

HILLS SHOWGROUND STATION PRECINCT - CONCEPT PROPOSAL

Noise and Vibration Assessment for Environmental Impact Statement

31 October 2019

Landcom

TL092-01F03 Acoustic Report for EIS (r5)

Document details

Detail	Reference
Doc reference:	TL092-01F03 Acoustic Report for EIS (r5)
Prepared for:	Landcom
Address:	Level 14, 60 Station Street Parramatta NSW 2150
Attention:	Katrina Lim

Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
01/10/2019	Draft WIP issue for comment	0	1	B. Panarodvong & H. Pearce		
14/10/2019	Revised issue	2	3	B. Panarodvong, H. Pearce & D. Suwandi		
25/10/2019	Revised issue	-	4	B. Panarodvong, H. Pearce & D. Suwandi		
31/10/2019	Minor amendments	-	5	B. Panarodvong, H. Pearce & D. Suwandi		

Important Disclaimer:

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

This document is issued subject to review and authorisation by the Team Leader noted by the initials printed in the last column above. If no initials appear, this document shall be considered as preliminary or draft only and no reliance shall be placed upon it other than for information to be verified later.

This document is prepared for the particular requirements of our Client referred to above in the 'Document details' which are based on a specific brief with limitations as agreed to with the Client. It is not intended for and should not be relied upon by a third party and no responsibility is undertaken to any third party without prior consent provided by Renzo Tonin & Associates. The information herein should not be reproduced, presented or reviewed except in full. Prior to passing on to a third party, the Client is to fully inform the third party of the specific brief and limitations associated with the commission.

In preparing this report, we have relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, we have not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

We have derived data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination and re-evaluation of the data, findings, observations and conclusions expressed in this report.

We have prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

The information contained herein is for the purpose of acoustics only. No claims are made and no liability is accepted in respect of design and construction issues falling outside of the specialist field of acoustics engineering including and not limited to structural integrity, fire rating, architectural buildability and fit-for-purpose, waterproofing and the like. Supplementary professional advice should be sought in respect of these issues.

Contents

Executive Summary	1
1 Introduction	3
2 Site description	4
2.1 Site location	6
2.2 Overview of proposed development	6
2.3 Development Interaction with Castle Hills Showground	7
3 Secretary's Environmental Assessment Requirements	9
4 Ambient and background noise surveys	11
4.1 Monitoring Locations	11
4.2 Long Term Unattended Monitoring	12
4.2.1 Monitoring Period	12
4.2.2 Equipment Used	12
4.2.3 Long-term unattended noise monitoring results	13
4.3 Short-term Attended Measurements	13
4.3.1 Period of monitoring	13
4.3.2 Measurement locations	13
4.3.3 Equipment used	13
4.3.4 Short-term noise measurement results	14
5 External noise intrusion assessment	15
5.1 Noise intrusion criteria	15
5.1.1 NSW Road Noise Policy (RNP)	15
5.1.2 State Environmental Planning Policy (Infrastructure) 2007 (ISEPP)	15
5.1.3 Department of Planning publication 'Development near rail corridors and busy roads – Interim guideline'	17
5.1.4 Clarification of ISEPP noise limits	17
5.1.5 Australian/New Zealand Standard AS/NZS 2107:2016	18
5.2 Assessment of road traffic noise intrusion	22
5.3 Facade noise levels	22
5.3.1 Road traffic noise	22
5.3.2 Noise from carpark and station facilities	24
5.4 Recommended treatments	24
6 Rail vibration assessment	26
6.1 Ground-borne noise	26
6.2 Rail tactile vibration	26
6.3 Site rail measurements	28
6.3.1 Timing of measurements	28
6.3.2 Monitoring Locations	28

6.3.3	Equipment used	29
6.3.4	Results	29
7	Construction noise and vibration assessment	30
8	Operational noise assessment	31
8.1	Noise emission assessment guidelines	31
8.1.1	Road Noise Policy assessment criteria - residential land uses	31
8.1.2	Noise from the operation of the Castle Hill Showground and active street-fronts to receivers within the Site	32
8.1.2.1	Normal use	33
8.1.2.2	Special uses	34
8.1.3	Noise from the use of licensed premises to existing residential receivers	35
8.1.4	NSW Noise Policy for Industry	37
8.1.4.1	Project intrusive noise levels	37
8.1.4.2	Amenity noise levels	37
8.1.4.3	Project noise trigger levels	39
8.1.4.4	Sleep disturbance noise levels	40
8.2	Assessment of operational noise intrusion	40
8.2.1	In principle treatment of mechanical plant and equipment	40
8.2.2	Loading dock	41
9	Internal sound insulation	42
9.1	NCC BCA 2019 - Class 2 or 3	42
10	Conclusion	44
APPENDIX A	Glossary of terminology	47
APPENDIX B	Locations and results of noise and vibration surveys	49
APPENDIX C	Risk Management	50
C.1	Risk Management	50

List of tables

Table 1:	Noise monitoring locations	11
Table 2 -	Long-term unattended noise monitoring results	13
Table 3:	Summary of short-term noise measurements	14
Table 4:	ISEPP noise criteria for new residential development	18
Table 5:	Design sound levels and reverberation times for different areas of occupancy in buildings	19
Table 6 -	Peak hourly traffic volumes - 2019 (current), 2031 (future) and 2031 developed	22
Table 7 -	Predicted increase in traffic noise from 2019 to "2031 with development"	22
Table 8 -	Predicted traffic noise at future facades (2031 with development volumes)	23
Table 9 -	Predicted traffic noise at future facades	23
Table 10 -	Predicted operational noise at future facades	24

Table 11: Recommended internal noise criteria for regenerated rail noise	26
Table 12: Acceptable VDV _s for intermittent vibration in residential buildings $\text{m/s}^{1.75}$	28
Table 13: Noise monitoring locations	29
Table 14: Road traffic noise assessment criteria for residential land uses	31
Table 15: L&GNSW noise goals - $L_{10(15\text{min})}$ dB(Z)	36
Table 16 - Cumulative Site patron and music noise levels dB(A) $L_{\text{eq}(15\text{min})}$	36
Table 17: Intrusiveness noise levels	37
Table 18: Project amenity noise levels	38
Table 19: Project amenity noise levels	39
Table 20: Project noise trigger levels	39
Table 21: Sleep disturbance assessment levels	40

List of figures

Figure 1: Aerial photograph (dated 16 August 2019) showing the site and surrounds	5
Figure 2: Castle Hill Showground Masterplan Zoning. Castle Hill Showground is currently being masterplanned by The Hills Shire Council. This diagram is indicative only and subject to change (Source: https://www.thehills.nsw.gov.au/Contact-Us/Have-Your-Say/Castle-Hill-Showground-Master-Plan)	8
Figure 3: Locations of unattended long-term noise monitors and short-term noise measurements	11
Figure 4 - Figure A1 from AS2107:2016 - Mean Reverberation Times	21
Figure 5: Tactile vibration criteria for residential buildings	27
Figure 6: Locations of attended short-term vibration measurements	28

Executive Summary

Renzo Tonin & Associates was engaged to undertake an Acoustic Impact Assessment of the proposed Hills Showground Station Precinct Concept Plan (SSD9653) to:

- investigate the existing acoustic environment
- to assess the acoustic impacts from the use of the site on the surrounding receivers
- to assess the acoustic impacts from the surrounding sources (predominantly road traffic and Metro Rail) on the future residents and users of the subject site.

This report presents the outcomes from Renzo Tonin & Associates site investigations to address Key Issues 9 – *Amenity* (part only) and 10 – *Noise and Vibration* of the amended Planning Secretary's Environmental Assessment Requirements (SEARs), dated the 9th of October 2019.

Renzo Tonin & Associates have undertaken attended and unattended noise and vibration measurements at the Hills Showground Station Precinct. Existing environmental noise impacts from road traffic noise on Showground Road and Carrington Road are capable of complying with the requirements of the SEPP (Infrastructure) 2007 and ISEPP Guideline 2008 subject to detailed design.

Noise emission goals from the use of mechanical plant and equipment and vehicles being driven on site have been set in accordance with the NSW EPA Noise Policy for Industry. Compliance with those goals to existing residential receivers is achievable (subject to careful siting and design).

The recommendations are summarised in the following table:

Guidelines/Policies/ Standards	Report section	Recommendations / Findings
RNP ISEPP DPIE Development in Rail Corridors and Busy Roads - Interim Guideline (road noise) AS/NZS 2107:2016	5	Indicative glazing for facades fronting the roads, subject to detailed design
DPIE Development in Rail Corridors and Busy Roads - Interim Guideline (rail noise) DEC Assessing Vibration: A technical guideline (rail vibration)	6	Vibration impacts from the Metro rail movements were measured and found to be compliant with the DPIE and DEC Guidelines, without additional treatments (based on the proposed range of uses).
The Sydney Metro Underground Corridor Protection - Technical Guidelines	7	Preparation of a CNVMP during the construction certificate phase
NPfl	8	Project noise trigger levels have been set in accordance with the NPfl. Detailed assessments will be required for DA and CC submissions, subject to detailed design.

Guidelines/Policies/ Standards	Report section	Recommendations / Findings
Liquor and Gaming NSW (patron and music noise from licensed premises to receivers external to the precinct)	8	<p>Noise emission goals from the use of a licensed premise to residential receivers outside of the Hills Showground Station Precinct have been set. Controls for compliance shall be subject to detailed design for DA and CC.</p> <p>In addition, goals have been set for the assessment of noise from cumulative operation of the Site licensed premises to existing residential receivers using an approach previously applied at the Barangaroo South Masterplan Noise Assessment.</p>
Noise from active street-fronts – there are no state level guidelines specifically addressing impacts of active street-fronts or community uses on a residential Precinct	8	<p>Cumulative goals for patron and music noise at Site residential façades have been set for “normal use” of active street-fronts and “normal use” of Castle Hill Showground, as informed by the Barangaroo South Master Plan Noise Assessment. The corresponding cumulative external patron and music noise goals (assuming windows closed and residences provided with alternative ventilation) will be determined by the performance of the facade, subject to detailed design.</p> <p>For the management of noise from “special uses” of the Castle Hill Showground, noise management protocols have been set as informed by the Sydney Cricket Ground and Allianz Stadium Noise Management Plan. The corresponding external goals (assuming windows closed and residences provided with alternative ventilation) will be determined by the performance of the façade, subject to detailed design.</p> <ul style="list-style-type: none"> Note: The Castle Hill Showground Masterplan is currently being prepared and should be available for acoustic review for DA/CC.
National Construction Code / Building Code of Australia Part F5	9	<p>The design of compliant systems for the acoustic separation of sole occupancy units and separation of different classifications is to be addressed in detailed design. The version of the code applicable to the Site will depend on the “Stop the clock” date for that Site. The current NCC/BCA 2019 acoustic separation requirements are included for information.</p>

1 Introduction

Renzo Tonin & Associates was engaged to undertake an Acoustic Impact Assessment of the proposed Hills Showground Station Precinct Concept Plan (SSD9653) to:

- investigate the existing acoustic environment
- to assess the acoustic impacts from the use of the site on the surrounding receivers
- to assess the acoustic impacts from the surrounding sources (predominantly road traffic and Metro Rail) on the future residents and users of the subject site.

This report presents the outcomes from Renzo Tonin & Associates site investigations to address Key Issues 9 – *Amenity* (part only) and 10 – *Noise and Vibration* of the amended Planning Secretary's Environmental Assessment Requirements (SEARs), dated the 9th of October 2019.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. APPENDIX A contains a glossary of acoustic terms used in this report.

2 Site description

An aerial photograph showing the site and surrounds is presented in Figure 1 overleaf.

Figure 1: Aerial photograph (dated 16 August 2019) showing the site and surrounds



2.1 Site location

The proposed development is located within the Showground Station Precinct at 1-5 Carrington Road, Castle Hill.

The eastern part of the Site (Hills Showground Precinct East – Lot 56 DP 1253217) currently contains the former Council administration building and associated parking and landscaping. It was being used as a Sydney Metro's construction site office but is proposed to be demolished by way of a separate DA (304/2020/LA) currently under consideration by Council.

The western part of the Site contains the recently opened Hills Showground Metro Station, plaza and commuter car park. The remainder was cleared to create the two development lots (Lots 53 and Lot 55 DP 1253217) and associated internal roads.

Former development on the western part of the Site consisted of The Hills Entertainment Centre which included an Auditorium and Council's works depot that were demolished to make way for the metro.

The Site is bordered by the following:

- North and northwest – De Clambe Drive with a drainage basin and Castle Hill Showground further north
- West – De Clambe Drive and Cattai Creek riparian zone with commercial/industrial warehouses further west
- South to southeast – Carrington Road across which are low density residential developments, a child care centre and medical/physiotherapy rooms
- East – Showground Road across which are low density residential development. The Hills Showground Metro station is located immediately southeast of the site, adjacent to the proposed Doran Drive Precinct, with the underground rail tunnel running directly under the southwest portion of the proposed Hills Showground Precinct East.

Showground Road is situated northeast of the site and is identified as a road with traffic volume greater than 40,000 Annual Average Daily Traffic ('AADT') by the Roads and Maritime Services ('RMS') Traffic Volume Maps. Accordingly, consideration has to be given to the State Environmental Planning Policy (Infrastructure) 2007 ('ISEPP'). The ISEPP sets out internal noise criteria for residential development adjacent roads having AADT greater than 40,000.

2.2 Overview of proposed development

This report has been prepared for Landcom on behalf of Sydney Metro to support a Concept State Significant Development Application (SSDA) under Section 4.22 of the *Environmental Planning and Assessment Act 1979 (EP&A Act)*.

The concept for which approval is sought is for a high-density mixed-use precinct with a new public park and plaza, and associated facilities on land located within the Hills Showground Station Precinct on development lots (Lot 53, Lot 55 and 56 in DP 1253217).

The Concept Proposal comprises residential, retail and commercial uses and building envelopes of varying heights from four to up to twenty storeys. The proposal also includes provision of car parking and bicycle racks, roads, landscaping, and the concept principal subdivision of development lot 56 DP 1253217.

An indicative yield of up to 1,900 dwellings is anticipated to be provided.

2.3 Development Interaction with Castle Hills Showground

The development is also intended to support the redevelopment of the adjacent Castle Hill Showground site however the master planning of the Showground site planning is in its early stage [ref: <https://www.thehills.nsw.gov.au/Contact-Us/Have-Your-Say/Castle-Hill-Showground-Master-Plan>]. The concept Masterplan Zoning (downloaded from Council's website on 11 October 2019) is shown in Figure 2 overleaf. The Hills Shire Council advised via email dated the 11th of October 2019:

At this stage there hasn't been any firm determination of what noise levels might be generated from the Showground in the future, but it is anticipated to be much greater than currently experienced there.

Based on the community consultation that has taken place to date, and is continuing, the site will become significantly activated and is likely to contain quite a bit of consistent night activity in the form of having food outlets/ restaurants in and around the Showground drawing people after work and on weekends, and a regional playground (though that will primarily draw day time usage only) will attract large numbers. Additionally, major events like concerts and sport will attract bigger numbers more regularly to the Showground, also generating new levels of noise.

