so on. That is, the sound of 85dB is four times as loud as a sound of 65dB. The smallest change which can be readily heard is approximately 2dB. An increase beyond 5dB is considered to represent the level at which a change in loudness begins to be clearly perceived.

$L_1$ The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.

$L_{10}$ The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

$L_{90}$ The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the $L_{90}$ noise level expressed in units of dB(A).

$L_{eq}$ Equivalent sound pressure level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.

*Microphone* An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.

| | |
|---|---|
| *Noise* | Sound which a listener does not wish to hear. |
| *Noise Monitor* | See “sound level meter”. |
| *Reflection* | Sound wave changed in direction of propagation due to a solid object obscuring its path. |
| *SEL* | Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations. |
| *Sound* | An alteration in pressure, stress, particle displacement, or particle velocity which is propagated in an elastic material or the superposition of such propagated alterations. |
| *Sound Level Meter* | An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels. |
| *Sound Pressure Level* | The level of sound pressure, expressed in decibels, as measured by a standard sound level meter with a microphone. |
| *Sound Power Level* | Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power. |

# APPENDIX B – SPECIFICATION FOR DETERMINING THE SOUND POWER LEVELS OF CONSTRUCTION PLANT

## B1. SCOPE

This document specifies methods for determination of sound power levels for construction plant including earthmoving equipment and other ancillary plant and equipment used during construction.

## B2. REFERENCED STANDARDS

- Australian Standard 1259 – 1990: “Acoustics - Sound Level Meters”,
- Australian Standard 2012.1-1990: “Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - stationary test condition - Part 1: Determination of compliance with limits for exterior noise”
- ISO 6395: “Acoustics & Measurement of airborne noise emitted by earthmoving machinery - Dynamic test conditions”
- AS1217.5-1985: “Acoustics – Determination of sound power levels of noise sources – Part 5 – Engineering methods for free-field conditions over a reflecting plane”
- AS1217.7-1985: “Acoustics – Determination of sound power levels of noise sources – Part 5 – Survey method”

## B3. TESTING PROCEDURES – EARTHMOVING MACHINERY

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

Each significant plant item shall be tested in terms of both the ‘stationary’ and the ‘dynamic’ testing procedures detailed below.

All sound level meters used must be Type 1 instruments as described in Australian Standard 1259.2-1990 “Acoustics - Sound Level Meters” and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the meters shall be checked in the field before and after the noise measurement period.

### B3.1 STATIONARY TESTING

Stationary measurements shall be performed on all earthmoving plant according to the method of AS2012.1-1990.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in Table 1 of AS2012.1-1990.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be

at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish octave-band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $L_{A10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

All measured noise level data and determined sound power levels shall be included in the test reports.

### B3.2 DYNAMIC TESTING

Details of equipment operation during testing will vary depending on the equipment type. Dynamic measurements shall be performed on all earthmoving plant according to the method in International Standard ISO 6395.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in International Standard ISO 6395.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed to establish octave-band sound power levels.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $L_{A10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

All measured noise level data and determined sound power levels shall be included in the test reports.

## B4. TESTING PROCEDURES – OTHER CONSTRUCTION PLANT

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All sound level meters used must be Type 1 instruments as described in Australian Standard 1259.2-1990 “Acoustics - Sound Level Meters”. The calibration of the meters shall be checked in the field before and after the noise measurement period.

Noise measurements shall be performed on all non-earthmoving construction plant according to the methods of either AS1217.5-1985 or AS1217.7-1985, whichever is applicable to the items of plant being tested.

Machinery shall be operated at high idle speed. In the case of drilling, boring and rock-breaking machines, the testing location shall allow for these machines to be operated in rock of characteristics that are typical for the project site.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in Table 1 of AS2012.1-1990.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish octave-band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $L_{A10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

All measured noise level data and determined sound power levels shall be included in the test reports.

# APPENDIX C – SPECIFICATION FOR CONSTRUCTION NOISE MONITORING

## C1. SCOPE

This document specifies methods for undertaking noise monitoring during the construction phase of the project.

## C2. REFERENCED STANDARDS & GUIDELINES

- Australian Standard 1259–1990: “Acoustics - Sound Level Meters”,
- Australian Standard 1055-1989 “Acoustics - Description and Measurement of Environmental Noise”,
- NSW Environment Protection Authority’s “Environmental Noise Control Manual”, and
- NSW Environment Protection Authority’s “Industrial Noise Policy”.

## C3. TESTING PROCEDURES

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All noise monitoring equipment used must be at least Type 2 instruments as described in Australian Standard 1259.2-1990 “Acoustics - Sound Level Meters” and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of long-term noise monitoring, calibration levels shall be checked at minimum weekly intervals.

Long-term noise monitoring equipment or Noise Loggers, consist of sound level meters and computers housed in weather resistant enclosures. The operator may either retrieve the data at the conclusion of each monitoring period either in person or via a telephone modem if the logger is fitted with a mobile phone option. The nominated long-term environmental noise level monitors are to be of the RTA Technology Pty Ltd [phone (02) 8218 0570] type or equivalent.

All environmental noise measurements shall be taken with the following meter settings:

- Time Constant – FAST (ie 125 milliseconds)
- Frequency Weightings – A-weighting
- Sample Period – 15 minutes

All outdoor noise measurements shall be undertaken with a windscreen over the microphone. Windscreens reduce wind noise at the microphones.

Measurements of noise should be disregarded when it is raining and the wind speed is greater than 5 m/s (18 km/hr).

### C3.1 LONG-TERM (UNATTENDED) MONITORING

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

Noise monitoring equipment shall be placed at positions which have unobstructed views of general site activities, whilst shielded as much as possible from non-construction site noise (eg. road traffic, rail noise and other surrounding noise).

Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory for later retrieval is the following A-weighted noise levels: $L_{min}$, $L_{90}$, $L_{eq}$, $L_{10}$, $L_1$ and $L_{max}$.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Meteorological conditions such as wind velocity, wind direction and rainfall shall also be either monitored on site or recorded from the nearest weather station to the project site, over the entire noise monitoring period.

### C3.2 SHORT-TERM (ATTENDED) MONITORING

Attended short-term noise monitoring shall be conducted at noise receiver locations with closest proximity to the construction activities.

Short-term noise monitoring shall be conducted within the first month of commencement of construction works, and then every 1 to 2 months thereafter, dependent on the level of complaint from construction activities.

All attended short-term noise monitoring shall be recorded over 15 minute sample intervals. Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory and reported are the following A-weighted noise levels: $L_{min}$, $L_{90}$, $L_{eq}$, $L_{10}$, $L_1$ and $L_{max}$.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Outdoor noise monitoring is to be undertaken with the microphone at a height of 1.2 – 1.5m from the ground, unless noise measurements are taken from a balcony or verandah, in which case the same microphone height shall apply off the floor.

Conditions such as wind velocity, wind direction, temperature, relative humidity and cloud cover shall also be recorded during short-term noise monitoring.

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

The following information shall be recorded:

- Date and time of measurements
- Type and model number of instrumentation
- Results of field calibration checks before and after measurements

- Description of the time aspects of each measurement (ie sample times, measurement time intervals and time of day)
- Sketch map of area
- Measurement location details and number of measurements at each location
- Weather conditions during measurements
- Operation and load conditions of the noise sources under investigation
- Any adjustment made for presence or absence of nearby reflecting surfaces
- Noise due to other sources (eg traffic, aircraft, trains, dogs barking, insects etc)

# APPENDIX D – SPECIFICATION FOR CONSTRUCTION VIBRATION MONITORING

## D1. SCOPE

This document specifies methods for undertaking vibration monitoring during the construction phase of the project.

## D2. REFERENCED STANDARDS & GUIDELINES

- AS 2775 Mechanical Mounting of Accelerometers
- AS 2670.2 Part 2: Evaluation of human exposure to whole body vibration
- EPA ENCM Chapter 174 – Vibration in Buildings
- DIN 4150.3 Structural Vibration in Buildings – Effects on Structures
- BS 7385:1 Evaluation and Measurement for Vibration in Buildings – Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings
- BS 7385:2 Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Groundborne Vibration
- ISO 4866 Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings

## D3. TESTING PROCEDURES

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be calibrated at least once every two years to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The monitoring system should also have a measurement frequency range down to 1Hz.

Long-term vibration monitoring equipment or Vibration Loggers consist of a computer unit connected by cable to a triaxial vibration transducer which senses vertical, axial and horizontal vibration. Vibration levels are continuously monitored, and the data is processed statistically and stored in the computer memory. The operator may either retrieve the data at the conclusion of each monitoring period either in person or via a telephone modem if the logger is fitted with a mobile phone option. The nominated long-term Vibration Loggers are to be of the RTA Technology Pty Ltd [phone (02) 8218 0570] type or equivalent.

### D3.1 LONG-TERM (UNATTENDED) MONITORING

Vibration monitoring shall be undertaken at vibration sensitive locations determined to fall within the 'buffer distances' established for each item of plant during the commencement of use of each plant on site.

Vibration monitoring shall be undertaken over the following period(s):

- continuously whilst the vibrating plant is operational within the pre-determined 'buffer distances' from the potentially affected building.

Vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.

Vibration levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of vibration metrics to be stored in memory for later retrieval is the following:

- vector-sum root-mean-square (rms) – maximums and statistical metrics
- vector-sum peak-particle velocity (ppv) – maximums and statistical metrics.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.
- the surface should be solid and rigid in order to best represent the vibration levels entering the structure of the building under investigation
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using bees wax or a magnetic mounting plate onto a steel plate or bracket either fastened or glued to the surface of interest
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest and the vibration sensor or transducer shall be mounted on that.

### D3.2 SHORT-TERM (ATTENDED) MONITORING

Where vibration complaints or requests from relevant authorities are received, attended short-term vibration monitoring shall also be conducted at the requested location and at any other relevant vibration receiver location with closest proximity to the construction activities.

Short-term vibration monitoring shall be used to supplement long-term vibration monitoring undertaken at nearby locations, and to check whether or not the vibration levels measured by the long-term vibration monitors are caused by construction activities carried out on site.

All attended short-term vibration monitoring shall be recorded over 15 minute sample intervals. Vibration levels are to be recorded at a minimum rate of 10 samples per second. The minimum range of vibration metrics to be stored in memory and reported are the following:

- root-mean-square (rms) – maximums and statistical levels
- peak-particle velocity (ppv) – maximums and statistical levels.

In addition to measuring and reporting overall vibration levels, statistical vibration levels shall also be measured and reported in third-octave band frequencies from 1Hz to 250Hz.

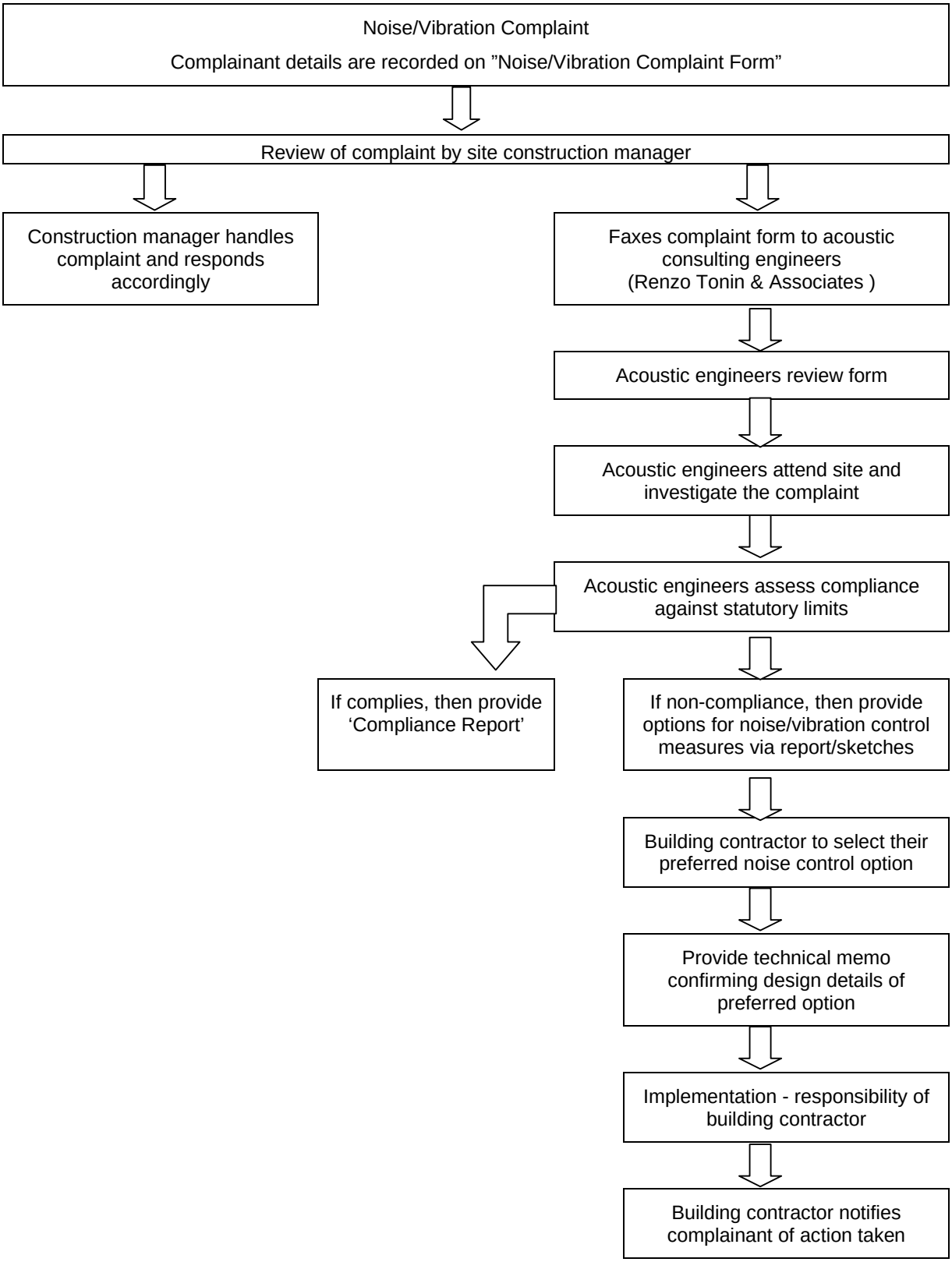
Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.
- the surface should be solid and rigid in order to best represent the vibration levels entering the structure of the building under investigation
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using either bees wax or a magnetic mounting plate onto a steel washer, plate or bracket which shall be either fastened or glued to the surface of interest
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that.

The following information shall be recorded:

- Date and time of measurements
- Type and model number of instrumentation
- Description of the time aspects of each measurement (ie sample times, measurement time intervals and time of day)
- Sketch map of area
- Measurement location details and number of measurements at each location
- Operation and load conditions of the vibrating plant under investigation
- Possible vibration influences from other sources (eg domestic vibrations, other mechanical plant, traffic, etc)

## APPENDIX E – NOISE / VIBRATION COMPLAINT MANAGEMENT PROCEDURE





# NOISE/VIBRATION COMPLAINT FORM

## COMPLAINANT'S DETAILS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date :** | | **Received by** (tick a box) **:** | **Phone** ☐ | **Written in** ☐ | **Person** ☐ | | |
| **Complaint Received By:** | | | **Complainant's Name:** | | | | |
| **Complainant's Address:** | | | | | | | |
| **Complainant's Contact Numbers:** | **Home:** | | **Work:** | | **Mob:** | | |

## COMPLAINT DETAILS

**Describe when the problem occurred (date and time), what equipment caused the complaint (if known) and where person was standing when he/she experienced the noise/vibration:**

……
……
……
……
……
……
……
……
……
……
……
……

## INVESTIGATION

**Question foreman responsible on site and obtain information on what equipment or processes would most likely have caused the complaint:**

……
……
……
……
……
……
……
……
……
……

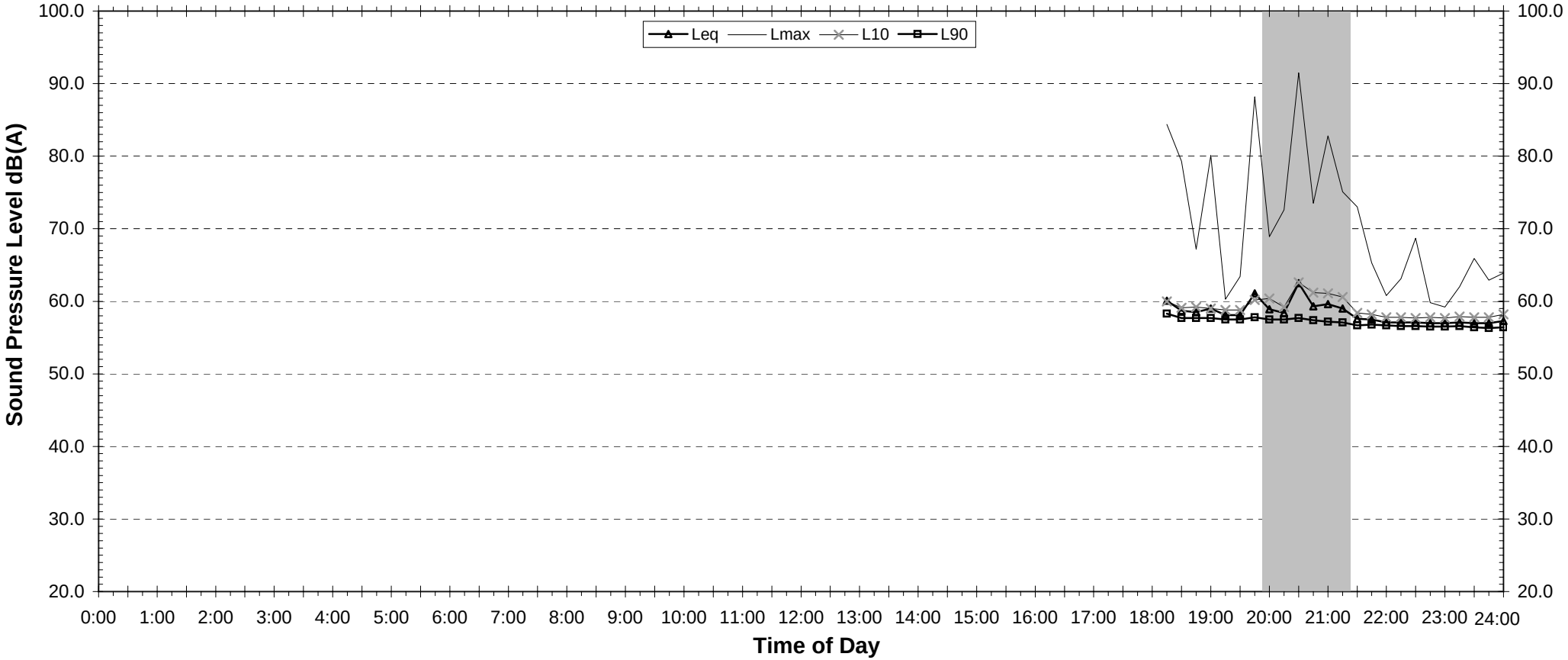
**Please fax this form to Renzo Tonin & Associates Pty Ltd for processing after obtaining approval from the Project Manager - Fax: (02) 8218 0501**

# APPENDIX F – NOISE MONITORING RESULTS

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Monday, 11 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | - | 56.7 | 55.9 |
| Leq (see note 3) | - | 58.7 | 57.2 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