More should be revealed once the initial draft Master Plans begin rolling out later this year/ early next year.

The kind of uses set out in the Castle Hill Showground Masterplan Zoning (refer Figure 2) can co-exist with new or existing residential development and good examples of these can be seen in Sydney Olympic Park and the Moore Park area in Sydney or The Gabba in Queensland, where high-rise residential apartment or hotel buildings overlook a sports stadium.

Figure 2: Castle Hill Showground Masterplan Zoning. Castle Hill Showground is currently being masterplanned by The Hills Shire Council. This diagram is indicative only and subject to change (Source: <https://www.thehills.nsw.gov.au/Contact-Us/Have-Your-Say/Castle-Hill-Showground-Master-Plan>)



3 Secretary's Environmental Assessment Requirements

The NSW Department of Planning, Industry & Environment ('DPIE') issued Secretary's Environmental Assessment Requirements ('SEARs') for the site (SSD9653), dated the 9th of October 2019.

Item 1 of the SEARs nominates the relevant environmental planning instruments, policies and guidelines applying to the site. Of those listed, the following documents are relevant to the assessment of noise and vibration:

- State Environmental Planning Policy (Infrastructure) 2007;
- State Environmental Planning Policy No. 65 – Design Quality of Residential Apartment Development and the Apartment Design Guide;
- The Hills Local Environmental Plan 2012;
- The Hills Development Control Plan; and
- Department of Planning publication "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008.

Items 9. *Amenity* (part only) and 10. *Noise and Vibration* include the following specific requirements regarding the assessment of noise and vibration for the project:

9. *Amenity* (part only)

The EIS shall:

- *Demonstrate consistency with the requirements of SEPP 65 and the Apartment Design Guide*
- *Address the following in relation to the surrounding area including neighbouring properties/buildings and the public domain. This includes neighbouring buildings within the proposal and future stages adjacent:*
 - o *Acoustic impacts*
 - o *Noise and vibration impacts*
- *consider impacts from servicing requirements including waste management, mechanical plant and vehicle accesses*

10. Noise and Vibration

The EIS shall include a noise impact assessment identifying:

- *Measures to minimise and mitigate potential noise and vibration impacts of the proposal on surrounding developments*
- *The impacts of likely noise and vibration from surrounding land uses, such as noise from the operation of the rail line, road networks, and events associated with the Castle Hill Showground and mitigation measures to protect amenity.*

4 Ambient and background noise surveys

A combination of short-term attended and long-term unattended noise measurements were undertaken surrounding the project site to capture the existing ambient and background noise environment.

4.1 Monitoring Locations

The short-term attended and long-term unattended monitoring was undertaken at the locations shown in Figure 3 below.

Figure 3: Locations of unattended long-term noise monitors and short-term noise measurements

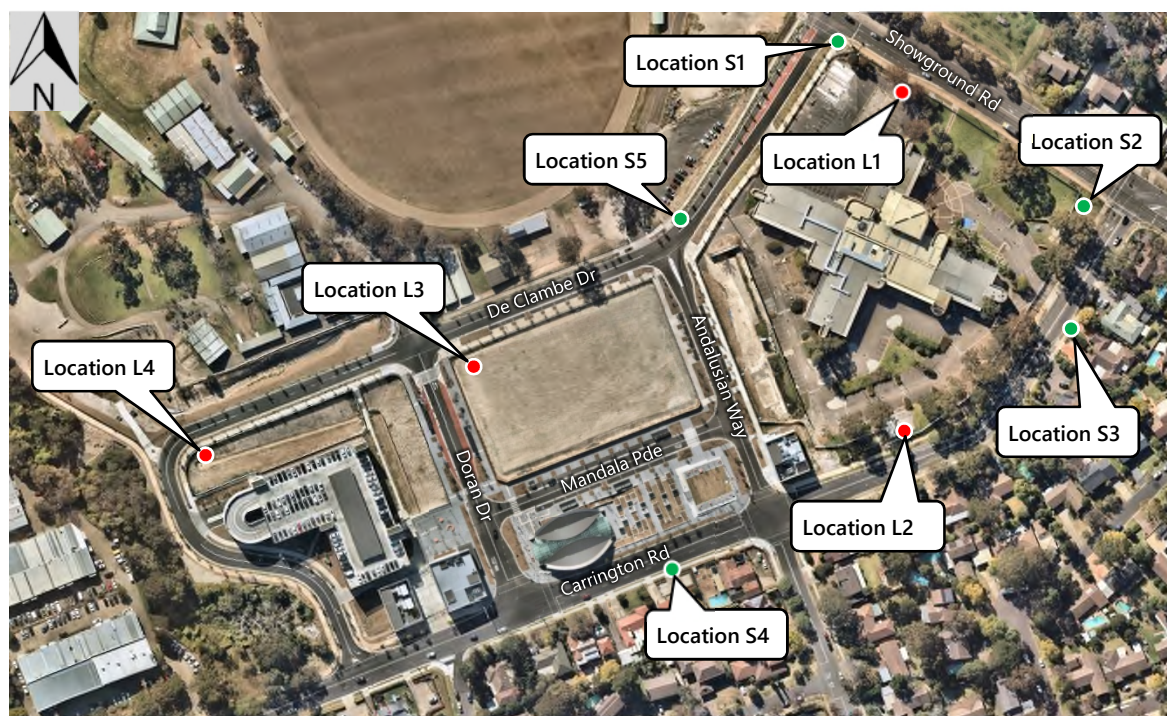


Table 1: Noise monitoring locations

Location ID	Description
Long-term noise monitoring	
L1	Noise monitor installed on the north-eastern side of the proposed Hills Showground Precinct East. The monitor was installed at a height of 1.5m from the ground and approximately 9m from Showground Road.
L2	Noise monitor installed on the south-eastern side of the proposed Hills Showground Precinct East. The monitor was installed at a height of 1.5m from the ground and approximately 8m from Carrington Road.
L3	Noise monitor installed on the north-western side of the proposed Doran Drive Precinct. The monitor was installed at a height of 1.5m from the ground and approximately 12m from De Clambe Drive.
L4	Noise monitor installed on the north-western side of the proposed Hills Showground Precinct West. The monitor was installed at a height of 1.5m from the ground and approximately 12m from De Clambe Drive.
Short-term measurements	
S1	Short-term noise measurements undertaken on the corner of Showground Road and De Clambe Drive. Noise measurements undertaken on 20th September 2019 from 1:43pm to 1:58pm.

Location ID	Description
S2	Short-term noise measurements undertaken on the corner of Showground Road and Carrington Road. Noise measurements undertaken on 20th September 2019 from 2:01pm to 2:16pm.
S3	Short-term noise measurements undertaken south-east of the proposed Hills Showground Precinct East. The measurements were undertaken at the boundary of a residential property along Carrington Road. Noise measurements undertaken on 20th September 2019 from 2:18pm to 2:33pm.
S4	Short-term noise measurements undertaken south-east of the site across Carrington Road. The measurements were undertaken at the boundary of a childcare centre. Noise measurements undertaken on 20th September 2019 from 2:45pm to 3:00pm.
S5	Short-term noise measurements undertaken north-west of the site across De Clambe Drive. Noise measurements undertaken on 20th September 2019 from 3:06pm to 3:21pm.

4.2 Long Term Unattended Monitoring

4.2.1 Monitoring Period

Two unattended long-term noise monitors were installed at locations L1 and L2 from 19th September 2019 to 27th September 2019. An additional two unattended long-term noise monitors were installed from 20th September 2019 to 27th September 2019. Monitors were installed to determine the existing level of ambient and background noise levels pertinent to the site.

Locations of the long-term noise monitors are presented in Figure 3 and detailed in Table 1.

4.2.2 Equipment Used

The equipment used for noise measurements was four (4) NTi Audio Type XL2 precision sound level analysers which is a class 1 instrument having accuracy suitable for field and laboratory use. The instrument was calibrated prior and subsequent to measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

The noise monitors recorded noise levels on a continuous basis and stored data every fifteen minutes. The monitors were calibrated before and after measurements and no significant deviation in calibration was noted.

4.2.3 Long-term unattended noise monitoring results

The summary results of the long-term unattended noise monitoring are presented in Table 2 below.

Table 2 - Long-term unattended noise monitoring results

Location	Rating Background Noise Levels ¹ dB(A) L ₉₀ (15min)			Environmental Noise (at 1m from a façade) dB(A) L _{eq} (period)	
	Day	Evening	Night	Day (7am -10pm)	Night (10pm – 7am)
L1- Showground Road	54	53	34	69	64
L2- Carrington Road	47	43	32	65	57
L3- De Clambe Drive (Castle Hill Showground)	42	41	32	58	54
L4- Cattai Creek	43	42	38	56	51

1. Periods are as defined by the NSW EPA Noise Policy for Industry. Day is 7am – 6pm Monday to Friday and 8am – 6pm Saturday, Sunday and Public Holidays; Evening is 6pm – 10pm daily; Night is 10pm – 7am Monday to Friday and 10pm-8am Saturday, Sunday and Public Holidays

Detailed results of the background and ambient noise monitoring undertaken are presented in APPENDIX B.

4.3 Short-term Attended Measurements

4.3.1 Period of monitoring

Short term attended monitoring was undertaken on Friday the 20th of September 2019 between 1:30pm and 3:30pm, for 15 minutes at each location.

4.3.2 Measurement locations

Short-term noise measurements were undertaken at multiple locations simultaneous to the long-term noise monitoring. Locations of the long-term noise monitors and short-term noise measurements are presented in Figure 3 and detailed Table 1.

4.3.3 Equipment used

The equipment used for noise measurements was an NTi Audio Type XL2 precision sound level analysers which is a class 1 instrument having accuracy suitable for field and laboratory use. The instrument was calibrated prior and subsequent to measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All instrumentation complies with IEC 61672 (parts 1-3) 'Electroacoustics - Sound Level Meters' and IEC 60942 'Electroacoustics - Sound calibrators' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

The monitor was calibrated before and after measurements and no significant deviation in calibration was noted.

4.3.4 Short-term noise measurement results

Results from the short-term noise measurements are summarised in Table 3 below.

Table 3: Summary of short-term noise measurements

Location (refer Figure 3 and Table 3)	Measurement date and time	L _{eq, 15min} dB(A)	L _{90, 15min} dB(A)
Location S1 Showground Road & De Clambe Drive	20 th September 2019 1:43pm to 1:58pm	69	58
Location S2 Showground Road & Carrington Road	20 th September 2019 2:01pm to 2:16pm	72	62
Location S3 Carrington Road, South East of Hills Showground Precinct East	20 th September 2019 2:18pm to 2:33pm	69	54
Location S4 Carrington Road in front of Childcare	20 th September 2019 2:45pm to 3:00pm	68	52
Location S5 North-west of the site across De Clambe Drive	20 th September 2019 3:06pm to 3:21pm	60	49

5 External noise intrusion assessment

5.1 Noise intrusion criteria

5.1.1 NSW Road Noise Policy (RNP)

The NSW *Road Noise Policy* (RNP) was introduced in July 2011 and replaced the NSW *Environmental Criteria for Road Traffic Noise* (ECTRAN). Table 3 of the RNP outlines criteria to be applied to particular types of road development and land use. The criteria apply when assessing noise impact and determining mitigation measures for existing developments that are potentially affected by road traffic noise, with the aim of preserving the amenity appropriate to the land use.

Unlike the ECTRAN, the RNP no longer stipulates noise criteria for new land use developments potentially impacted by road traffic noise. Criteria for new developments affected by existing roads are now addressed through the State Environmental Planning Policy (Infrastructure) 2007 ('ISEPP') and the associated NSW Department of Planning 'Development Near Rail Corridors and Busy Roads – Interim Guideline'.

The RNP will be utilised in the assessment of additional noise from traffic generated by the development.

5.1.2 State Environmental Planning Policy (Infrastructure) 2007 (ISEPP)

The NSW State Environmental Planning Policy (Infrastructure) 2007 (known as 'ISEPP') came into force in NSW on 1 January 2008 to facilitate the effective delivery of infrastructure across the State. The aim of the policy includes identifying the environmental assessment category into which different types of infrastructure and services development fall and identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure.

Application of the ISEPP is mandatory for new residential developments in or adjacent to rail corridors (Clause 87) and to road corridors carrying in excess of 40,000 vehicles per day (Clause 102).

Pertinent to noise assessment, the ISEPP includes the following clauses:

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

- *This clause applies to development for any of the following purposes that is on land in or adjacent to a rail corridor and that the consent authority considers is likely to be adversely affected by rail noise or vibration:*
 - a. *a building for residential use,*
 - b. *a place of public worship,*
 - c. *a hospital,*
 - d. *an educational establishment or child care centre.*

- *Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.*
- *If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:*
 - a. *in any bedroom in the building - 35 dB(A) at any time between 10 pm and 7am,*
 - b. *anywhere else in the building (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.*

102 *Impact of road noise or vibration on non-road development*

- *This clause applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RTA) and that the consent authority considers is likely to be adversely affected by road noise or vibration:*
 - c. *a building for residential use,*
 - d. *a place of public worship,*
 - e. *a hospital,*
 - f. *an educational establishment or child care centre.*
- *Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.*
- *If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:*
 - a. *in any bedroom in the building - 35 dB(A) at any time between 10 pm and 7am,*
 - b. *anywhere else in the building (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.*
- *In this clause, "freeway", "tollway" and "transitway" have the same meanings as they have in the Roads Act 1993*

5.1.3 Department of Planning publication 'Development near rail corridors and busy roads – Interim guideline'

To support the ISEPP, the DPIE, previously known as the Department of Planning, released the *Development in Rail Corridors and Busy Roads – Interim Guideline* (December 2008). The Guideline assists in the planning, design and assessment of developments in, or adjacent to, major transport corridors in terms of noise, vibration and air quality. While the ISEPP is mandatory only to roads with an AADT greater than 40,000 vehicles, the guideline is also recommended for other road traffic noise affected sites.

5.1.4 Clarification of ISEPP noise limits

The Guideline clarifies the time period of measurement and assessment. Section 3.4 '*What Noise and Vibration Concepts are Relevant*' and Table 3.1 of Section 3.6.1 confirms that noise assessment is based over the following time periods:

- Daytime 7:00am - 10:00pm $L_{Aeq(15hr)}$
- Night-time 10:00pm - 7:00am $L_{Aeq(9hr)}$

The noise criteria nominated in the ISEPP apply to internal noise levels with windows and doors closed. However as the preliminary noise assessment is based on measurements/predictions at external locations, equivalent external noise criteria has been established. The equivalent external noise criterion is used to determine which areas of the development may require acoustic treatment in order to meet the internal noise requirements of the ISEPP. The equivalent external goals have been determined on the following basis:

- The ISEPP states: "*If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, 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.*" The internal criteria with windows open is therefore 10dB(A) above the criteria explicitly outlined in the ISEPP.
- The generally accepted noise reduction through an open window from a free-field external position is 10dB(A). Windows/doors are assumed to be open no more than 5% of room floor area, in accordance with the Building Code of Australia (BCA) ventilation requirements.

Table 4 presents the ISEPP internal noise criteria along with the equivalent external noise criteria for residential premises.

Whilst only those apartments affected by noise from traffic on Showground Road require a mandatory assessment under the ISEPP, for consistency across the development the same project noise intrusion goals are proposed for all the residential uses (refer Table 4).

Table 4: ISEPP noise criteria for new residential development

Room	Location	L _{Aeq} , 15hr Day 7am – 10pm	L _{Aeq} 9hr Night 10pm – 7am
Living rooms ¹	Internal, windows closed	40	40
	Internal, windows open	50	50
	External free-field (allowing windows to remain open) ²	60	60
Bedrooms ¹	Internal, windows closed	40 ³	35
	Internal, windows open	50	45
	External free-field (allowing windows to remain open) ²	60	55

Notes: 1 Requisite for 40,000AADT Roads only under ISEPP 2007.

2 ISEPP Guideline states that where internal noise criteria are exceeded by more than 10dB(A) with windows open mechanical ventilation is required. External goals have been calculated on the basis of nominal 10dB(A) reduction through an open window to a free-field position. Windows open to 5% of floor area in accordance with the National Construction Code 2019 requirements.

3. ISEPP does not define noise goals in bedrooms during the Day (7am – 10pm). For residential amenity, Renzo Tonin & Associates propose a limit of 40dB(A) L_{eq} (15 hour) internally with windows closed i.e. the same as in a Living Room during the Day.

5.1.5 Australian/New Zealand Standard AS/NZS 2107:2016

It is proposed to utilise Australian/New Zealand Standard AS/NZS 2107:2016 "Acoustics - Recommended design sound levels and reverberation times for building interiors" (AS2107) to set design internal noise goals for spaces other than residential habitable rooms (which are covered by the ISEPP). Based on advice received to date on the type of other uses likely on site (i.e. residential, commercial, retail and community facilities), the corresponding internal noise goals from AS2107 are presented in Table 5. If a proposed use is not included below, refer to AS2107 for guidance.

AS2107 recommends design criteria for conditions affecting the acoustic environment within building interiors to ensure a healthy, comfortable and productive environment for the occupants and the users. The background sound levels recommended take into account the function of the area(s) and apply to the sound level measured within the space unoccupied but ready for occupancy. The Standard is applicable to steady-state or quasi-steady-state sounds such as mechanical services equipment and road traffic noise intrusion, but not intended for transient or variable sources such as aircraft noise, railways and construction noise. The reverberation times recommended are for the occupied state of the space.

The sound levels given in this Standard are for the design of spaces in buildings and are provided as a range with a recommended lower level and upper level. Sound levels within the given ranges have been found to be acceptable by most people for the space under consideration. When the sound level is greater than the upper level of the range most people occupying the space will become dissatisfied with the level of sound. When the sound level is below the lower level of the range, the inadequacy of background sound to provide masking sound can become problematic, for example, by allowing other intermittent noise sources to cause distraction, annoyance, or lack of privacy.

Table 5: Design sound levels and reverberation times for different areas of occupancy in buildings

Item	Type of occupancy/activity	Design sound level (L _{Aeq,t}) range	Design reverberation time (T) range, s
5	OFFICE BUILDINGS		
	Board and conferences rooms	30 to 40	0.6 to 0.8
	Cafeterias	45 to 50	< 1.0
	Call centres	40 to 45	0.1 to 0.4
	Corridors and lobbies	45 to 50	< 1.0
	Executive office	35 to 40	0.4 to 0.6
	General office areas	40 to 45	0.4 to 0.6
	Meeting room (small)	40 to 45	< 0.6
	Open plan office	40 to 45	0.4 (see Note 1)
	Public spaces	40 to 50	0.5 to 1.0
	Quiet rooms	40 to 45	< 0.6
	Reception areas	40 to 45	0.6 to 0.8
	Rest rooms and break-out spaces	40 to 45	0.4 to 0.6
	Toilets	45 to 55	-
	Undercover car parks	<65	-
	Video/audio conference rooms	30 to 40	0.2 to 0.4
6	PUBLIC BUILDINGS		
	Art galleries	40 to 45	See Note 1
	Cinemas (see Notes 3 and 6)	30 to 35	Curve 1*
	Corridors and lobbies	45 to 50	0.6 to 0.8
	Exhibition areas	40 to 50	See Note 1
	Parking stations (carpark areas)	55 to 65	-
	Post offices and general banking areas	45 to 50	< 0.8
	Restaurants and cafeterias -		
	Cafeterias	40 to 50	See Note 1
	Food courts	45 to 55	See Note 1
	Coffee shops	40 to 50	See Note 1
	Restaurants	40 to 50	See Note 1
7	RESIDENTIAL BUILDINGS (see Note 5 and Clause 5.2)		
	Houses and apartments in inner city areas or entertainment districts or near major roads -		
	Apartment common areas (e.g. foyer, lift lobby)	45 to 50	-
	Living areas	35 to 45	-
	Sleeping areas (night time)	35 to 40	-
	Work areas	35 to 45	-
	Houses and apartments in suburban areas or near minor roads -		
	Apartment common areas (e.g. foyer, lift lobby)	45 to 50	-
	Living areas	30 to 40	-
	Sleeping areas (night time)	30 to 35	-

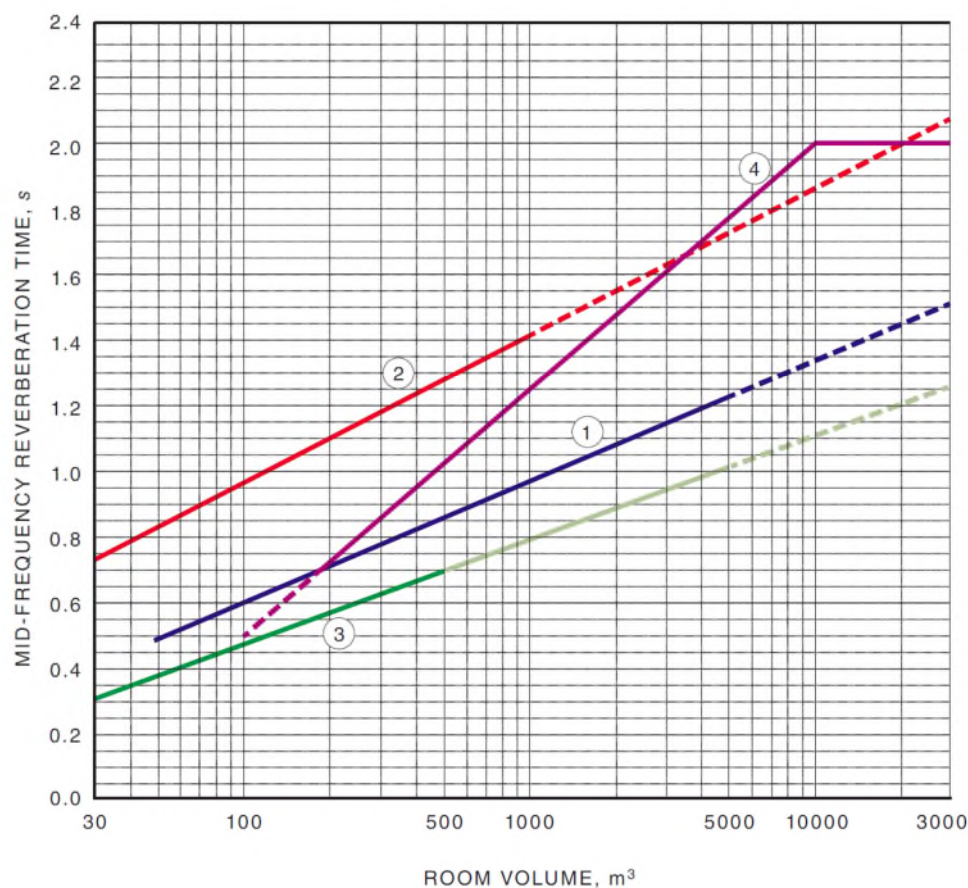
Item	Type of occupancy/activity	Design sound level (L _{Aeq,t}) range	Design reverberation time (T) range, s
	Work areas	35 to 40	-
	Hotels and motels -		
	Bars and lounges	< 50	0.6 to 1.0
	Conference areas -		
	Without sound reinforcement -		
	Up to 50 persons	35 to 40	Curve 1*
	From 50 to 250 persons	30 to 35	Curve 1*
	With sound reinforcement	35 to 45	Curve 1*
	Dining rooms	40 to 45	See Note 1
	Enclosed carparks	< 65	-
	Foyers and recreation areas	45 to 50	See Note 1
	Kitchen, laundry and maintenance areas	< 55	-
	Sleeping areas (night time) -		
	Hotels and motels in inner city areas or entertainment districts or near major roads	35 to 40	-
	Hotels and motels in suburbs or near minor roads	30 to 35	-
	Washrooms and toilets	45 to 55	-
	Hostels, residential halls and barracks -		
	Cafeterias	45 to 50	< 1.0
	Common rooms	40 to 45	< 1.0
	Games rooms	45 to 50	< 1.0
	Kitchens and service areas	45 to 55	-
	Sleeping areas (night time) -		
	Hostels, residential halls and barracks in inner city areas or entertainment districts or near major roads	35 to 40	-
	Hostels, residential halls and barracks in suburbs or near minor roads	30 to 35	-
	Retirement homes/villages	See Houses and apartments; and Clause 5.2	
8	SHOP BUILDINGS		
	Department stores -		
	Main floor	< 55	See Note 1
	Upper floor	< 50	See Note 1
	Enclosed carparks	< 65	-
	Small retail stores (general)	< 50	See Note 1
	Shopping malls	< 55	See Note 1
	Show rooms	< 50	See Note 1
	Specialty Shops (where detailed discussion is necessary in transactions)	< 45	See Note 1
	Supermarkets	< 55	See Note 1
* See Figure 4 for all references to 'Curve' in this Table.			

Item	Type of occupancy/activity	Design sound level ($L_{Aeq,t}$) range	Design reverberation time (T) range, s
------	----------------------------	---	---

NOTES:

1. Reverberation time should be minimized for noise control.
2. Certain teaching spaces, including those intended for students with learning difficulties and students with English as a second language, should have reverberation times at the lower end of the range.
3. Specialist advice should be sought for these spaces.
4. A very wide range of noise levels can occur in the occupied state in spaces housing manufacturing processes, and the levels are primarily subject to control as part of a noise management program (see AS/NZS 1269.2). The possibilities for segregating very noisy processes from quieter ones by partitioning vary between particular industries and plants. For reasons such as these, it is difficult to make generalized recommendations for desirable, or even maximum, design levels for the unoccupied state, but one guiding principle may still be observed-when the activity in one area of a manufacturing plant is halted, it is desirable that the local level should if possible drop to 70 dB(A) or lower to permit speech communication without undue effort.
5. In situations where traffic noise levels may vary widely over a 24 h period, measurement to assess compliance with this Standard should be taken at the relevant time and for an appropriate measurement period according to the area of occupancy or activity in the building. Where traffic noise fluctuates rapidly with the passage of individual vehicles, the community reaction may not correlate well with the equivalent continuous noise level as measured.

Figure 4 - Figure A1 from AS2107:2016 - Mean Reverberation Times



LEGEND:

- Curve 1 = Speech/Lecture
 Curve 2 = Music
 Curve 3 = Teaching/Communication
 Curve 4 = Sport

NOTE: The graphic in Figure A1 is based on DIN 18041.

FIGURE A1 MEAN REVERBERATION TIMES

5.2 Assessment of road traffic noise intrusion

Showground Road on the North-Eastern boundary of the site carries in excess of 40,000 vehicles per day, triggering mandatory noise assessment under the SEPP (Infrastructure) 2007 (Refer to Section 5.1.4 for criteria). Carrington Road has not been identified as a road carrying in excess of 40,000 vehicles per day, however its use does result in significant noise impacts onto the subject site. As such, it is recommended to apply the goals of the SEPP Guideline 2008 to residential premises within the Hills Showground Station Precinct.

5.3 Facade noise levels

5.3.1 Road traffic noise

Traffic consultants SCT Consulting have provided the peak hour traffic volumes as presented in Table 6 below.

Table 6 - Peak hourly traffic volumes - 2019 (current), 2031 (future) and 2031 developed

Location	2019 AM	2019 PM	2031 AM Base	2031 PM Base	2031 AM With Development	2031 PM With Development
Showground Road between Carrington Rd & De Clambe Dr	2,200 (106)	2,330 (64)	3,130 (146)	3,320 (87)	3,130 (146)	3,330 (87)
Carrington Rd between Showground Rd & Andalusian Way	1,140 (22)	1,270 (4)	1,590 (30)	1,590 (6)	1,780 (30)	1,840 (6)
Carrington Rd between Doran Dr & De Clambe Dr	1,250 (34)	1,530 (26)	1,460 (41)	1,835 (29)	1,760 (41)	2,190 (29)

The volume shown are two-way flows: Total volumes (Heavy Vehicle volumes)

Based on the above traffic volume increases, the facade noise levels are predicted to increase by the values nominated below in Table 7.

Table 7 - Predicted increase in traffic noise from 2019 to "2031 with development"

Location	AM Peak: Noise increase from 2019 base to 2031 With Development (dB)	PM Peak: Noise increase from 2019 base to 2031 With Development (dB)	Average Increase (dB)
Showground Road between Carrington Rd & De Clambe Dr	1.5	1.6	1.5
Carrington Rd between Showground Rd & Andalusian Way	1.9	1.6	1.8
Carrington Rd between Doran Dr & De Clambe Dr	1.5	1.6	1.5

Assuming the period average (15 hour / 9 hour) volumes increase by the same rate as the average of peak hours (as period volumes have not been provided), the predicted "2031 With Development" noise levels are predicted at the four (4) monitoring locations, based on the Oculus Cox "Showground Station Precinct - Urban Design and Landscape Report", draft, dated September 2019 (minimum setback 9.5m from the property boundary). The summary results are presented in Table 8 below.

Table 8 - Predicted traffic noise at future facades (2031 with development volumes)

Location	Predicted Traffic Noise (at 1m from a façade) dB(A) $L_{eq}(\text{period})$	
	Day (7am -10pm)	Night (10pm – 7am)
L1- Showground Road future facade	69	64
L2- Carrington Road	65	57

1. Periods are as defined by the NSW EPA Noise Policy for Industry. Day is 7am – 6pm Monday to Friday and 8am – 6pm Saturday, Sunday and Public Holidays; Evening is 6pm – 10pm daily; Night is 10pm – 7am Monday to Friday and 10pm-8am Saturday, Sunday and Public Holidays

Measured average noise levels at Locations 3 and 4 are be impacted by existing flows on De Clambe Drive and Doran Drive. The traffic engineers have predicted a generation rate of 45-55 vehicles per hour on the internal roads. Applying this additional traffic to the existing levels measured by the unattended monitoring predicted an increase of up to 1dB.