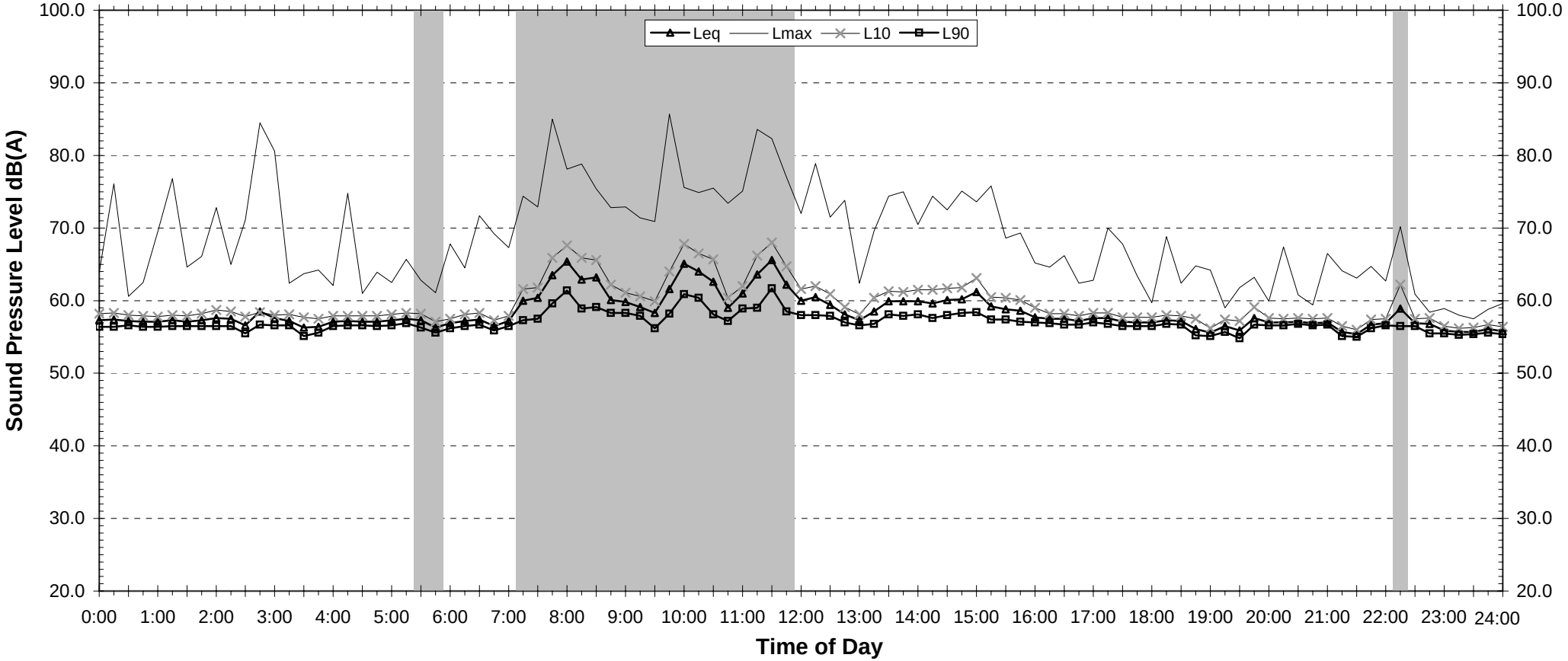
| NSW ECRTN Policy (1m from facade) (see note3) | | |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 61.2 | 59.7 |
| $L_{eq\ 1hr}$ upper 10 percentile | 61.8 | 60.1 |
| $L_{eq\ 1hr}$ lower 10 percentile | 59.9 | 59.3 |

| Night Time Maximum Noise Levels (see note 4) | | | |
|---|---|---|---|
| Lmax (Range) | 74.8 | to | 84.5 |
| Lmax - Leq (Range) | 17.6 | to | 26.9 |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Tuesday, 12 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 56.5 | 55.0 | 55.3 |
| Leq (see note 3) | 58.9 | 56.7 | 56.8 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

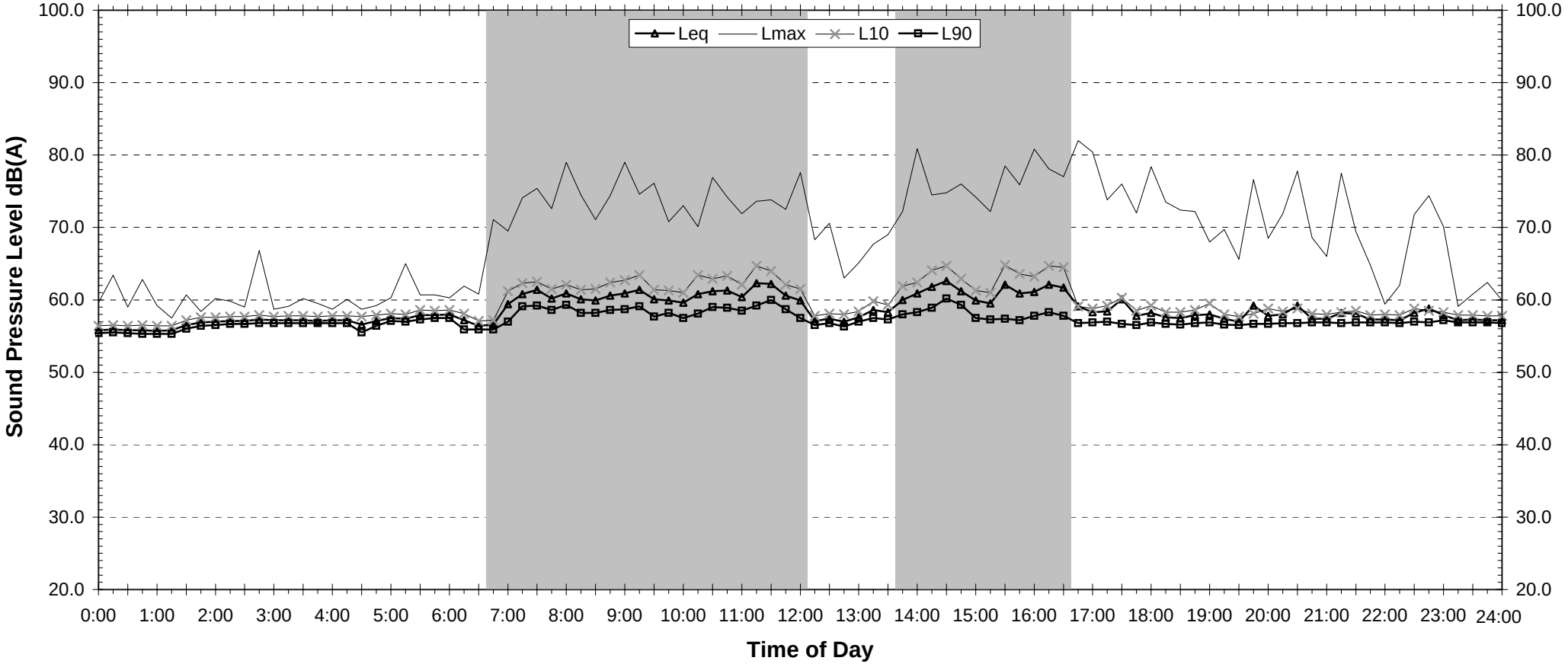
| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 60.6 | 59.3 |
| $L_{eq\ 1hr}$ upper 10 percentile | 62.8 | 60.3 |
| $L_{eq\ 1hr}$ lower 10 percentile | 58.8 | 58.3 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | - | to | - |
| Lmax - Leq (Range) | - | to | - |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Wednesday, 13 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 56.5 | 56.6 | 56.7 |
| Leq (see note 3) | 58.2 | 57.9 | 57.3 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

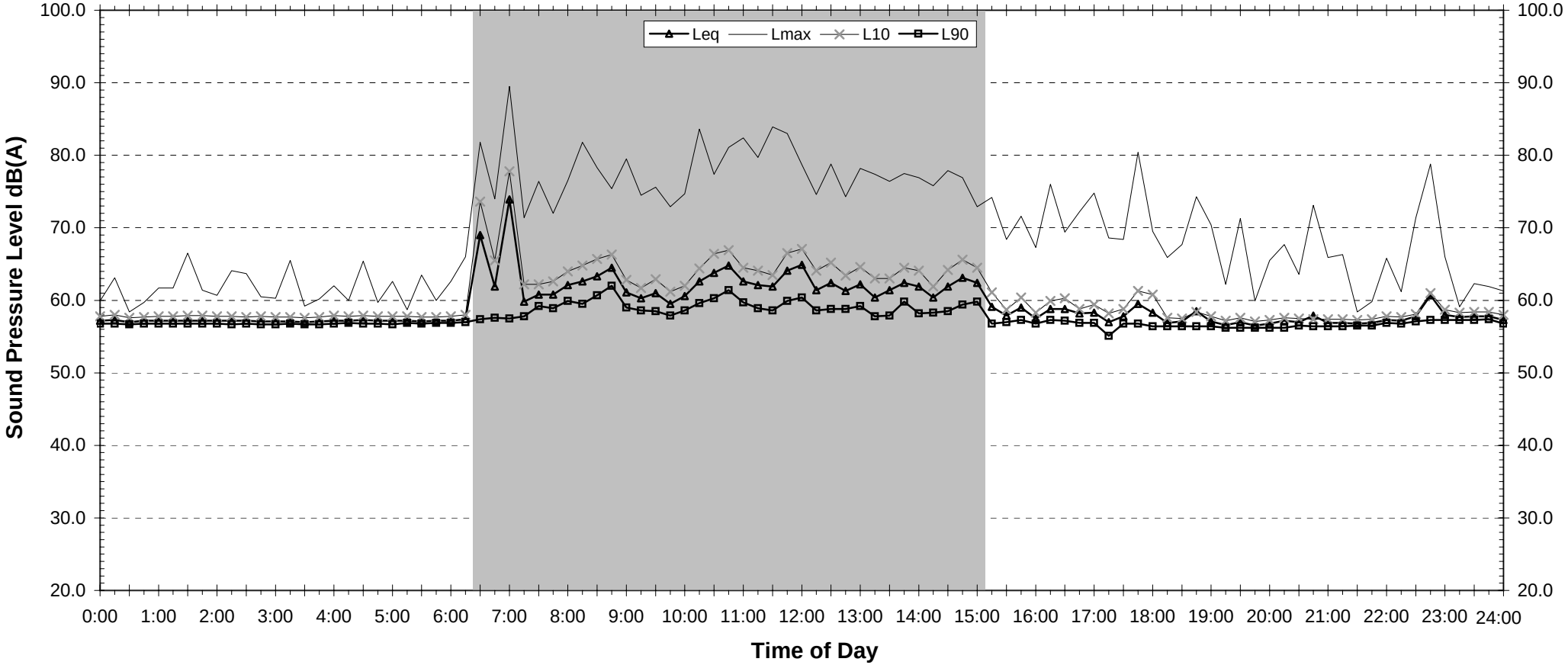
| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 60.5 | 59.8 |
| $L_{eq\ 1hr}$ upper 10 percentile | 61.2 | 60.6 |
| $L_{eq\ 1hr}$ lower 10 percentile | 59.8 | 59.6 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 74.4 | to | 74.4 |
| Lmax - Leq (Range) | 16.3 | to | 16.3 |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Thursday, 14 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 56.4 | 56.2 | 55.3 |
| Leq (see note 3) | 58.4 | 57.1 | 57.0 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