Table 9 - Predicted traffic noise at future facades

Location	Predicted Traffic Noise (at 1m from a façade) dB(A) $L_{eq}(\text{period})$	
	Day (7am -10pm)	Night (10pm – 7am)
L3- De Clambe Dr at Doran Dr	60	56
L4- North Façade De Clambe Dr near carpark	59	55

1. Periods are as defined by the NSW EPA Noise Policy for Industry. Day is 7am – 6pm Monday to Friday and 8am – 6pm Saturday, Sunday and Public Holidays; Evening is 6pm – 10pm daily; Night is 10pm – 7am Monday to Friday and 10pm-8am Saturday, Sunday and Public Holidays

5.3.2 Noise from carpark and station facilities

Predicted noise from use of the Metro Station carpark and station facilities was presented in the Renzo Tonin & Associates report, reference: TG264-05 4F17 (R5) SHW STAGE 3 NWRLOTS-NRT-SHW-AV-RPT301542-D, dated the 24th of August 2016.

Table 10 - Predicted operational noise at future facades

Location	Noise Source	Predicted operational Noise dB(A) $L_{eq}(15min)$	
		Day / Evening (7am -10pm)	Night (10pm – 7am)
Southern façade of Site 3	Carpark	57	54
Near side of Site 3 at 13.5m height	Mechanical plant (at Doran and Carrington)	40-44	40-44
Site 1 – 16m North of Services Building	Mechanical plant (at Andalusian and Carrington)	53	53
Site 1 – 54m North of Services Building	Mechanical plant (at Andalusian and Carrington)	44	44

1. Periods are as defined by the NSW EPA Noise Policy for Industry. Day is 7am – 6pm Monday to Friday and 8am – 6pm Saturday, Sunday and Public Holidays; Evening is 6pm – 10pm daily; Night is 10pm – 7am Monday to Friday and 10pm-8am Saturday, Sunday and Public Holidays

5.4 Recommended treatments

Based on the results of the long-term unattended noise monitoring on site (and supplemented by the attended monitoring) and including noise from traffic generated by the development, indicative glazing would be as follows:

- Showground Road (in line with L1)
 - Living Room: 6m x 4m x 2.7; glazed area 4m x 2.7m; glazing 10.38mm laminated with full perimeter acoustic seals, R_w 35.
 - Bedroom: 3m x 3.5m x 2.7; glazed area 3m x 2.7m; glazing 10.38mm laminated with full perimeter acoustic seals, R_w 35.
- Carrington Road (in line with L2)
 - Living Room: 6m x 4m x 2.7; glazed area 4m x 2.7m; glazing 6.38mm laminated with full perimeter acoustic seals, R_w 32.
 - Bedroom: 3m x 3.5m x 2.7; glazed area 3m x 2.7m; glazing 6.38mm laminated with full perimeter acoustic seals, R_w 32.
- De Clambe Drive / Doran Drive, facing carpark or street
 - Living Room: 6m x 4m x 2.7; glazed area 4m x 2.7m; glazing 6mm Float with full perimeter acoustic seals, R_w 28.
 - Bedroom: 3m x 3.5m x 2.7; glazed area 3m x 2.7m; glazing 6.38mm laminated with full perimeter acoustic seals, R_w 32.

The above treatments are applicable to the façade nearest the road. The treatments will depend on the final building alignments and the distance from the façade to the road. As such, it is subject to detailed design for DA and CC.

For Showground Road and Carrington Road, the noise impacts at L1 and L2 are such that receivers at these locations would need to be provided with alternative ventilation so that they can close the windows/doors against the traffic noise (if they choose).

In remaining areas, it is likely that the design will be more sensitive to noise from traffic generated by the development, noise from the Castle Hill Showground Precinct and noise from the proposed supermarket loading dock which are investigated in further Sections.

Based on the advice of the traffic engineer, all the internal roads within the master plan are considered as "access ways" with traffic generation of 45-55 vehicles per hour and under the ISEPP and RNP, this would not require any further assessment. The noise impacts of these roads upon the buildings within the master plan should be considered in future DAs.

Future DAs for construction of the buildings will need to demonstrate that the noise criteria set out in this report can be met through detailed assessments.

6 Rail vibration assessment

The rail vibration assessment is broken into two parts - the assessment for human comfort in accordance with the DECC 'Assessing Vibration; a technical guideline' (DECC, 2006) and structure borne noise requirements from the ISEPP Guideline 2008.

6.1 Ground-borne noise

The ISEPP Guideline 2008 provides recommended criteria for ground-borne or regenerated rail noise for residential developments.

Table 11 below provides a summary of the recommended noise limits for this project.

Table 11: Recommended internal noise criteria for regenerated rail noise

Occupancy	Period	Recommended Maximum Design Noise Level, L_{Amax} (slow)
Habitable Rooms	Day Time (7am to 10pm)	40
	Night Time (10pm to 7am)	35
Commercial (Offices)	When in use	45
Community spaces (Function Room)	When in use	45
Retail (Restaurant)	When in use	50

Notes:

6. L_{Amax} (slow) is A-weighted maximum sound pressure level measures using "Slow" response time for 95% of rail pass-by events.
7. Internal noise criteria not covered by the ISEPP have been determined in accordance with AS2107.

6.2 Rail tactile vibration

In addition to regenerated rail noise, Section 3.6.3 of the DPIE Guideline 2008 provides recommended vibration criteria based on the following documents:

1. Department of Environment and Conservation's Assessing Vibration: A technical guideline 2006 ('DEC Guideline 2006');
2. German Standard DIN4150, Part 3 1999;
3. British Standard BS7385 Part 2 1993; and
4. Australian Standard AS2670.2 1990 ('AS2670.2').

The above documents have been reviewed and the criteria for assessment of tactile vibration from train pass-bys affecting the proposed development are quantified from the following:

- Department of Environment and Conservation's Assessing Vibration: A technical guideline 2006; and

- British Standard BS6472:1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)" ('BS6472')

The criteria curves presented in BS6472 are identical to those presented in AS2670.2 and the International Standard ISO2631-2.1989.

Criteria for continuous vibration from the British Standard BS6472 for residential spaces, offices and commercial workshop environments are shown in Figure 5 below.

Figure 5: Tactile vibration criteria for residential buildings

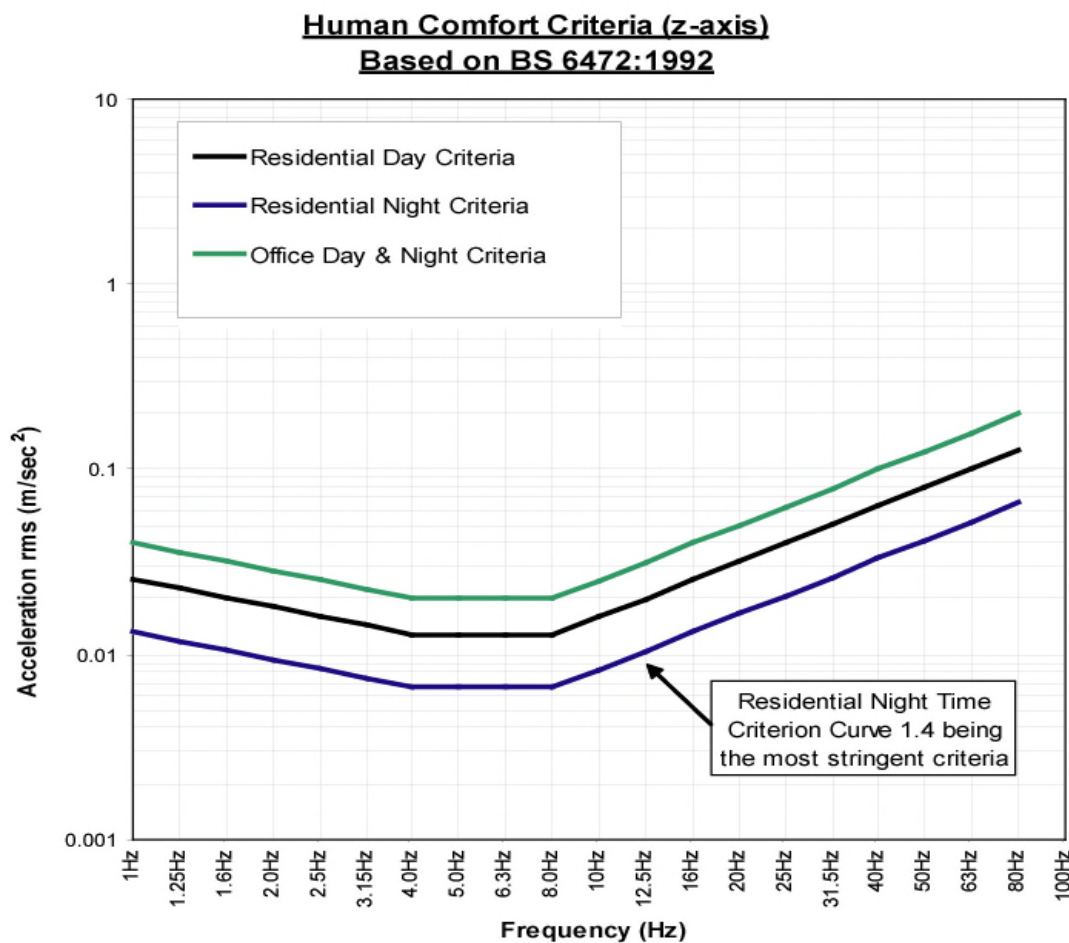


Table 2.4 of the DEC Guideline 2006 presents acceptable vibration dose values for intermittent vibration. Table 12 below outlines DEC's requirements.

Table 12: Acceptable VDV_s for intermittent vibration in residential buildings m/s^{1.75}

Location	Period	Preferred VDV m/s ^{1.75}	Maximum VDV m/s ^{1.75}
Residences	Day time (7am – 10pm)	0.20	0.40
	Night time (10pm – 7am)	0.13	0.26
Offices	Day time (7am – 10pm)	0.40	0.80
	Night time (10pm – 7am)	0.40	0.80

6.3 Site rail measurements

6.3.1 Timing of measurements

Attended vibration measurements were undertaken on Friday the 20th of September 2019 between 10am and 3pm.

6.3.2 Monitoring Locations

The short-term attended monitoring was undertaken at the locations shown in Figure 6 and Table 13 below.

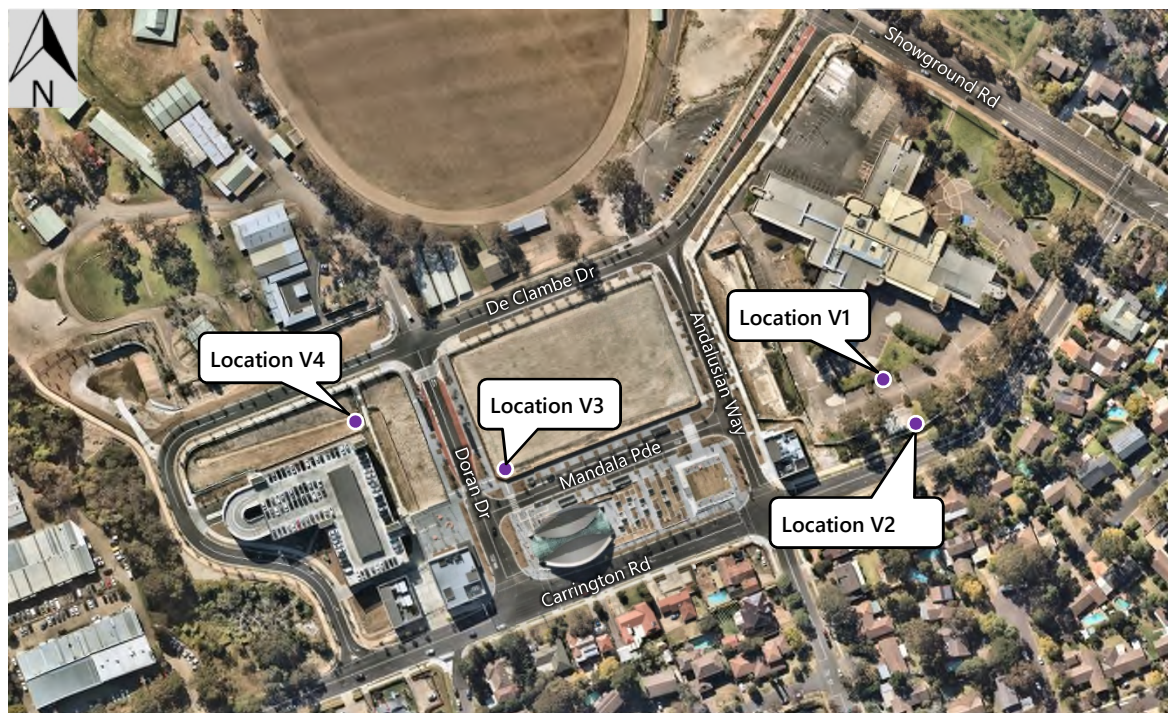
Figure 6: Locations of attended short-term vibration measurements

Table 13: Noise monitoring locations

Location ID	Description
Vibration monitoring	
V1	Vibration monitor was installed approximately parallel to V2, but 15m North of the Metro Tunnel
V2	Vibration monitor installed on the north-eastern side of the proposed Hills Showground Precinct East. The monitor was installed approximately 9m from Showground Road, directly over the Metro Tunnel.
V3	Vibration monitor was installed at the intersection of Doran Drive and Mandala Parade.
V4	Vibration monitor was installed in line with the Eastern façade of the Commuter Carpark at Hills Showground Station Precinct West.

6.3.3 Equipment used

Vibration levels were measured in one-third octave band frequencies using the Soundbook multichannel sound & vibration analyser and three PCB Type 393B12 accelerometers.

The accelerometers were calibrated prior and subsequent to measurements using a Bruel & Kjaer Type 4294 calibrator. No significant drift in calibration was observed.

The vibration measurement system has been laboratory calibrated and is traceable to national calibration standards. The calibration certificate is current and falls within the calibration period permitted by Australian Standards.

All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

6.3.4 Results

Daily vibration dose value calculated from the site measured levels was less than $0.01 \text{ m/s}^{1.75}$ at the worst affected location (V1), which indicates compliance with the project criteria for human annoyance.

Refer to APPENDIX B for full reports of results.

The measured acceleration at locations V1-V4 were assessed for structure borne noise. The predicted level at the worst affected location (V1) was predicted to be less than 30dB(A) L_{Amax} , indicating compliance with the project internal noise goals.

7 Construction noise and vibration assessment

The Sydney Metro Underground Corridor Protection - Technical Guidelines sets out the requirements for noise and vibration (Sections 5.2, 5.4, 7.2, 8.6 and 9.3 of the Guidelines) during construction of the development.

Construction activities associated with the proposed development will likely result in increased noise levels during construction hours. The works undertaken in the various stages of excavation and construction is likely to consist of a mixture of both high and low noise activities.

Potential impacts of the construction on surrounding areas including the adjoining rail corridor and the public realm with respect to noise and vibration should be addressed in the future planning and development stages through a Construction Noise and Vibration Management Plan (CNVMP).

The CNVMP identifies potentially noisy activities, their impacts on surrounding receivers, including the underground rail tunnel, and outlines management strategies to control the impacts of noise and vibration during the excavation and civil works, structure construction, building fit out and landscaping.

8 Operational noise assessment

External noise emissions from the operation of mechanical plant and equipment and vehicles being driven on site shall be designed for compliance with the NSW Environment Protection Authority (EPA) Noise Policy for Industry (NPfI), where reasonable and feasible.