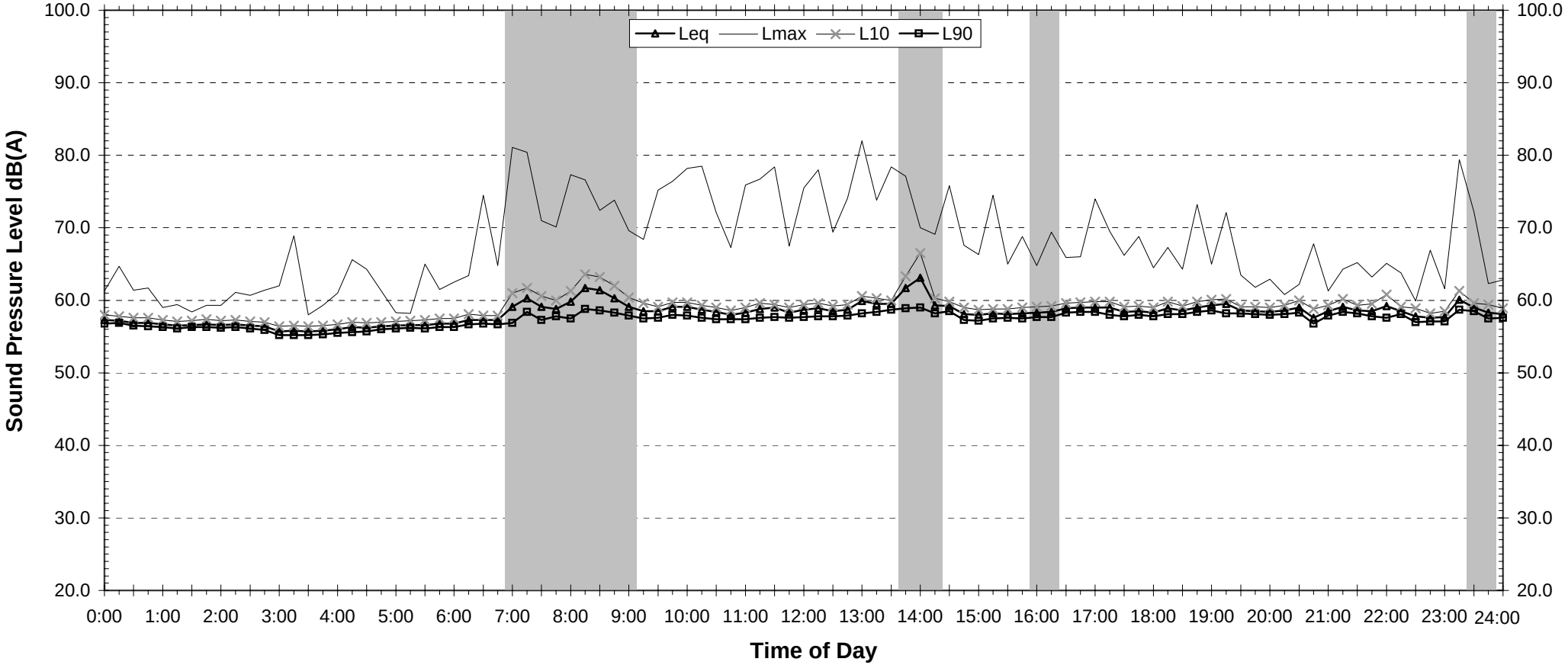
| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 60.2 | 59.5 |
| $L_{eq\ 1hr}$ upper 10 percentile | 61.0 | 61.2 |
| $L_{eq\ 1hr}$ lower 10 percentile | 59.2 | 58.3 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 74.5 | to | 78.8 |
| Lmax - Leq (Range) | 17.2 | to | 20.1 |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Friday, 15 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 57.4 | 57.6 | 55.9 |
| Leq (see note 3) | 58.7 | 58.8 | 57.7 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

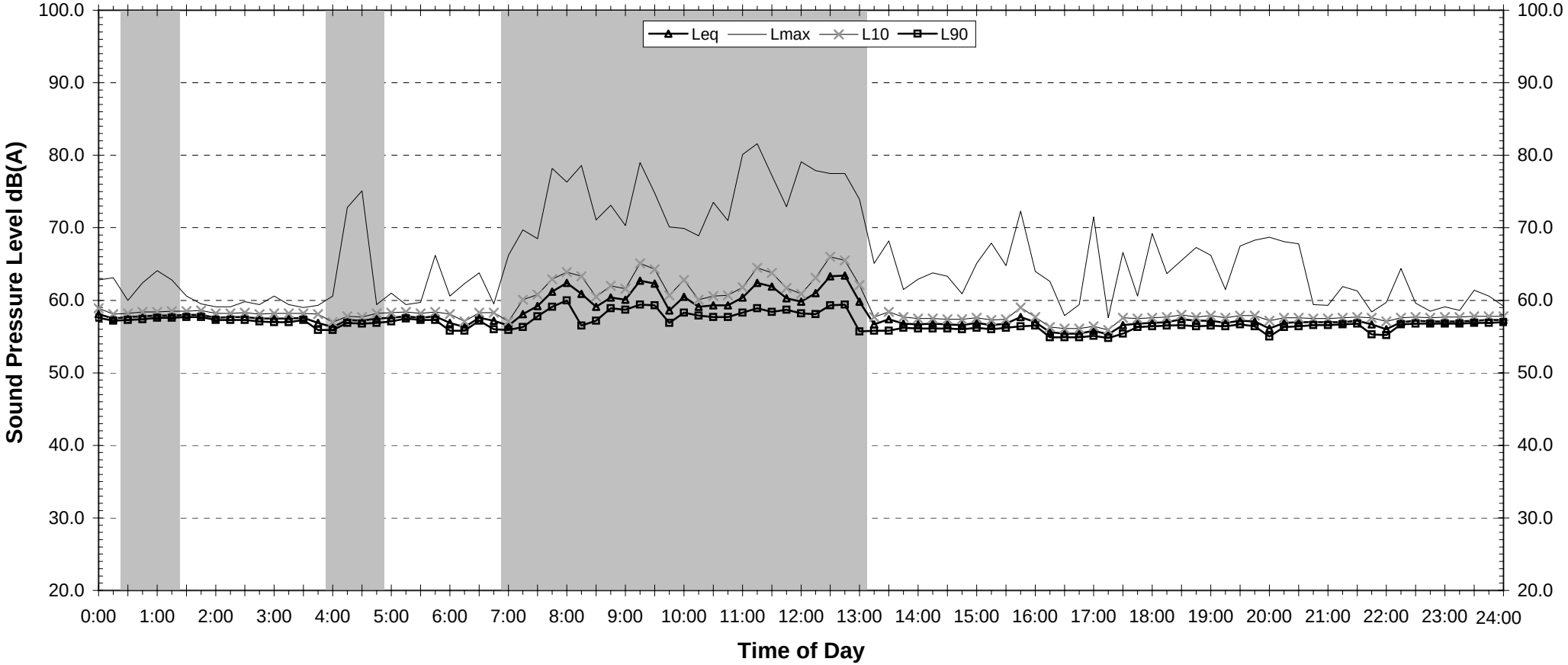
| NSW ECRTN Policy (1m from facade) (see note3) | | |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 61.2 | 60.2 |
| $L_{eq\ 1hr}$ upper 10 percentile | 61.9 | 61.7 |
| $L_{eq\ 1hr}$ lower 10 percentile | 60.7 | 59.6 |

| Night Time Maximum Noise Levels (see note 4) | | | |
|---|---|---|---|
| Lmax (Range) | 79.4 | to | 79.4 |
| Lmax - Leq (Range) | 20.2 | to | 20.2 |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Saturday, 16 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 54.9 | 55.2 | 56.3 |
| Leq (see note 3) | 56.6 | 56.9 | 57.4 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

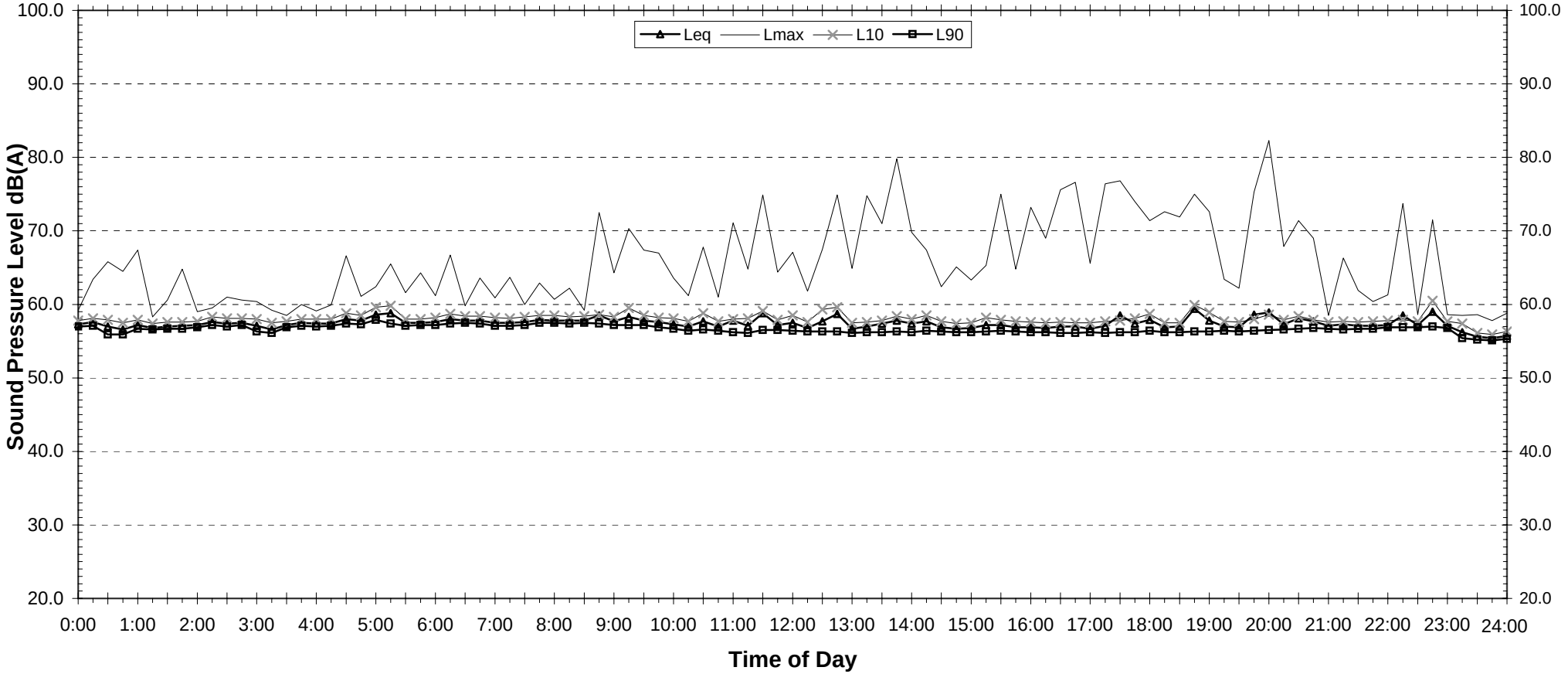
| NSW ECRTN Policy (1m from facade) (see note3) | | |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 59.2 | 59.9 |
| $L_{eq\ 1hr}$ upper 10 percentile | 59.7 | 60.5 |
| $L_{eq\ 1hr}$ lower 10 percentile | 58.1 | 59.5 |

| Night Time Maximum Noise Levels (see note 4) | | | |
|---|---|---|---|
| Lmax (Range) | - | to | - |
| Lmax - Leq (Range) | - | to | - |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Sunday, 17 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 56.1 | 56.2 | 55.4 |
| Leq (see note 3) | 57.5 | 57.7 | 57.4 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

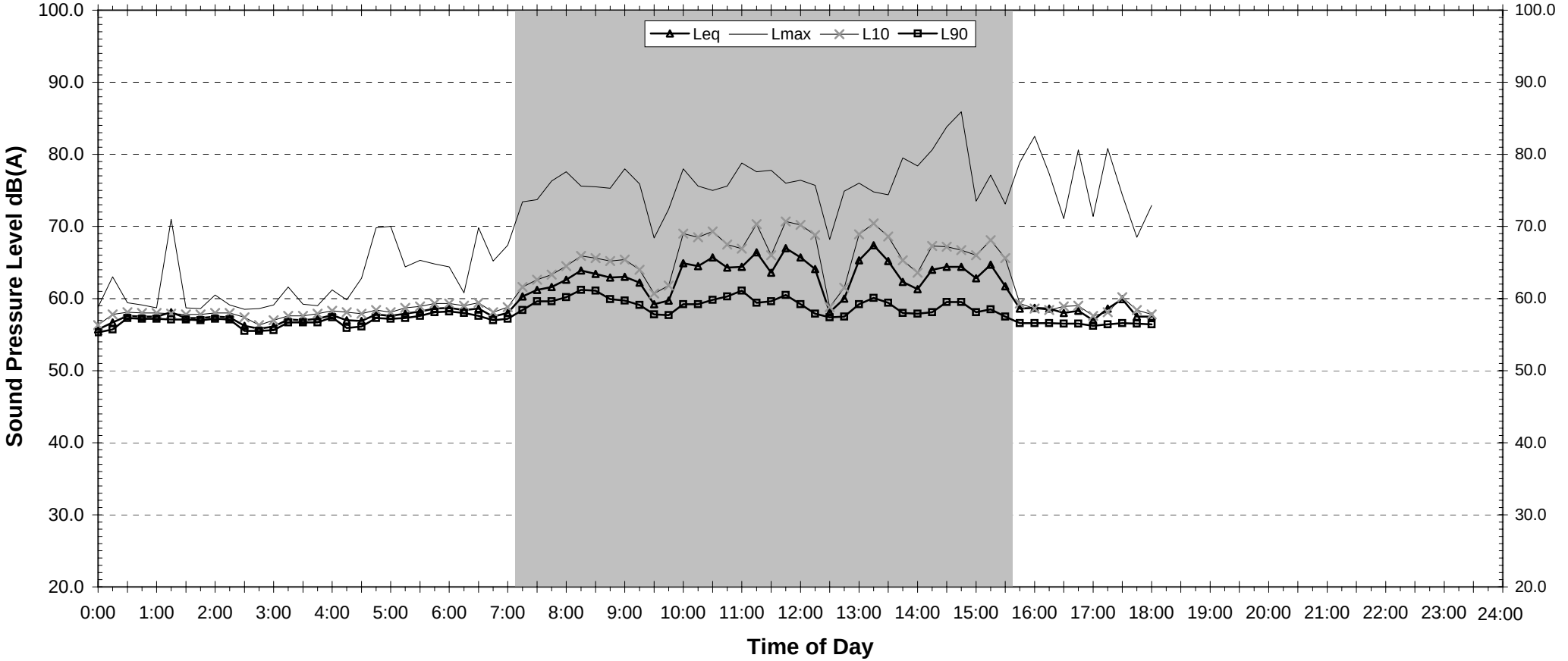
| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 60.0 | 59.9 |
| $L_{eq\ 1hr}$ upper 10 percentile | 60.5 | 60.9 |
| $L_{eq\ 1hr}$ lower 10 percentile | 59.5 | 58.2 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 73.7 | to | 73.7 |
| Lmax - Leq (Range) | 15.7 | to | 15.7 |

# EXISTING AMBIENT NOISE LEVELS

## Northern side of SOPA building

## Monday, 18 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 56.3 | - | - |
| Leq (see note 3) | 58.3 | - | - |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

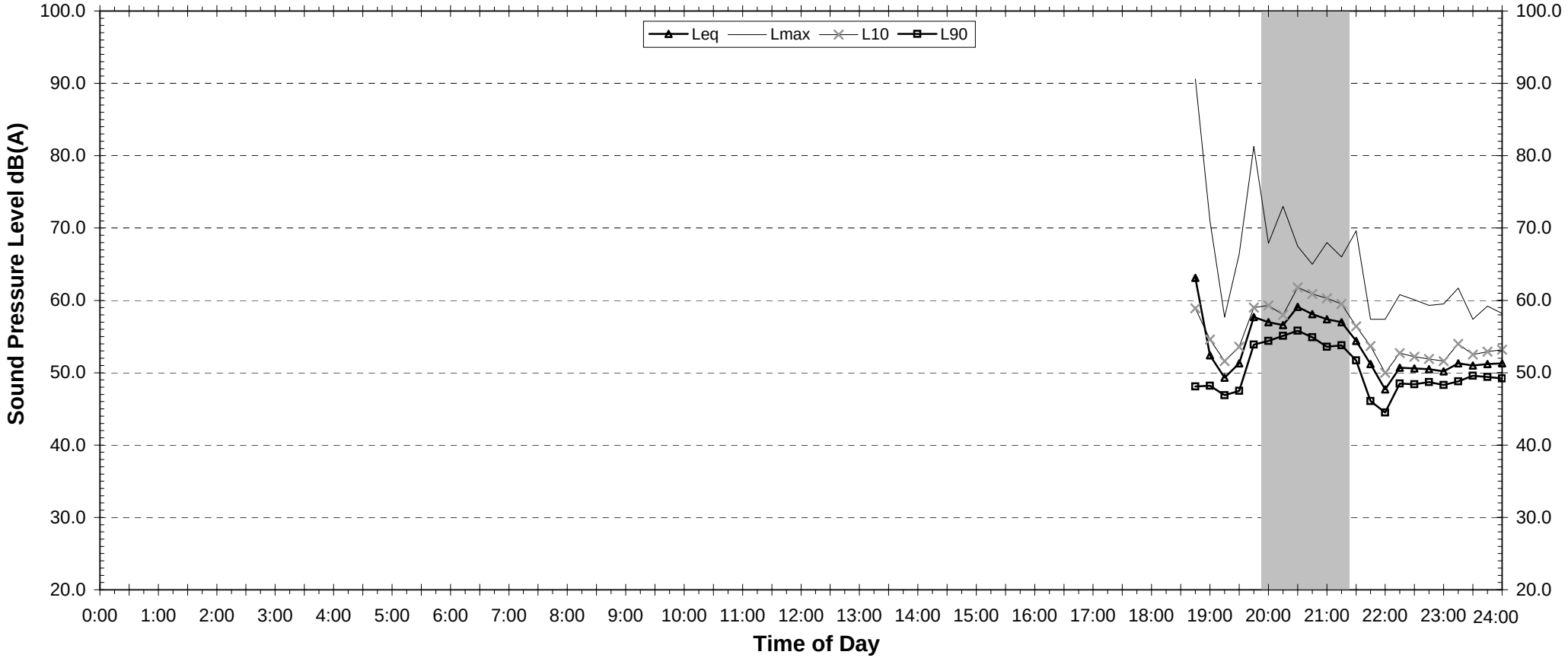
| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 60.8 | - |
| $L_{eq\ 1hr}$ upper 10 percentile | 61.2 | - |
| $L_{eq\ 1hr}$ lower 10 percentile | 60.5 | - |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | - | to | - |
| Lmax - Leq (Range) | - | to | - |