Given the proximity of residential receivers to the loading dock, it may not be feasible to control external noise emissions in accordance with the trigger levels of the NPfI. In that instance, internal noise goals should be set in accordance with AS2107:2016 (Refer Table 5) and the façade designed for compliance internally (based on the loading dock operational requirements). This approach would mean that the affected residences should be provided with alternative ventilation so that they can keep their doors/windows closed against the noise (if they wish).

Noise from traffic generated by the development shall be assessed in accordance with the NSW EPA Road Noise Policy as part of future DAs.

8.1 Noise emission assessment guidelines

8.1.1 Road Noise Policy assessment criteria - residential land uses

Table 3 of the RNP, which is repeated in Table 14 below, sets out the assessment criteria for residences to be applied to particular types of project, road category and land use. These criteria are for assessment against façade corrected noise levels when measured in front of a building facade. In Table 3 of the RNP, freeways, arterial roads and sub-arterial roads are grouped together and attract the same criteria.

Table 14: Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day 7:00am-10:00pm	Night 10:00pm-7:00am
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	L _{Aeq} (15 hour) 55 (external)	L _{Aeq} (9 hour) 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway / arterial / sub-arterial roads	L _{Aeq} (15 hour) 60 (external)	L _{Aeq} (9 hour) 55 (external)
	3. Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	L _{Aeq} (15 hour) 60 (external)	L _{Aeq} (9 hour) 55 (external)
Local roads	4. Existing residences affected by noise from new local road corridors	L _{Aeq} (1 hour) 55 (external)	L _{Aeq} (1 hour) 50 (external)
	5. Existing residences affected by noise from redevelopment of existing local roads		
	6. Existing residences affected by additional traffic on existing local roads generated by land use developments		

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day	Night
		7:00am-10:00pm	10:00pm-7:00am

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for sensitive developments near busy roads (refer to Appendix C10 of the RNP).

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.

In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

For existing residences and other sensitive land uses affected by *additional traffic on existing roads generated by land use developments*, any increase in the total traffic noise level (where the assessment criteria cannot be achieved) should be limited to 2 dB above that of the corresponding 'no build option'.

8.1.2 Noise from the operation of the Castle Hill Showground and active street-fronts to receivers within the Site

It is intended to set reasonable and feasible controls for the management of noise from the Castle Hill Showground and active street fronts within the both the Castle Hill Showground and the Hills Showground Station Precinct. At the time of writing, the Castle Hill Showground redevelopment master planning is underway however little detail is available on the proposed operations.

The intention is to activate the Showground site, including at the interface between the Showground and the Showground Station precincts. The Showground redevelopment is intended to allow for high profile sporting fixtures (such as AFL/NRL trial matches), public entertainment (such as concerts and the Castle Hill Show) and will also include food and beverage (licensed premises).

Controls would be set on the basis of:

- Classification of "normal use" and "special uses"; and
- Corresponding hours, frequency and duration of use; and source noise levels, nature and location/s.

Having both sites being re-developed under Master-planning arrangements allows for the designs to respond to the relevant risks and opportunities. If the Showground were to operate without any limits on noise emissions, it could preclude residential use on the Showground Station site. As such, coordination will be required between the project teams to determine appropriate noise emission limits from the operation of the Showground site, including "normal use" and "special use".

8.1.2.1 Normal use

For "normal use" mode Renzo Tonin & Associates suggest application of controls similar to the Barangaroo South Precinct, which had/has numerous retail tenancies (including licensed premises) proximate to residential receivers and where an active streetscape was desirable. At Barangaroo South Precinct, separate controls were applied for receivers within the Precinct versus outside. The same approach is proposed for the Hills Showground Station Precinct (the Site).

For residential receivers outside of the Site, each licensed premise shall assess its noise emissions to the nearest residential receivers external to the Precinct for compliance with the NSW Liquor and Gaming background + 5dB(A) L_{10} spectrum assessment up to midnight (and inaudibility after midnight). In addition, a control of Background + 5dB(A) $L_{eq(15min)}$ shall be applied to the cumulative operation of the retail tenancies to any residential receiver external to the Site up to midnight. Refer to Section 8.1.3 for details. Note: Once the overall number of tenancies impacting each receiver is known, each tenancy could be allocated a broadband noise emission limit to ensure that cumulative impacts could comply overall with background + 5dB(A) $L_{eq(15min)}$.

For noise impacts within the Precinct, design internal noise goals (cumulative) are proposed. The goals are those applied by Wilkinson Murray at the Barangaroo South Precinct which were informed by controls applied in New York and San Francisco.

The proposed combined patron and music internal noise levels from "normal use" of the active street-fronts and Castle Hill Showground are follows:

- Daytime/Evening (7am to 10pm): 38dB(A) $L_{eq(15min)}$ in bedrooms (internally, windows closed); and 43dB(A) $L_{eq(15min)}$ in living rooms (internally, windows closed);
- Late Evening (10pm - midnight): 35dB(A) $L_{eq(15min)}$ in bedrooms (internally, windows closed); and 40dB(A) $L_{eq(15min)}$ in living rooms (internally, windows closed) from 7am up to midnight.
- Overnight (midnight to 7am): Each tenancy inaudible at any residential receptor.

Note: Application of internal noise criteria requires that the affected residential apartments could not be conventionally "naturally ventilated" unless the façade noise level is within 10dB of the project internal noise goal (i.e. so that once the noise travels to inside through the window open for natural ventilation, it would be compliant internally).

Using the design internal noise goals and their proposed façade construction (subject to detailed design), a developer can calculate the cumulative allowable patron and music noise level to a residential façade within the Site (i.e. outside a bedroom or living room window). From that, once the Castle Hill Showground noise is considered, each tenancy within the Site can be allocated a noise emission contribution to the nearest residential receiver based on the number of tenancies impacting that receiver. This approach allows flexibility to balance operational restrictions on the retail premises versus cost of façade treatments whilst maintaining amenity to residential premises within the Site.

8.1.2.2 Special uses

For "special uses", the controls will be informed by license conditions applied to similar premises, bearing in mind the time of use, frequency, duration, level and nature of the noise. If the frequency, duration or level of events is different from the presented assumptions, then the controls are to be revised.

It is proposed to utilise the controls applied to the Sydney Cricket Ground and Allianz Stadium as nominated in the Noise Management Plan (NMP) prepared by ERM (Reference: 0348672RP01_F03, Dated: 25th of January 2017) to inform the goals for "special uses" of the Castle Hill Showground.

Concerts, rehearsals and sound tests

During sound test/s, rehearsal/s and concert/s, the L_{Amax} and L_{Cmax} shall not exceed 60dB(A) and 80dB(C) when measured within a habitable room of a residential premise (assuming windows are open for natural ventilation). If the residential premise is alternatively ventilated, internal noise goals of 60dB(A) $L_{max (15min)}$ and 80dB(C) $L_{max (15min)}$ shall be applied internally (windows closed).

Concerts, rehearsals and sound tests must not commence prior to 10:00am.

Rehearsals and sound tests shall conclude by 7:00pm and their duration should be kept to an absolute minimum.

Concerts shall conclude by 11:00pm (and should not be scheduled to conclude any later than 10:30pm).

Concerts (or similar events) shall be limited to 5 per calendar year. If an event (like a festival) extends over multiple days, each day shall count as a separate event.

Sporting events and other outdoor events with sound amplification

Events shall not commence before 8:00am or be scheduled to finish after 10:30pm (if use outside these hours is required, the noise goals shall be revised).

Other than sporting events, events on days preceding working days shall not finish after 8:00pm.

The $L_{Amax (15min)}$ of noise emanating from any sound amplification equipment must not exceed 50dB(A) when measured within a habitable room of a residential premise (assuming windows are open for natural ventilation). If the residential premise is mechanically ventilated, an internal noise goal of 50dB(A) $L_{Amax (15min)}$ shall be applied internally (windows closed).

8.1.3 Noise from the use of licensed premises to existing residential receivers

Noise from the use of a licensed premise on the Site to existing residential receivers external to the Hills Showground Station Precinct shall be assessed for compliance with the Liquor and Gaming NSW (L&GNSW) standard noise criteria. Noise emission from licensed premises in NSW, such as restaurants, bars and clubs, should aim to comply with the standard noise criteria set by L&GNSW. The L&GNSW criteria applies to all noise emission associated with activities from the licensed area of the premises, including music and patron noise, but excludes mechanical services equipment.

L&GNSW, through the Liquor Act 2007, is the regulatory authority that deals with noise pollution issues pertaining to licensed premises. L&GNSW recommends the use of their standard noise criteria when assessing noise impact from licensed premises and when determining the occurrence of noise nuisance and annoyance. Noise emissions are assessed in terms of the following 'Standard Noise Condition':

"The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5Hz – 8kHz inclusive) by more than 5dB between 7:00am and 12:00 midnight at the boundary of any affected residence.*

The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5Hz – 8kHz inclusive) between 12:00 midnight and 7:00am at the boundary of any affected residence.*

Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of 12:00 midnight and 7:00am.

Interior noise levels which still exceed safe hearing levels are in no way supported or condoned by the NSW Office of Liquor, Gaming and Racing.

This is a minimum standard. In some instances the Board may specify a time earlier than midnight in respect of the above condition.

**For the purposes of this condition, the LA10 can be taken as the average maximum deflection of the noise emission from the licensed premises."*

For the determination of octave band criteria, octave band noise levels measured by the long-term noise loggers at L1 and L2 have been utilised. The assessment periods for the proposed operations are;

- 7am - 6pm
- 6pm - 10pm
- 10pm - 12am; and
- 12am - 7am

The long term noise logger measurements were analysed between the above time periods to establish the L&GNSW noise goals and are set out in Table 15: L&GNSW noise goals Table 15 below.

Table 15: L&GNSW noise goals - $L_{10(15min)}$ dB(Z)

Assessment period	Octave band centre frequency - Hz (dBZ)								
	31.5	63	125	250	500	1k	2k	4k	8k
Location L1									
7am – 6pm	61	64	57	52	51	55	50	42	31
6pm - 10pm	58	61	55	49	49	54	50	38	26
10pm - 12am	50	53	46	41	41	43	37	23	21
12am - 7am (external - inaudibility)*	48	32	27	21	18	18	10	5	7
Location L2									
7am – 6pm	57	59	54	49	45	47	43	34	23
6pm - 10pm	53	56	51	43	41	44	39	26	20
10pm - 12am	48	50	45	38	35	37	30	21	19
12am - 7am (external - inaudibility)*	48	30	27	18	17	17	10	4	7

Notes:

* Assumed that if inaudibility is achieved externally the internal inaudibility criterion will also be achieved.

^ Threshold of hearing in accordance with AS3657.1, taken as the lowest third octave level for the respective octave band.

For the assessment of inaudibility Renzo Tonin and Associates adopt a design criterion of 10dB below the background noise level in each octave band for intermittent noise sources such as patrons and music.

In addition to the controls presented in Table 15, as the development of the Hills Showground Station Precinct could result in numerous licensed premises impacting a receiver, to protect existing residential receivers from cumulative impacts from multiple licensed premises, it is proposed to limit cumulative impacts to any existing residential receivers external to the Site to background + 5dB prior to midnight, and background + 0dB after midnight. This same approach was applied for the redevelopment of the Barangaroo South Precinct which also included activated street-fronts with the potential for existing receivers (i.e. external to the precinct) to be impacted by noise from multiple licensed premises.

Based on the site measured background noise levels, Table 16 presents the Site cumulative patron and music noise limits at existing external residential receivers.

Table 16 - Cumulative Site patron and music noise levels dB(A) $L_{eq(15min)}$

Location	Cumulative patron and music noise levels dB(A) $L_{90(15min)}$			
	Day 7am - 6pm	Evening (6pm - 10pm)	Late Evening (10pm - 12am)	Overnight (12am - 7am)
L1- Showground Road	59	58	39	34
L2- Carrington Road	52	48	37	32
L3- De Clambe Drive (Castle Hill Showground)	47	46	37	32
L4- Cattai Creek	48	47	43	38

8.1.4 NSW Noise Policy for Industry

Noise impact is assessed in accordance with the NSW 'Noise Policy for Industry' (NPfI), 2017. The assessment procedure has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for residences and other land uses.

In accordance with the NPfI, noise impact should be assessed against the project noise trigger level which is the lower value of the project intrusiveness noise levels and project amenity noise levels.

8.1.4.1 Project intrusive noise levels

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the $L_{Aeq,15min}$ descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is determined as follows:

$$L_{Aeq,15min} \text{ Intrusiveness noise level} = \text{Rating Background Level ('RBL')} \text{ plus } 5\text{dB(A)}$$

Based on the background noise monitoring results and the proposed operating hours of the facility, the intrusiveness noise levels for residential receivers are reproduced in Table 17 below.

Table 17: Intrusiveness noise levels

Receiver	Intrusiveness noise level, $L_{Aeq,15min}$		
	Day	Evening	Night
Showground Rd Residences	54 + 5 = 59	53 + 5 = 58	34 + 5 = 39
Carrington Road Residences	47 + 5 = 52	43 + 5 = 48	32 + 5 = 37

Notes: Day: 7:00 to 18:00 Monday to Saturday and 8:00 to 18:00 Sundays & Public Holidays
 Evening: 18:00 to 22:00 Monday to Sunday & Public Holidays
 Night: 22:00 to 7:00 Monday to Saturday and 22:00 to 8:00 Sundays & Public Holidays

8.1.4.2 Amenity noise levels

The project amenity noise levels for different time periods of day are determined in accordance with Section 2.4 of the NPfI. The NPfI recommends amenity noise levels ($L_{Aq,period}$) for various receivers including residential, commercial, industrial receivers and sensitive receivers such as schools, hotels, hospitals, churches and parks. These "recommended amenity noise levels" represent the objective for total industrial noise experienced at receiver location. However, when assessing a single industrial development and its impact on an area, "project amenity noise levels" apply.

The recommended amenity noise levels applicable for the surrounding area are reproduced in Table 18 below.

Table 18: Project amenity noise levels

Type of Receiver	Noise Amenity Area	Time of Day	Recommended amenity noise level, L_{Aeq} , dB(A)
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom (internal)	All	Noisiest 1-hour period when in use	35
Hospital ward	All		
Internal		Noisiest 1-hour	35
external		Noisiest 1-hour	50
Place of worship (internal)	All	When in use	40
Passive recreation (e.g. national park)	All	When in use	50
Active recreation (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	When in use	Add 5 dB(A) to recommended noise amenity area

- Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
 2. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
 3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
 4. The recommended amenity noise levels refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated

To ensure that the total industrial noise level (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level that applies for each new industrial noise source is determined as follows:

$$L_{Aeq,period} \text{ Project amenity noise level} = L_{Aeq,period} \text{ Recommended amenity noise level} - 5\text{dB(A)}$$

Furthermore, given that the intrusiveness noise level is based on a 15 minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods.

$$L_{Aeq,15minute} = L_{Aeq,period} + 3dB(A)$$

The project amenity noise levels ($L_{Aeq, 15min}$) applied for this project are reproduced in Table 19 below, based on a 'suburban' noise amenity area.