# EXISTING AMBIENT NOISE LEVELS

## Western Side of SOPA Building

## Monday, 11 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | - | - | 47.2 |
| Leq (see note 3) | - | - | 51.7 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

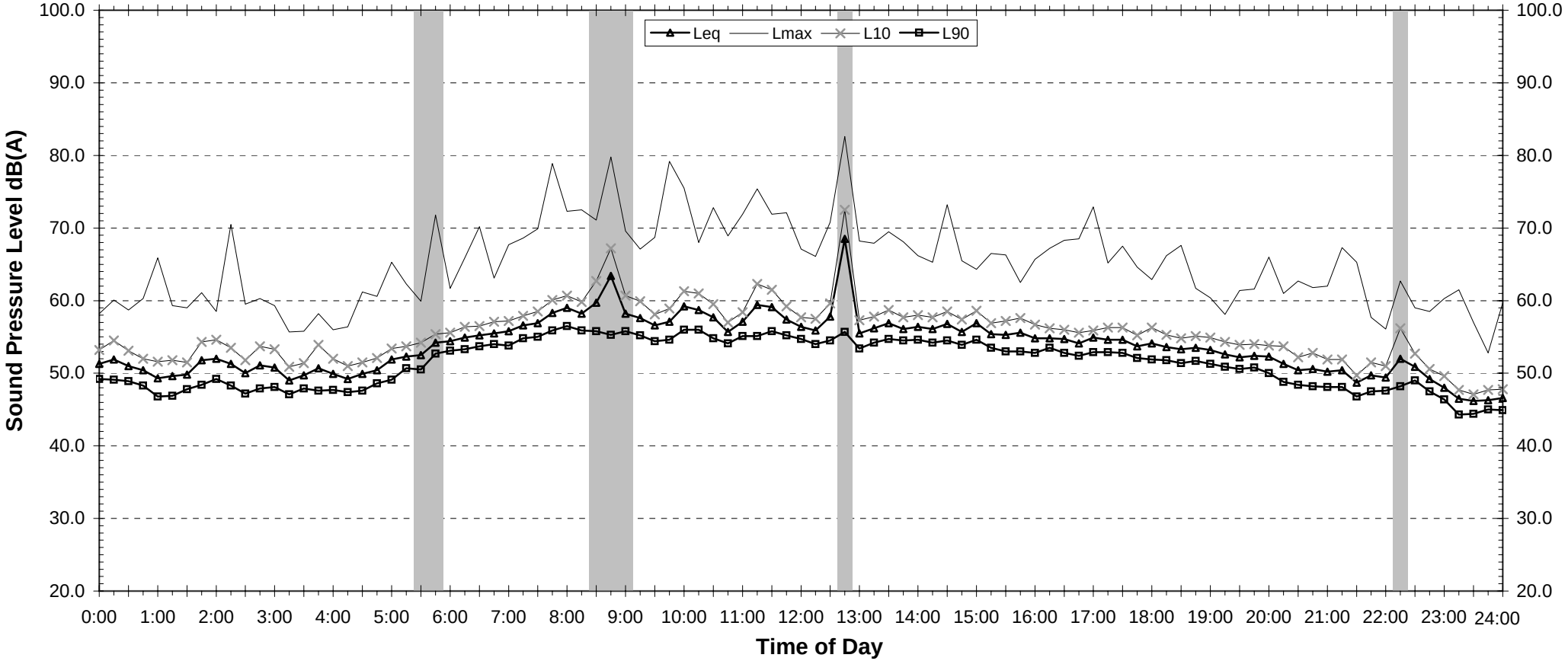
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 58.9 | 54.2 |
| $L_{eq\ 1hr}$ upper 10 percentile | 62.9 | 57.9 |
| $L_{eq\ 1hr}$ lower 10 percentile | 54.4 | 52.4 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 65.9 | to | 70.5 |
| Lmax - Leq (Range) | 15.1 | to | 19.7 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Tuesday, 12 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 52.8 | 47.5 | 42.7 |
| Leq (see note 3) | 56.7 | 51.8 | 46.8 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

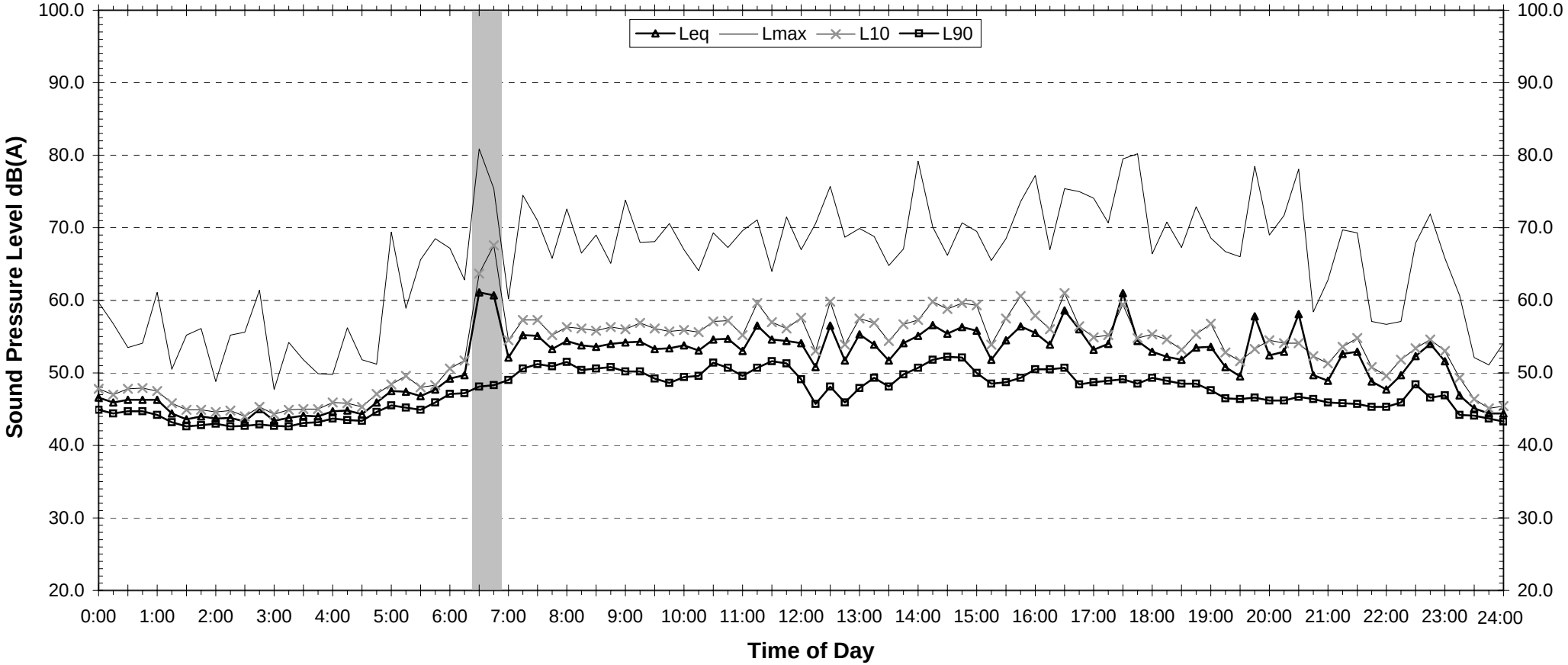
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 58.3 | 49.3 |
| $L_{eq\ 1hr}$ upper 10 percentile | 60.7 | 53.6 |
| $L_{eq\ 1hr}$ lower 10 percentile | 52.7 | 46.4 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 68.5 | to | 69.4 |
| Lmax - Leq (Range) | 15.1 | to | 23.6 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Wednesday, 13 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 48.1 | 45.3 | 42.4 |
| Leq (see note 3) | 54.9 | 53.1 | 47.7 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