Table 19 Project amenity noise levels

Type of Receiver	Noise Amenity Area	Time of Day	Recommended Noise Level, dB(A)	
			$L_{Aeq, Period}$	$L_{Aeq, 15min}$
Residence	Suburban	Day	$55 - 5 = 50$	$50 + 3 = 53$
		Evening	$45 - 5 = 40$	$40 + 3 = 43$
		Night	$40 - 5 = 35$	$35 + 3 = 38$
Commercial Premises	All	When in use	$65 - 5 = 60$	$60 + 3 = 63$
Industrial Premises	All	When in use	$70 - 5 = 65$	$65 + 3 = 68$
Active recreation area (Showground)	All	When in use	$55 - 5 = 50$	$50 + 3 = 53$

- Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
 2. On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.
 3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

8.1.4.3 Project noise trigger levels

In accordance with the NPfI the project noise trigger levels, which are the lower (i.e. more stringent) value of the project intrusiveness noise level and project amenity noise level, have been determined as shown in Table 20 below.

Table 20 Project noise trigger levels

Receiver Location	$L_{Aeq, 15min}$ Project noise trigger levels, dB(A)		
	Day	Evening	Night
Residential Receivers Showground Road	53	43	38
Residential Receivers Carrington Road	52	48	37
Commercial	63 (when in use)		
Industrial	68 (when in use)		
Active recreation area	53 (when in use)		

8.1.4.4 Sleep disturbance noise levels

The potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered. In accordance with NPfI, a detailed maximum noise level event assessment should be undertaken where the subject development night-time noise levels at a residential location exceed:

- $L_{Aeq,15min}$ 40dB(A) or the prevailing RBL plus 5dB, whichever is the greater, and/or
- L_{AFmax} 52dB(A) or the prevailing RBL plus 15dB, whichever is the greater.

Where there are noise events found to exceed the initial screening level, further analysis is undertaken to identify:

- The likely number of events that might occur during the night assessment period,
- The extent to which the maximum noise level exceeds the rating background noise level.

The sleep disturbance noise levels for the project are presented in Table 21.

Table 21: Sleep disturbance assessment levels

Receiver type	Assessment Level $L_{Aeq,15min}$	Assessment Level L_{AFmax}
Residential Receivers	40	52

8.2 Assessment of operational noise intrusion

Assessment of operational noise intrusion from the operation of the Hills Showground Station Precincts is to be undertaken during future DAs when the design parameters are known.

8.2.1 In principle treatment of mechanical plant and equipment

Mechanical plant associated with the development has the potential to impact on nearby noise sensitive properties. In order to carry out a quantitative assessment of mechanical equipment, a complete specification of equipment is required. At this stage of the development appropriate detail for mechanical plant is not typically available. A qualitative assessment has therefore been carried out and in-principle noise management measures outlined:

- Acoustic assessment of mechanical services equipment should be undertaken during the detail design phase of the development to ensure that the cumulative noise of all equipment does not exceed the applicable noise criteria. Development Consent Conditions typically require detailed assessment of mechanical plant and equipment prior to issue of the Construction Certificate.
- Noise control treatment can affect the operation of the mechanical services system. An acoustic engineer should be consulted during the initial design phase of mechanical services system to reduce potential redesign of the mechanical system.

- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
 - procurement of 'quiet' plant
 - strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises
 - commercially available acoustic attenuators for air discharge and air intakes of plant
 - acoustically lined and lagged ductwork
 - acoustic barriers between plant and sensitive neighbouring premises
 - partial or complete acoustic enclosures over plant.
- The specification and location of mechanical plant should be confirmed prior to installation on site, and
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 '*Rotating and Reciprocating Machinery – Mechanical Vibration*'.

8.2.2 Loading dock

The built-form of the loading docks is subject to design and as such, it is not possible to conduct a meaningful assessment of noise emission at this time. A full assessment shall be conducted during DA stage of the supermarket site.

9 Internal sound insulation

9.1 NCC BCA 2019 - Class 2 or 3

The internal sound insulation of the future residential apartments will need to be designed for compliance with the National Construction Code. The particular constructions for compliance with the code will be subject of design by the future development team/s for DA/CC.

The current National Construction Code Series (NCC) 2019 - Volume 1, Building Code of Australia sets out the following acoustic provisions for Class 2 and 3 buildings:

F5.2 Determination of airborne sound insulation ratings

A form of construction required to have an airborne sound insulation rating must –

- c. have the required value for weighted sound reduction index (R_w) or weighted sound reduction index with spectrum adaptation term ($R_w + C_{tr}$) determined in accordance with AS/NZS 1276.1 or ISO 717.1 using results from laboratory measurements; or*
- d. comply with Specification F5.2.*

F5.3 Determination of impact sound insulation ratings

- e. A floor in a building required to have an impact sound insulation rating must –*
 - i. have the required value for weighted normalised impact sound pressure level ($L_{n,w}$) determined in accordance with AS/ISO 717.2 using results from laboratory measurements; or*
 - ii. comply with Specification F5.2.*
- f. A wall in a building required to have an impact sound insulation rating must –*
 - iii. for a Class 2 or 3 building be of discontinuous construction;*
- g. For the purposes of this part, discontinuous construction means a wall having a minimum 20 mm cavity between 2 separate leaves, and*
 - iv. for masonry, where wall ties are required to connect leaves, the ties are of the resilient type; and*
 - v. for other than masonry, there is no mechanical linkage between leaves except at the periphery.*

F5.4 Sound insulation rating of floors

- h. A floor in a Class 2 or 3 building must have an $R_w + C_{tr}$ (airborne) not less than 50 and an $L_{n,w}$ (impact) not more than 62 if it separates –*
 - vi. sole-occupancy units; or*

- vii. *a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.*

F5.5 Sound insulation rating of walls

- i. *A wall in a Class 2 or 3 building must –*
 - viii. *have an $R_w + C_{tr}$ (airborne) not less than 50, if it separates sole-occupancy units; and*
 - ix. *have an R_w (airborne) not less than 50, if it separates a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification; and*
 - x. *comply with F5.3(b) if it separates:*
 - (A) *a bathroom, sanitary compartment, laundry or kitchen in one sole-occupancy unit from a habitable room (other than a kitchen) in an adjoining unit; or*
 - (B) *a sole-occupancy unit from a plant room or lift shaft.*
- j. *A door may be incorporated in a wall in a Class 2 or 3 building that separates a sole-occupancy unit from a stairway, public corridor, public lobby or the like, provided the door assembly has an R_w not less than 30.*
- k. *Where a wall required to have sound insulation has a floor above, the wall must continue to –*
 - xi. *the underside of the floor above; or*
 - xii. *a ceiling that provides the sound insulation required for the wall.*

F5.6 Sound insulation rating of services

- l. *If a duct, soil, waste or water supply pipe, including a duct or pipe that is located in a wall or floor cavity, serves or passes through more than one sole-occupancy unit, the duct or pipe must be separated from the rooms of any sole-occupancy unit by construction with an $R_w + C_{tr}$ (airborne) not less than –*
 - xiii. *40 if the adjacent room is a habitable room (other than a kitchen); or*
 - xiv. *25 if the adjacent room is a kitchen or non-habitable room.*
- m. *If a storm water pipe passes through a sole-occupancy unit it must be separated in accordance with (a).*

10 Conclusion

Renzo Tonin & Associates have undertaken attended and unattended noise and vibration measurements at the Hills Showground Station Precinct. Existing environmental noise impacts from road traffic noise on Showground Road and Carrington Road are capable of complying with the requirements of the SEPP (Infrastructure) 2007 and ISEPP Guideline 2008 subject to detailed design.

Noise emission goals from the use of mechanical plant and equipment and vehicles being driven on site have been set in accordance with the NSW EPA NPfl. Compliance with those goals to existing residential receivers is achievable (subject to careful siting and design).

Criteria have been set for the management of normal noise emissions from use of activated street-fronts and use of the Castle Hill Showground. Additional controls have been set for special uses of the Castle Hill Showground. These controls may need to be refined pending the outcomes of the Castle Hill Showground Masterplan.

The recommendations are summarised in the following table:

Guidelines/Policies/Standards	Report section	Recommendations
RNP ISEPP DPIE Development in Rail Corridors and Busy Roads - Interim Guideline (road noise) AS/NZS 2107:2016	5	Indicative glazing for facades fronting the roads, subject to detailed design
DPIE Development in Rail Corridors and Busy Roads - Interim Guideline (rail noise) DEC Assessing Vibration: A technical guideline (rail vibration)	6	Vibration impacts from the Metro rail movements were measured and found to be compliant with the DPIE and DEC Guidelines, without additional treatments (based on the proposed range of uses).
The Sydney Metro Underground Corridor Protection - Technical Guidelines	7	Preparation of a CNVMP during the construction certificate phase
NPfl	8	Project noise trigger levels have been set in accordance with the NPfl. Detailed assessments will be required for DA and CC submissions, subject to detailed design.
Liquor and Gaming NSW (patron and music noise from licensed premises to receivers external to the precinct)	8	Noise emission goals from the use of a licensed premise to residential receivers outside of the Hills Showground Station Precinct have been set. Controls for compliance shall be subject to detailed design for DA and CC. In addition, goals have been set for the assessment of noise from cumulative operation of the Site licensed premises to existing residential receivers using an approach previously applied at the Barangaroo South Masterplan Noise Assessment.

Guidelines/Policies/ Standards	Report section	Recommendations
Noise from active street-fronts – there are no state level guidelines specifically addressing impacts of active street-fronts or community uses on a residential Precinct	8	<p>Cumulative goals for patron and music noise at Site residential façades have been set for “normal use” of active street-fronts and “normal use” of Castle Hill Showground, as informed by the Barangaroo South Master Plan Noise Assessment. The corresponding cumulative external patron and music noise goals (assuming windows closed and residences provided with alternative ventilation) will be determined by the performance of the facade, subject to detailed design.</p> <p>For the management of noise from “special uses” of the Castle Hill Showground, noise management protocols have been set as informed by the Sydney Cricket Ground and Allianz Stadium Noise Management Plan. The corresponding external goals (assuming windows closed and residences provided with alternative ventilation) will be determined by the performance of the façade, subject to detailed design.</p> <ul style="list-style-type: none"> Note: The Castle Hill Showground Masterplan is currently being prepared and should be available for acoustic review for DA/CC.
National Construction Code / Building Code of Australia Part F5	9	The design of compliant systems for the acoustic separation of sole occupancy units and separation of different classifications is to be addressed in detailed design. The version of the code applicable to the Site will depend on the “Stop the clock” date for that Site. The current NCC/BCA 2019 acoustic separation requirements are included for information.
RNP ISEPP DPIE Development in Rail Corridors and Busy Roads - Interim Guideline (road noise) AS/NZS 2107:2016	5	Indicative glazing for facades fronting the roads, subject to detailed design
DPIE Development in Rail Corridors and Busy Roads - Interim Guideline (rail noise) DEC Assessing Vibration: A technical guideline (rail vibration)	6	Vibration impacts from the Metro rail movements were measured and found to be compliant with the DPIE and DEC Guidelines, without additional treatments (based on the proposed range of uses).
The Sydney Metro Underground Corridor Protection - Technical Guidelines	7	Preparation of a CNVMP during the construction certificate phase
NPfl	8	Project noise trigger levels have been set in accordance with the NPfl. Detailed assessments will be required for DA and CC submissions, subject to detailed design.
Liquor and Gaming NSW (patron and music noise from licensed premises to receivers external to the precinct); Barangaroo South Masterplan Noise Assessment	8	<p>Noise emission goals from the use of a licensed premise to residential receivers outside of the Hills Showground Station Precinct have been set. Controls for compliance shall be subject to detailed design for DA and CC.</p> <p>In addition, goals have been set for the assessment of noise from cumulative operation of the Site licensed premises to existing residential receivers.</p>

Guidelines/Policies/ Standards	Report section	Recommendations
Noise from active street-fronts (as informed by the Barangaroo South Master Plan Noise Assessment) and Castle Hill Showground (as informed by the Sydney Cricket Ground and Allianz Stadium Noise Management Plan)	8	<p>Cumulative goals for patron and music noise at Site residential façades have been set for “normal use” of active street-fronts and Castle Hill Showground, as informed by the Barangaroo South Master Plan Noise Assessment. The corresponding cumulative external patron and music noise goals (assuming windows closed and residences provided with alternative ventilation) will be determined by the performance of the façade, subject to detailed design.</p> <p>For the management of noise from “special uses” of the Castle Hill Showground, noise management protocols have been set as informed by the Sydney Cricket Ground and Allianz Stadium Noise Management Plan. The corresponding external goals (assuming windows closed and residences provided with alternative ventilation) will be determined by the performance of the façade, subject to detailed design.</p> <p>Note: The Castle Hill Showground Masterplan is currently being prepared and should be available for acoustic review for DA/CC.</p>
National Construction Code / Building Code of Australia Part F5	9	<p>The design of compliant systems for the acoustic separation of sole occupancy units and separation of different classifications is to be addressed in detailed design. The version of the code applicable to the Site will depend on the “Stop the clock” date for that Site. The current NCC/BCA 2019 acoustic separation requirements are included for information.</p>

Risk management is an integral part of good management practice. AS/NZS 4360-1999 “Risk Management” has become part of our company’s culture and as a consequence it permeates all aspects of the company’s work and is actively promoted to our clients. APPENDIX C sets out Renzo Tonin & Associates’ risk analysis.

APPENDIX A Glossary of terminology

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

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
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. A point at which noise measurements are taken or estimated.
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 L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The A-weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in 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 on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L _{Max}	The maximum sound pressure level measured over a given period.
L _{Min}	The minimum sound pressure level measured over a given period.

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 L90 noise level expressed in units of dB(A).
L _{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
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 L _{eq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
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 noise, usually 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.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B **Locations and results of noise and vibration surveys**

Refer to Figure 3 for measurement locations.

Hills Showground Masterplan - Location L1

Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

Date	L _{A90} Background Noise Levels ⁴			L _{Aeq} Ambient Noise Levels		
	Day ¹	Evening ²	Night ³	Day ¹	Evening ²	Night ³
Thursday-19-September-2019	-	54	-	-	67	-
Friday-20-September-2019	56	55	33	67	66	62
Saturday-21-September-2019	56	52	35	67	65	61
Sunday-22-September-2019	53	51	33	66	65	61
Monday-23-September-2019	54	52	35	66	64	62
Tuesday-24-September-2019	52	53	34	67	66	63
Wednesday-25-September-2019	53	53	34	67	65	62
Thursday-26-September-2019	54	54	35	67	66	62
Friday-27-September-2019	-	-	-	-	-	-
Representative Weekday⁵	54	54	34	67	66	62
Representative Weekend⁵	55	52	34	67	65	61
Representative Week⁵	54	53	34	67	66	62

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times

2. Evening is 6:00pm to 10:00pm

3. Night is the remaining periods

4. Assessment Background Level (ABL) for individual days

5. Rating Background Level (RBL) for LA90 and logarithmic average for LAeq

6. Leq is calculated in the

free field. 2.5dB is subtracted from results if logger is placed at façade

7. Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

Hills Showground Masterplan - Location L1

Road / Rail Noise Monitoring Results (at one metre from façade)

Date	L _{Aeq} Noise Levels		L _{Aeq 1hr} Noise Levels			
	Day ¹	Night ²	Day - Up ⁴	Day - Low ⁵	Night - Up ⁴	Night - Low ⁵
Thursday-19-September-2019	70	64	70	69	68	58
Friday-20-September-2019	69	64	70	68	66	60
Saturday-21-September-2019	69	64	70	67	66	59
Sunday-22-September-2019	68	64	70	67	67	58
Monday-23-September-2019	68	64	69	67	68	59
Tuesday-24-September-2019	69	65	70	68	68	58
Wednesday-25-September-2019	69	64	70	68	68	59
Thursday-26-September-2019	69	65	70	69	68	60
Friday-27-September-2019	69	-	69	69	-	-
Representative Weekday³	69	64	70	68	68	59
Representative Weekend³	69	64	70	67	67	58
Representative Week³	69	64	70	68	68	59

Notes:

1. Day is 7:00am to 10:00pm

2. Night is 10:00pm to 7:00am

3. Median of daily L_{Aeq}

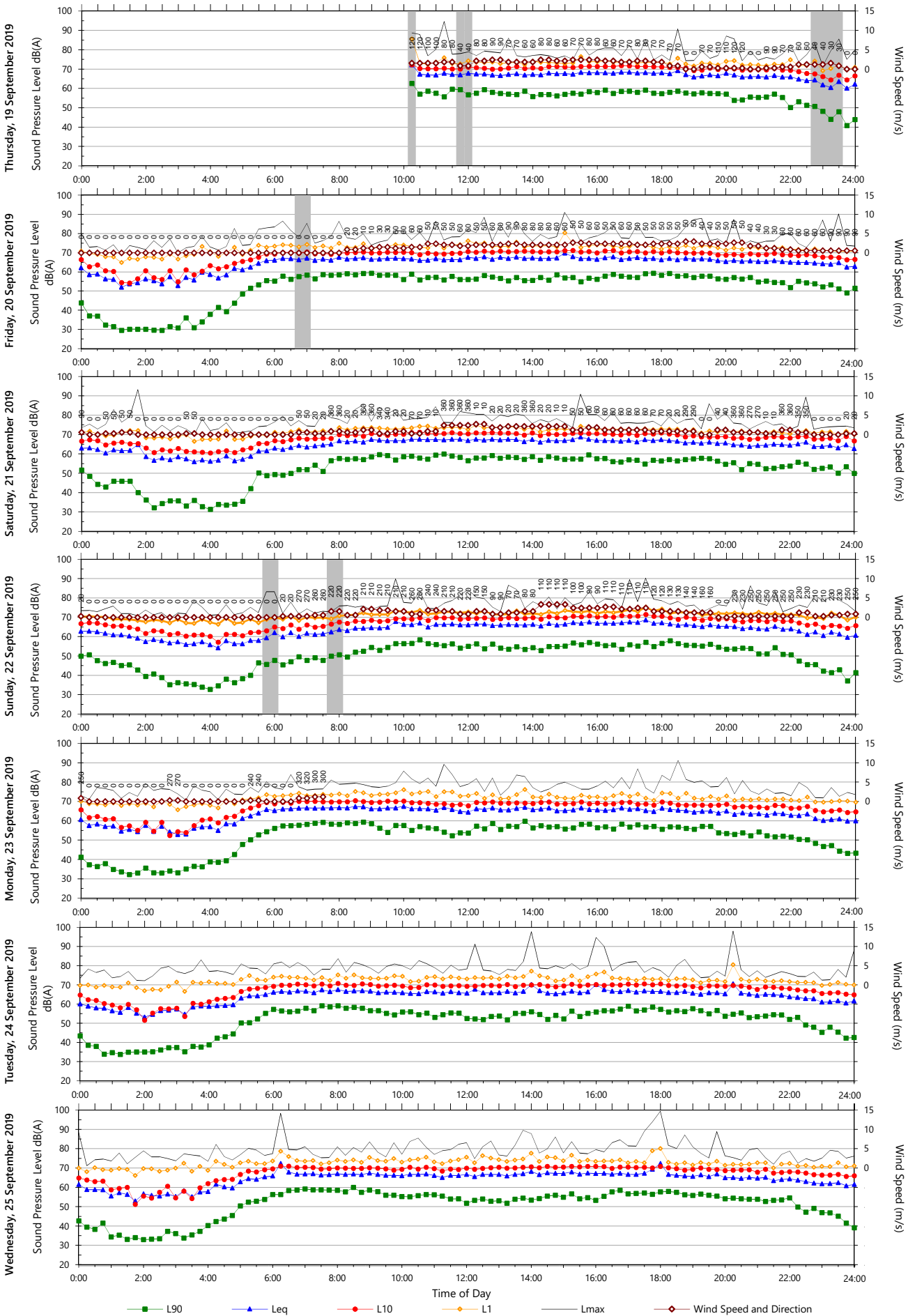
4. Upper 10th percentile L_{Aeq 1hr}

5. Lower 10th percentile L_{Aeq 1hr}

6. Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field

Unattended Monitoring Results

Location: Hills Showground Masterplan - Location L1

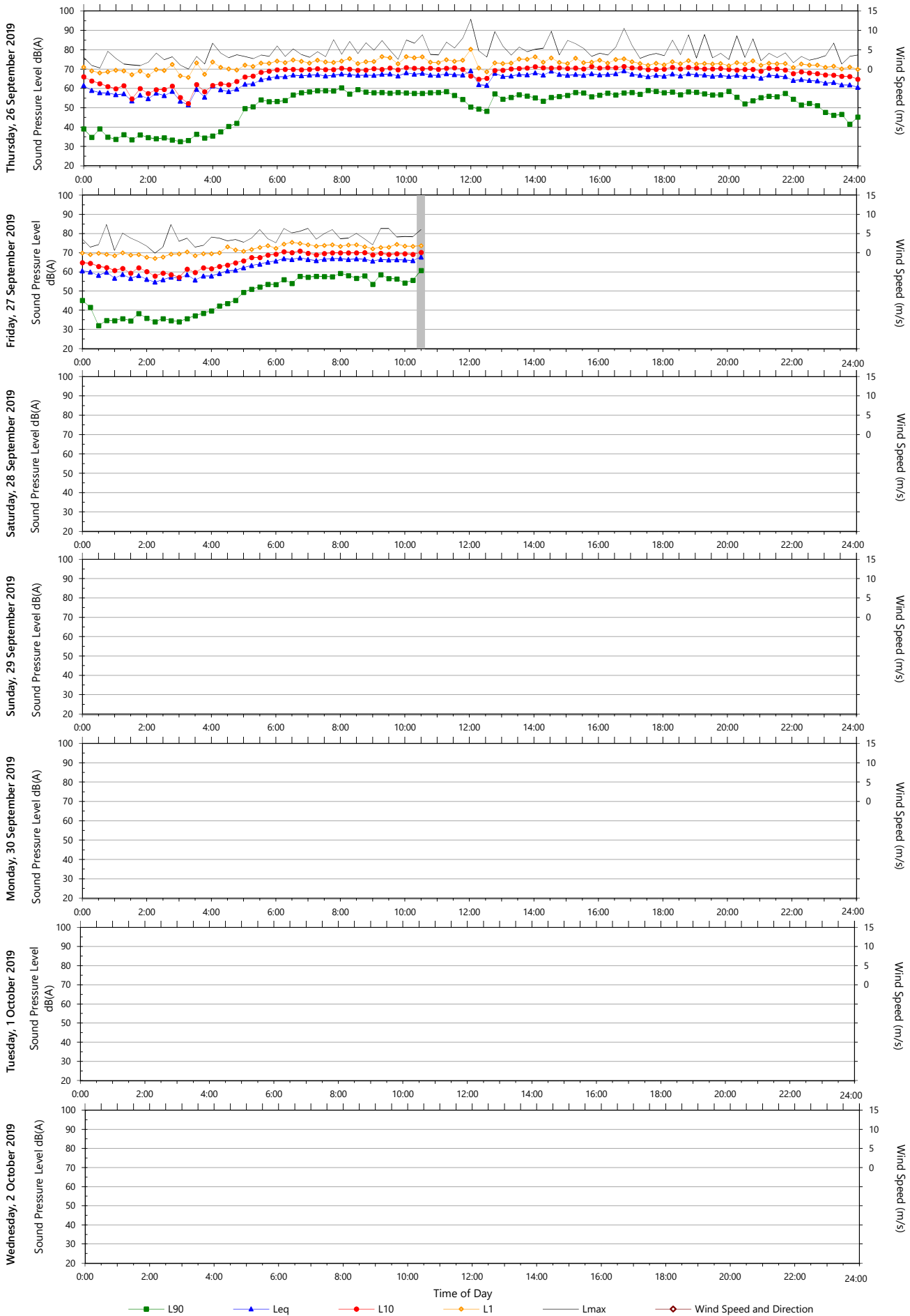


Data File: 2019-09-19_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r30)

Unattended Monitoring Results

Location: Hills Showground Masterplan - Location L1



Data File: 2019-09-19_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r30)

Hills Showground Masterplan - Location L2

Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

Date	L _{A90} Background Noise Levels ⁴			L _{Aeq} Ambient Noise Levels		
	Day ¹	Evening ²	Night ³	Day ¹	Evening ²	Night ³
Thursday-19-September-2019	-	45	-	-	61	-
Friday-20-September-2019	49	44	31	64	61	53
Saturday-21-September-2019	47	43	33	62	58	53
Sunday-22-September-2019	47	41	32	65	57	55
Monday-23-September-2019	50	44	35	64	61	55
Tuesday-24-September-2019	47	45	33	63	61	56
Wednesday-25-September-2019	47	42	32	63	61	55
Thursday-26-September-2019	47	43	31	63	62	55
Friday-27-September-2019	-	-	-	-	-	-
Representative Weekday⁵	47	44	32	64	61	55
Representative Weekend⁵	47	42	32	64	58	54
Representative Week⁵	47	43	32	64	61	55

Notes:

- Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
- Evening is 6:00pm to 10:00pm
- Night is the remaining periods
- Assessment Background Level (ABL) for individual days
- Rating Background Level (RBL) for LA90 and logarithmic average for LAeq
- Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at façade
- Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

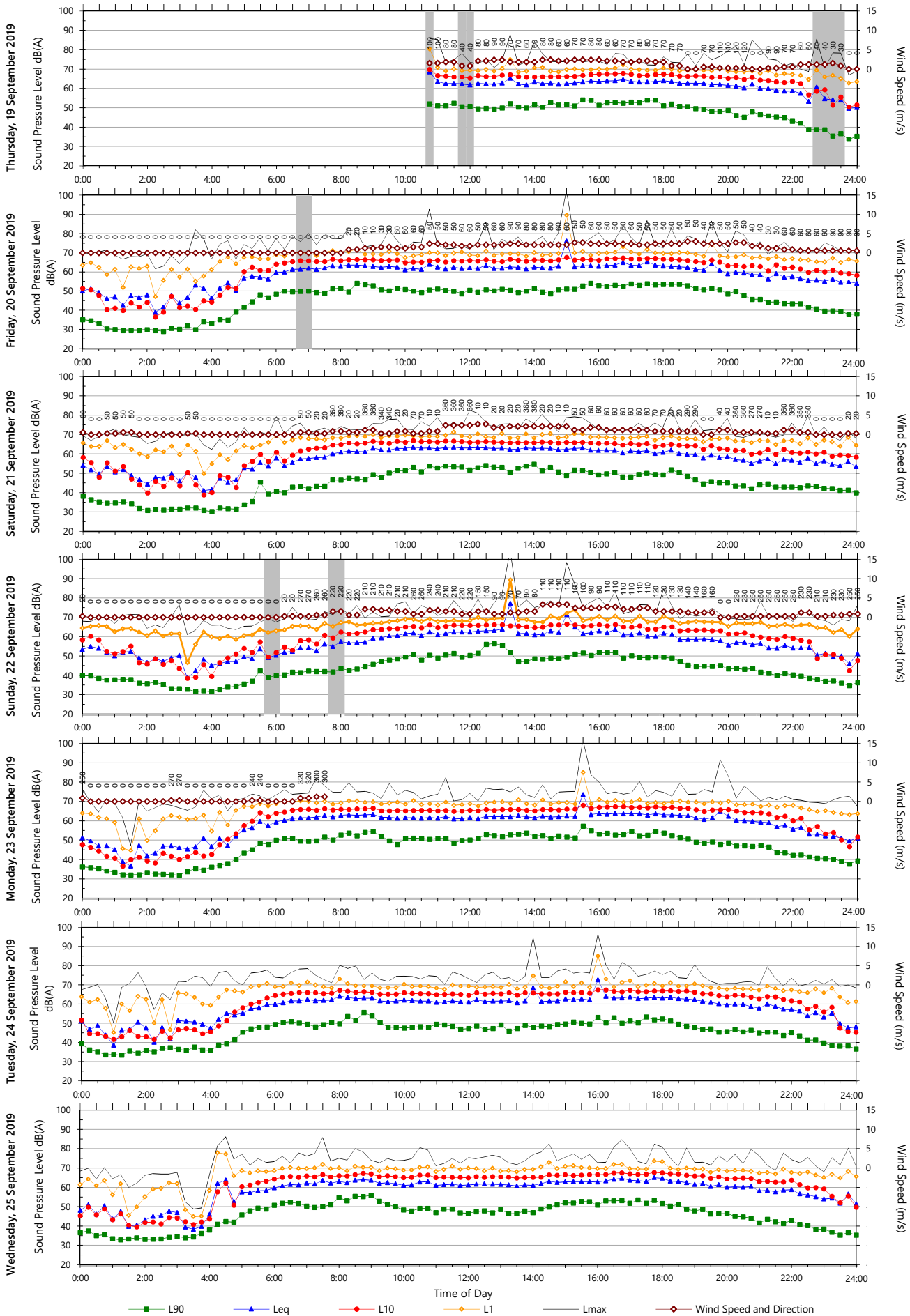
Hills Showground Masterplan - Location L2

Road / Rail Noise Monitoring Results (at one metre from façade)

Date	L _{Aeq} Noise Levels		L _{Aeq 1hr} Noise Levels			
	Day ¹	Night ²	Day - Up ⁴	Day - Low ⁵	Night - Up ⁴	Night - Low ⁵
Thursday-19-September-2019	65	57	66	64	61	49
Friday-20-September-2019	66	56	66	63	58	50
Saturday-21-September-2019	64	55	66	60	57	50
Sunday-22-September-2019	66	57	68	58	62	48
Monday-23-September-2019	65	58	66	63	62	50
Tuesday-24-September-2019	65	59	67	62	63	46
Wednesday-25-September-2019	65	57	66	63	61	47
Thursday-26-September-2019	66	58	68	62	62	50
Friday-27-September-2019	65	-	65	63	-	-
Representative Weekday³	65	58	66	63	61	49
Representative Weekend³	65	56	67	59	59	49
Representative Week³	65	57	66	63	61	49