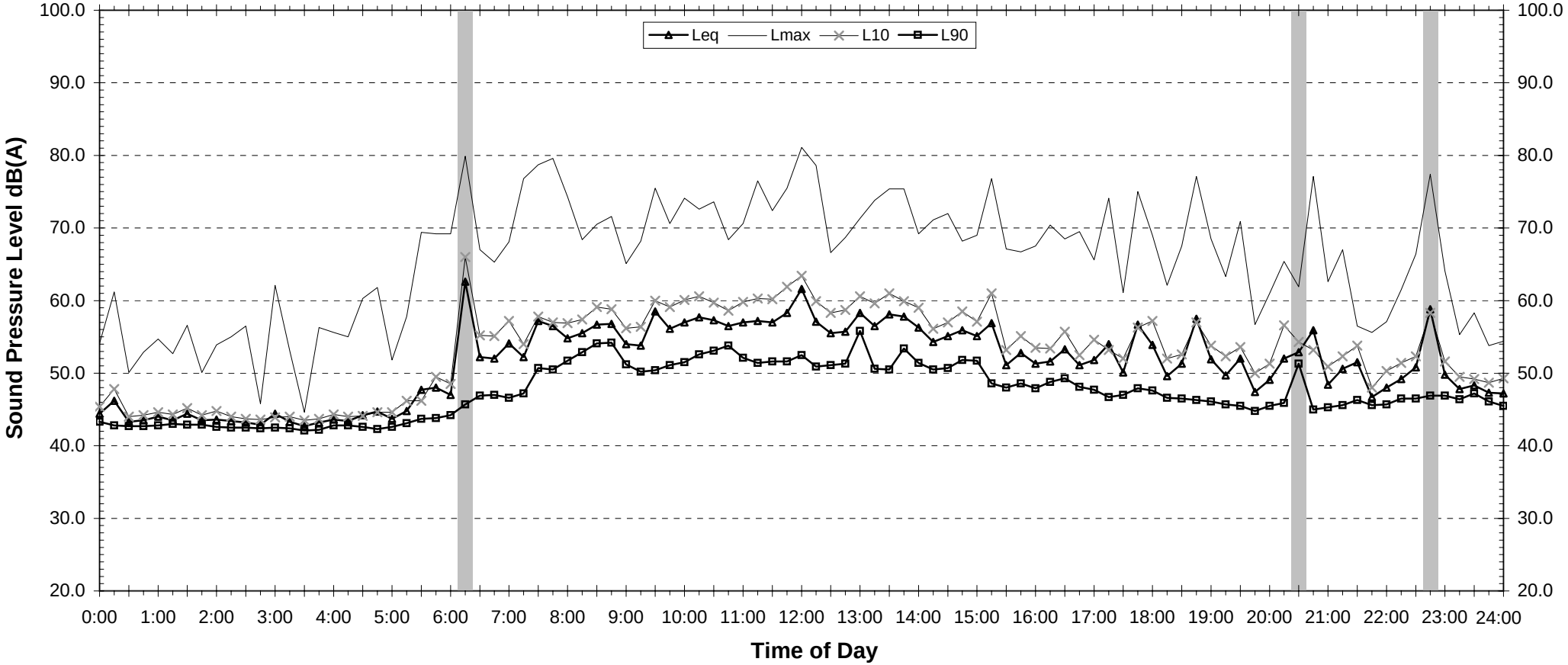
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 57.0 | 50.2 |
| $L_{eq\ 1hr}$ upper 10 percentile | 59.0 | 55.4 |
| $L_{eq\ 1hr}$ lower 10 percentile | 54.5 | 45.7 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 68.1 | to | 71.9 |
| Lmax - Leq (Range) | 15.2 | to | 22.4 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Thursday, 14 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 47.7 | 45.0 | 45.7 |
| Leq (see note 3) | 56.1 | 51.9 | 49.9 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

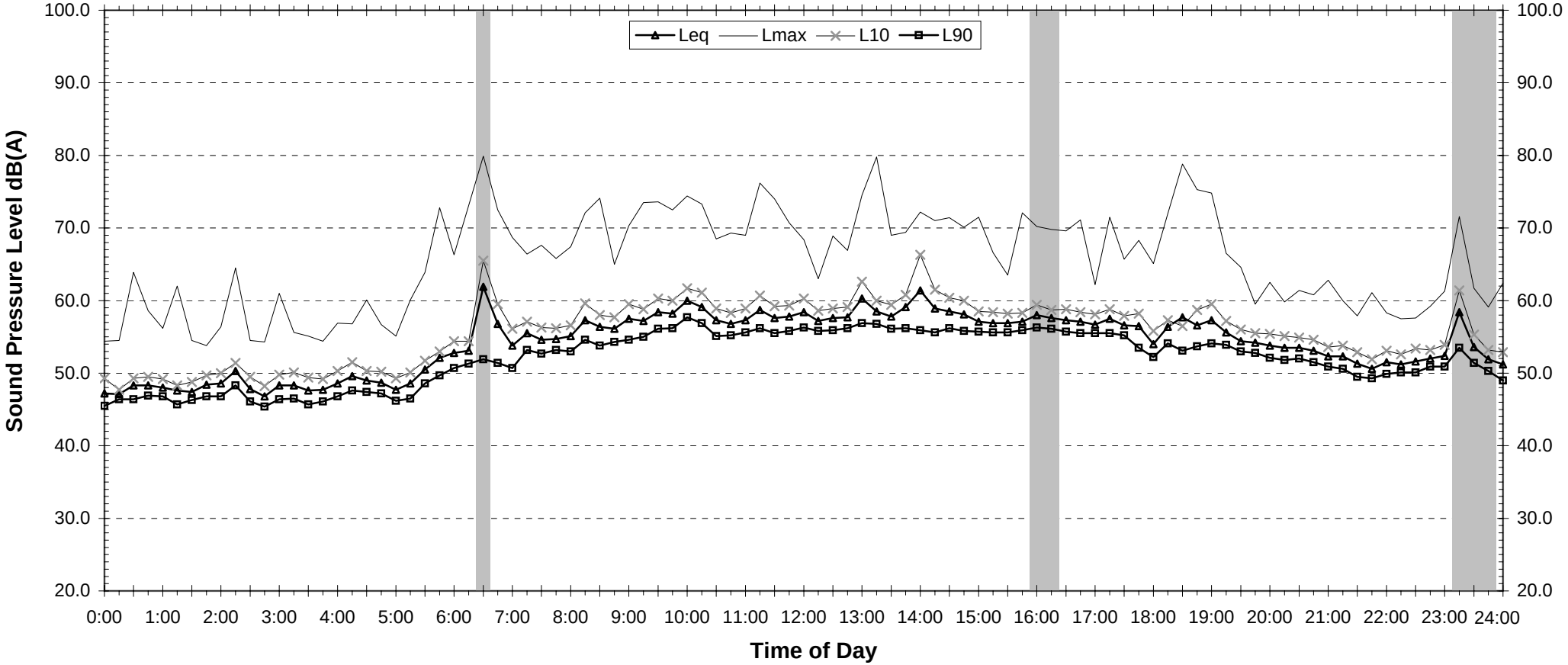
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 57.9 | 52.4 |
| $L_{eq\ 1hr}$ upper 10 percentile | 60.7 | 57.4 |
| $L_{eq\ 1hr}$ lower 10 percentile | 52.2 | 50.2 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 66.4 | to | 73.1 |
| Lmax - Leq (Range) | 15.9 | to | 21.5 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Friday, 15 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 53.2 | 49.5 | - |
| Leq (see note 3) | 57.7 | 54.5 | - |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

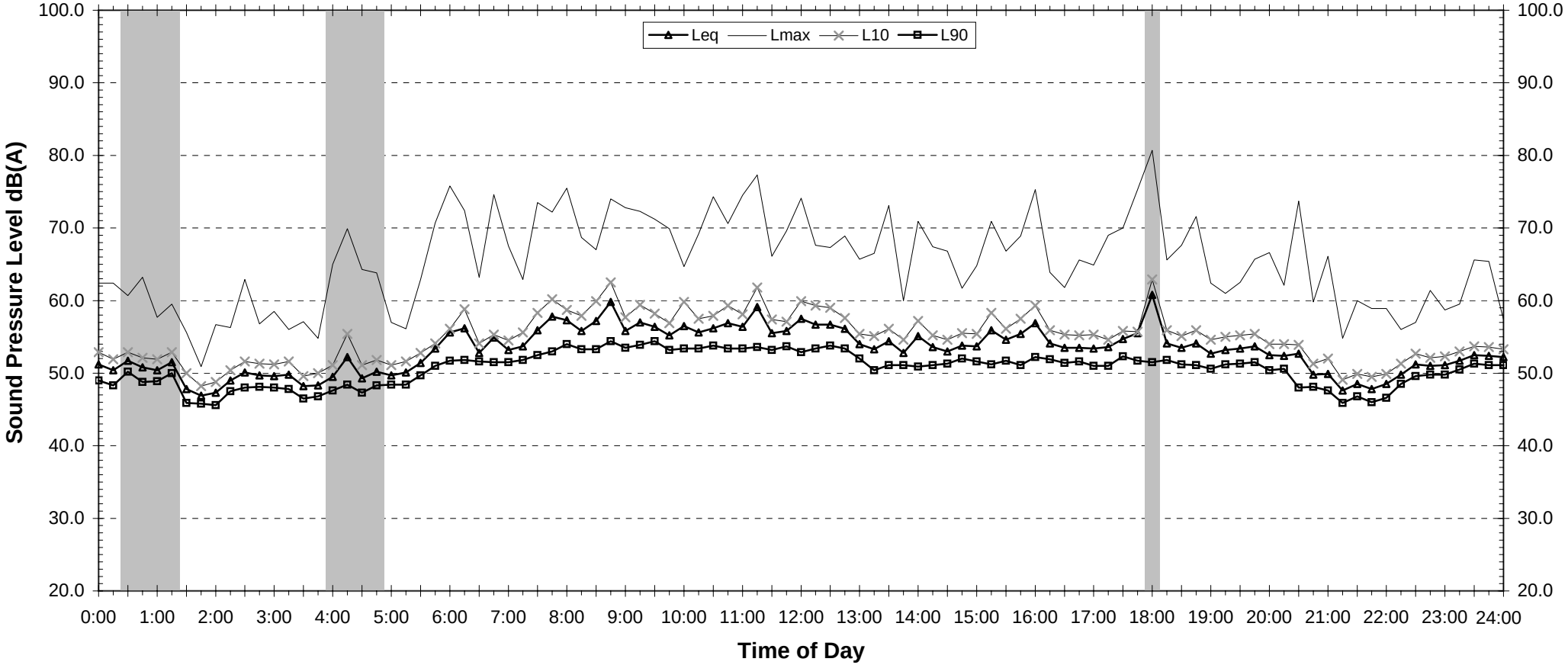
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) (see note3) | | |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 59.5 | 54.1 |
| $L_{eq\ 1hr}$ upper 10 percentile | 61.5 | 57.0 |
| $L_{eq\ 1hr}$ lower 10 percentile | 54.9 | 49.8 |

| Night Time Maximum Noise Levels (see note 4) | | | |
|---|---|---|---|
| Lmax (Range) | 74.6 | to | 75.8 |
| Lmax - Leq (Range) | 20.1 | to | 22.7 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Saturday, 16 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 51.1 | 46.0 | 47.6 |
| Leq (see note 3) | 55.8 | 52.1 | 52.0 |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

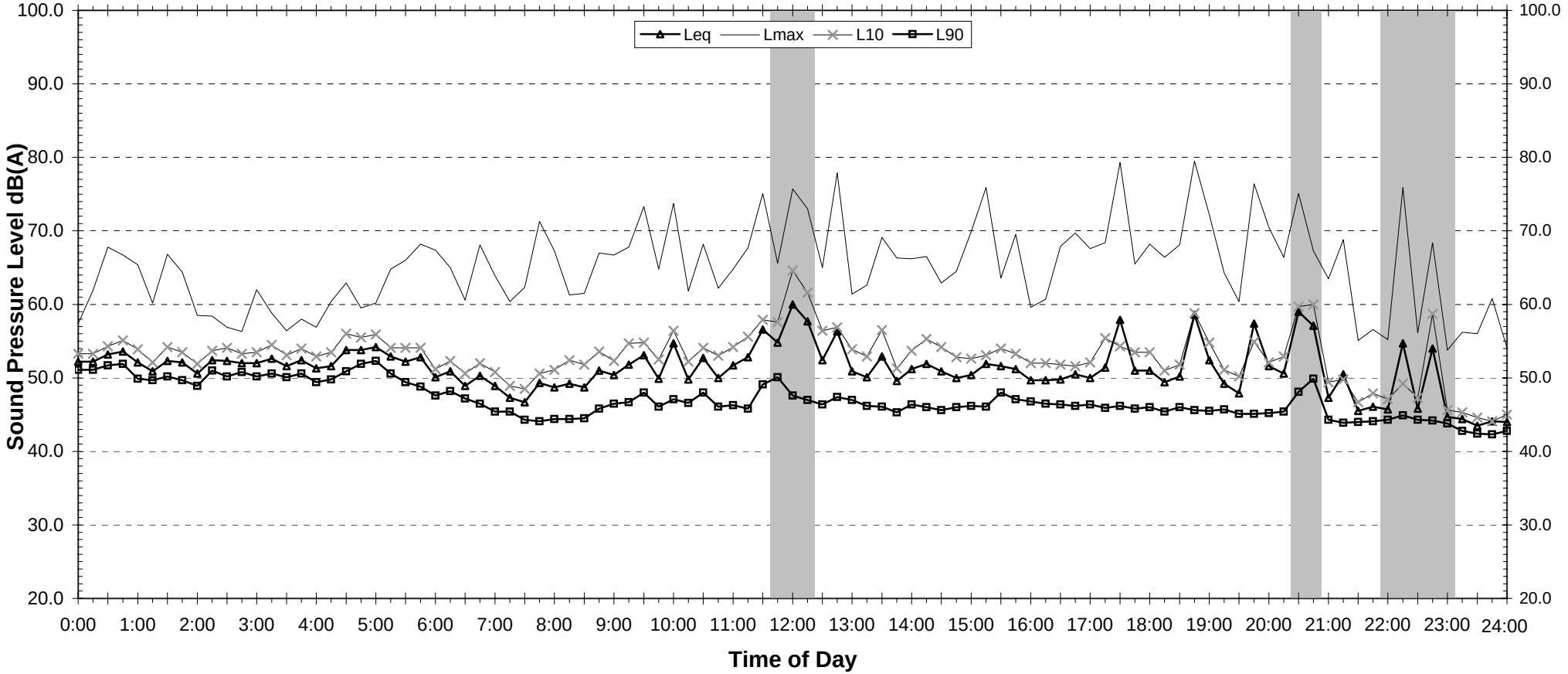
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 57.6 | 54.5 |
| $L_{eq\ 1hr}$ upper 10 percentile | 59.9 | 56.0 |
| $L_{eq\ 1hr}$ lower 10 percentile | 52.6 | 52.3 |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | 66.8 | to | 68.2 |
| Lmax - Leq (Range) | 15.3 | to | 18.3 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Sunday, 17 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 44.5 | - | - |
| Leq (see note 3) | 51.8 | - | - |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

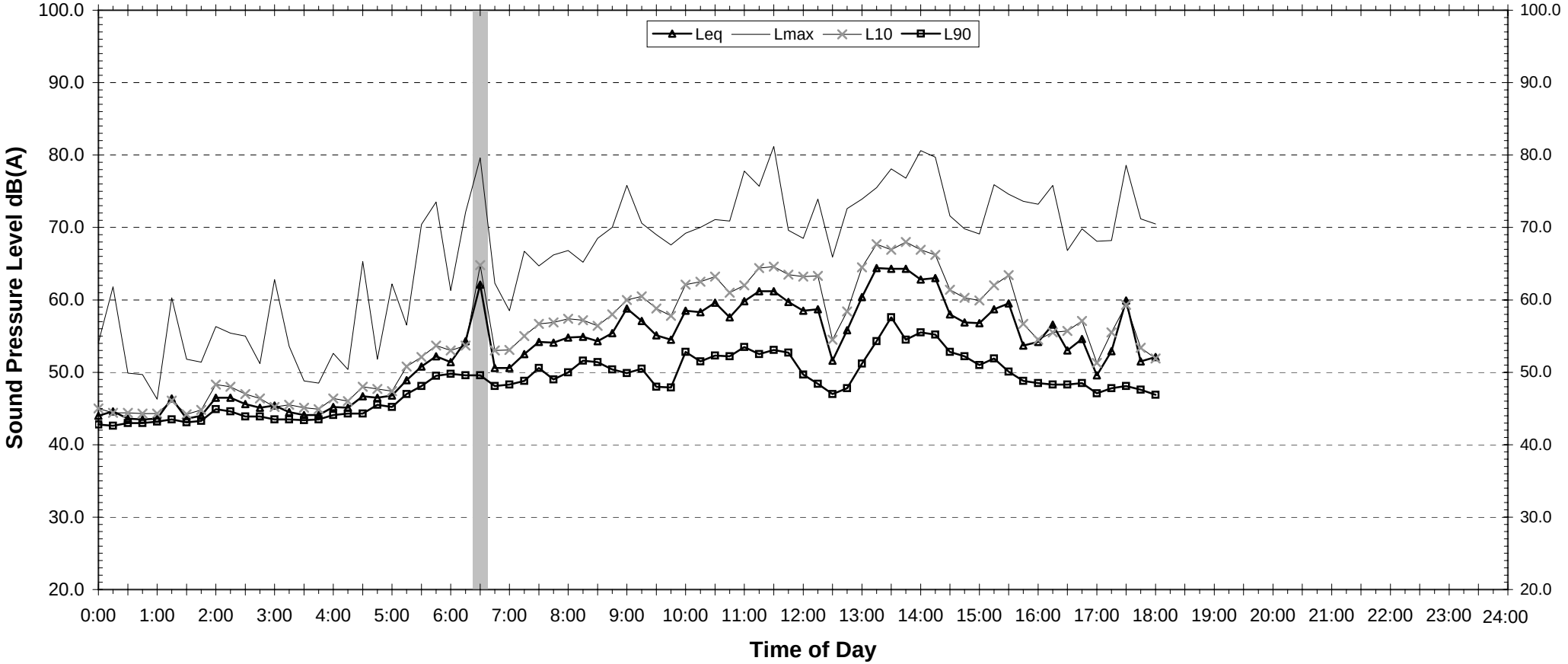
*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) (see note3) | | |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 54.5 | 50.1 |
| $L_{eq\ 1hr}$ upper 10 percentile | 57.2 | 54.7 |
| $L_{eq\ 1hr}$ lower 10 percentile | 50.6 | 46.3 |

| Night Time Maximum Noise Levels (see note 4) | | | |
|---|---|---|---|
| Lmax (Range) | 65.3 | to | 73.5 |
| Lmax - Leq (Range) | 16.8 | to | 22.5 |

# EXISTING AMBIENT NOISE LEVELS
## Western Side of SOPA Building
## Monday, 18 December 2006




| NSW Industrial Noise Policy (Free Field) | | | |
|---|---|---|---|
| Descriptor | Day 7am-6pm | Evening 6pm-10pm | Night[2] 10pm-7am |
| $L_{90}$ | 47.8 | - | - |
| Leq (see note 3) | 58.7 | - | - |

**NOTES:**

*1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.*

*2. "Night" relates to period from 10pm on this graph to 7am on the following graph.*

*INSTRUCTIONS NOT FOLLOWED*

*4. Night time Lmax values are shown only where Lmax > 65dB(A) and where Lmax-Leq ≥ 15dB(A)*

| NSW ECRTN Policy (1m from facade) | | (see note3) |
|---|---|---|
| Descriptor | Day 7am-10pm | Night[2] 10pm-7am |
| $L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$ | 61.2 | - |
| $L_{eq\ 1hr}$ upper 10 percentile | 66.2 | - |
| $L_{eq\ 1hr}$ lower 10 percentile | 56.5 | - |

| Night Time Maximum Noise Levels | | | (see note 4) |
|---|---|---|---|
| Lmax (Range) | - | to | - |
| Lmax - Leq (Range) | - | to | - |