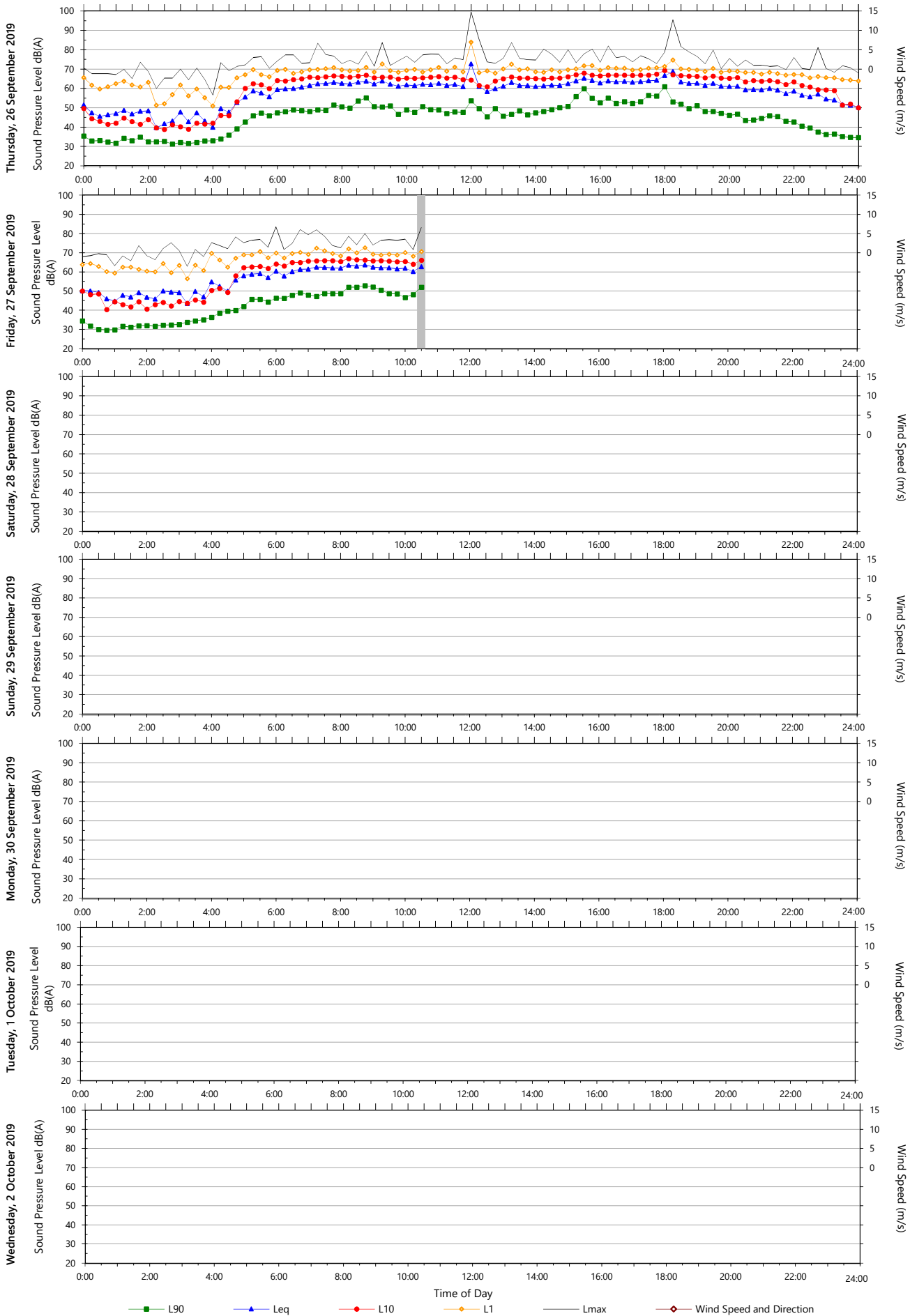
Notes:

- Day is 7:00am to 10:00pm
- Night is 10:00pm to 7:00am
- Median of daily L_{Aeq}
- Upper 10th percentile L_{Aeq 1hr}
- Lower 10th percentile L_{Aeq 1hr}
- Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field



Unattended Monitoring Results

Location: Hills Showground Masterplan - Location L2



Data File: 2019-09-19_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r30)

Hills Showground Masterplan - Location L3

Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

Date	L _{A90} Background Noise Levels ⁴			L _{Aeq} Ambient Noise Levels		
	Day ¹	Evening ²	Night ³	Day ¹	Evening ²	Night ³
Friday-20-September-2019	-	42	31	-	56	49
Saturday-21-September-2019	43	41	33	56	55	52
Sunday-22-September-2019	42	37	32	55	54	51
Monday-23-September-2019	44	42	34	57	56	52
Tuesday-24-September-2019	40	42	33	56	56	52
Wednesday-25-September-2019	40	40	31	56	56	53
Thursday-26-September-2019	41	40	29	56	58	50
Friday-27-September-2019	-	-	-	-	-	-
Representative Weekday⁵	41	42	31	56	56	51
Representative Weekend⁵	42	39	33	56	55	51
Representative Week⁵	42	41	32	56	56	51

Notes:

- Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
- Evening is 6:00pm to 10:00pm
- Night is the remaining periods
- Assessment Background Level (ABL) for individual days
- Rating Background Level (RBL) for LA90 and logarithmic average for LAeq
- Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at façade
- Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

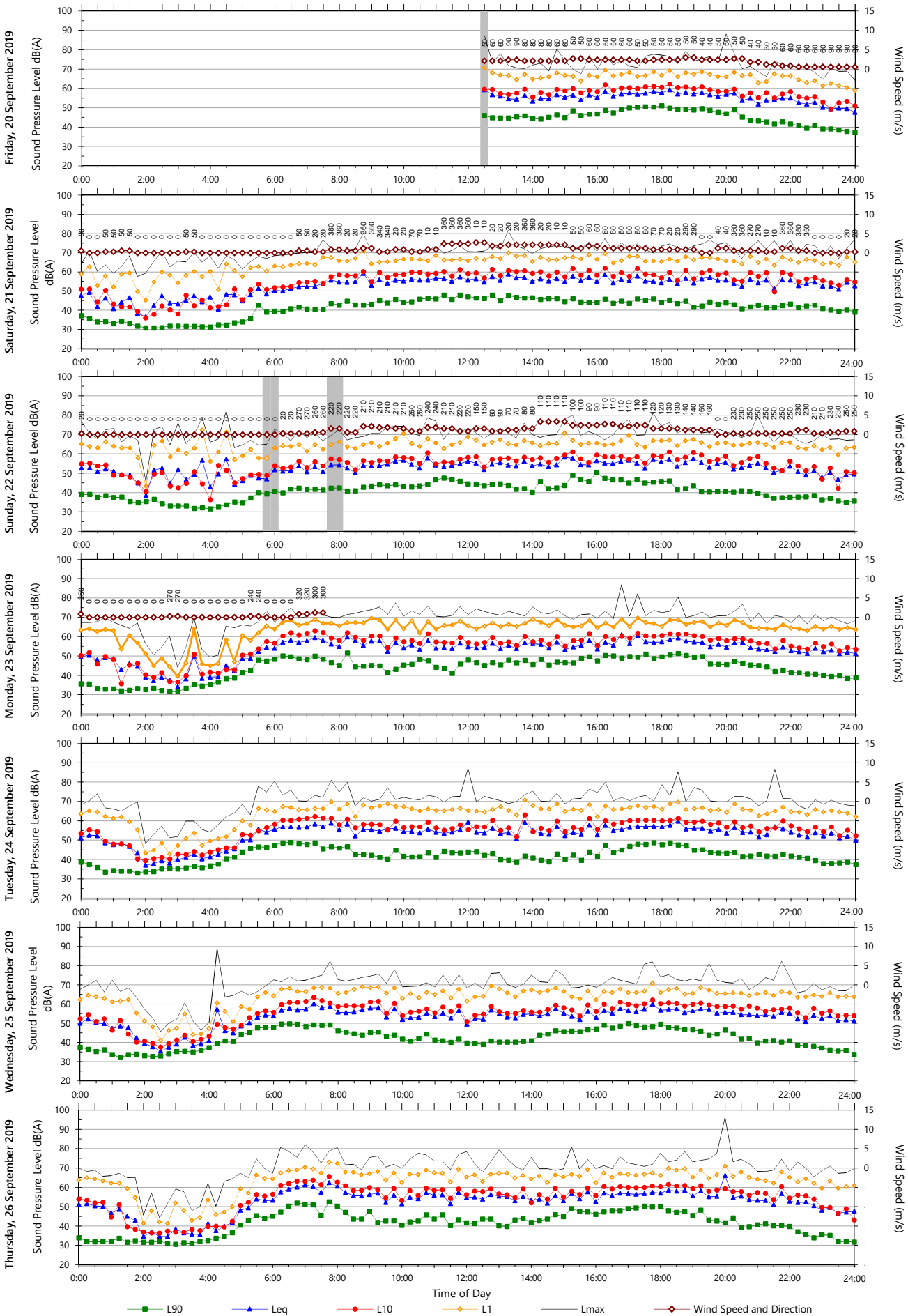
Hills Showground Masterplan - Location L3

Road / Rail Noise Monitoring Results (at one metre from façade)

Date	L _{Aeq} Noise Levels		L _{Aeq 1hr} Noise Levels			
	Day ¹	Night ²	Day - Up ⁴	Day - Low ⁵	Night - Up ⁴	Night - Low ⁵
Friday-20-September-2019	59	51	60	57	54	47
Saturday-21-September-2019	58	54	59	57	56	51
Sunday-22-September-2019	57	53	58	55	56	45
Monday-23-September-2019	59	54	61	57	57	43
Tuesday-24-September-2019	58	54	60	57	56	42
Wednesday-25-September-2019	58	55	60	56	57	40
Thursday-26-September-2019	59	53	62	57	55	41
Friday-27-September-2019	58	-	59	56	-	-
Representative Weekday³	59	54	60	57	56	42
Representative Weekend³	58	54	59	56	56	48
Representative Week³	58	54	60	57	56	43

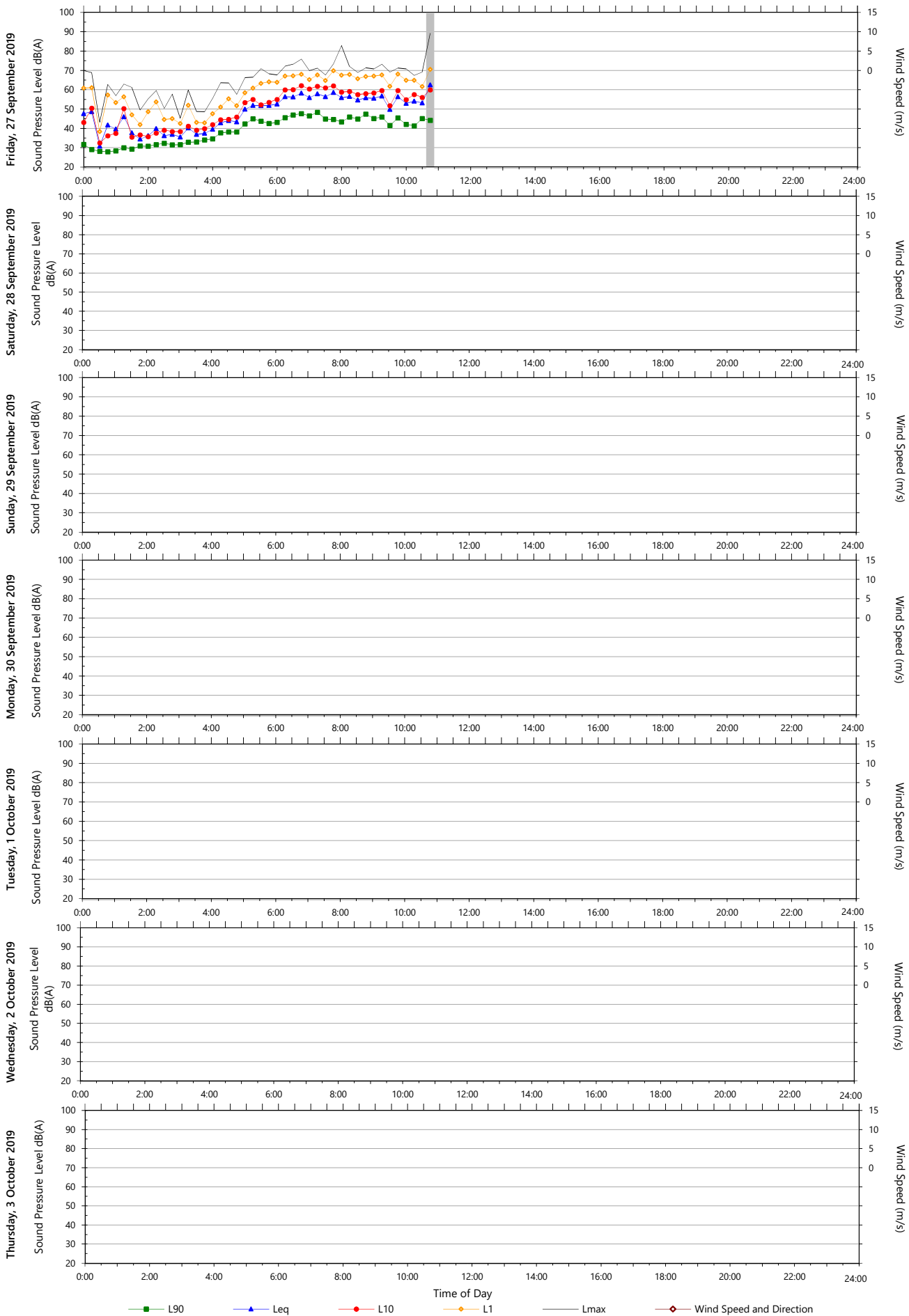
Notes:

- Day is 7:00am to 10:00pm
- Night is 10:00pm to 7:00am
- Median of daily L_{Aeq}
- Upper 10th percentile L_{Aeq 1hr}
- Lower 10th percentile L_{Aeq 1hr}
- Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field



Unattended Monitoring Results

Location: Hills Showground Masterplan - Location L3



Data File: 2019-09-20_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r30)

Hills Showground Masterplan - Location L4

Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

Date	L _{A90} Background Noise Levels ⁴			L _{Aeq} Ambient Noise Levels		
	Day ¹	Evening ²	Night ³	Day ¹	Evening ²	Night ³
Friday-20-September-2019	-	42	34	-	54	45
Saturday-21-September-2019	44	42	35	53	49	46
Sunday-22-September-2019	45	43	42	51	50	49
Monday-23-September-2019	45	44	40	54	53	50
Tuesday-24-September-2019	43	43	39	53	52	50
Wednesday-25-September-2019	42	41	38	53	53	49
Thursday-26-September-2019	43	41	32	53	54	48
Friday-27-September-2019	-	-	-	-	-	-
Representative Weekday⁵	43	42	38	53	53	49
Representative Weekend⁵	44	42	38	52	49	48
Representative Week⁵	43	42	38	53	52	48

Notes:

- Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
- Evening is 6:00pm to 10:00pm
- Night is the remaining periods
- Assessment Background Level (ABL) for individual days
- Rating Background Level (RBL) for LA90 and logarithmic average for LAeq
- Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at façade
- Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

Hills Showground Masterplan - Location L4

Road / Rail Noise Monitoring Results (at one metre from façade)

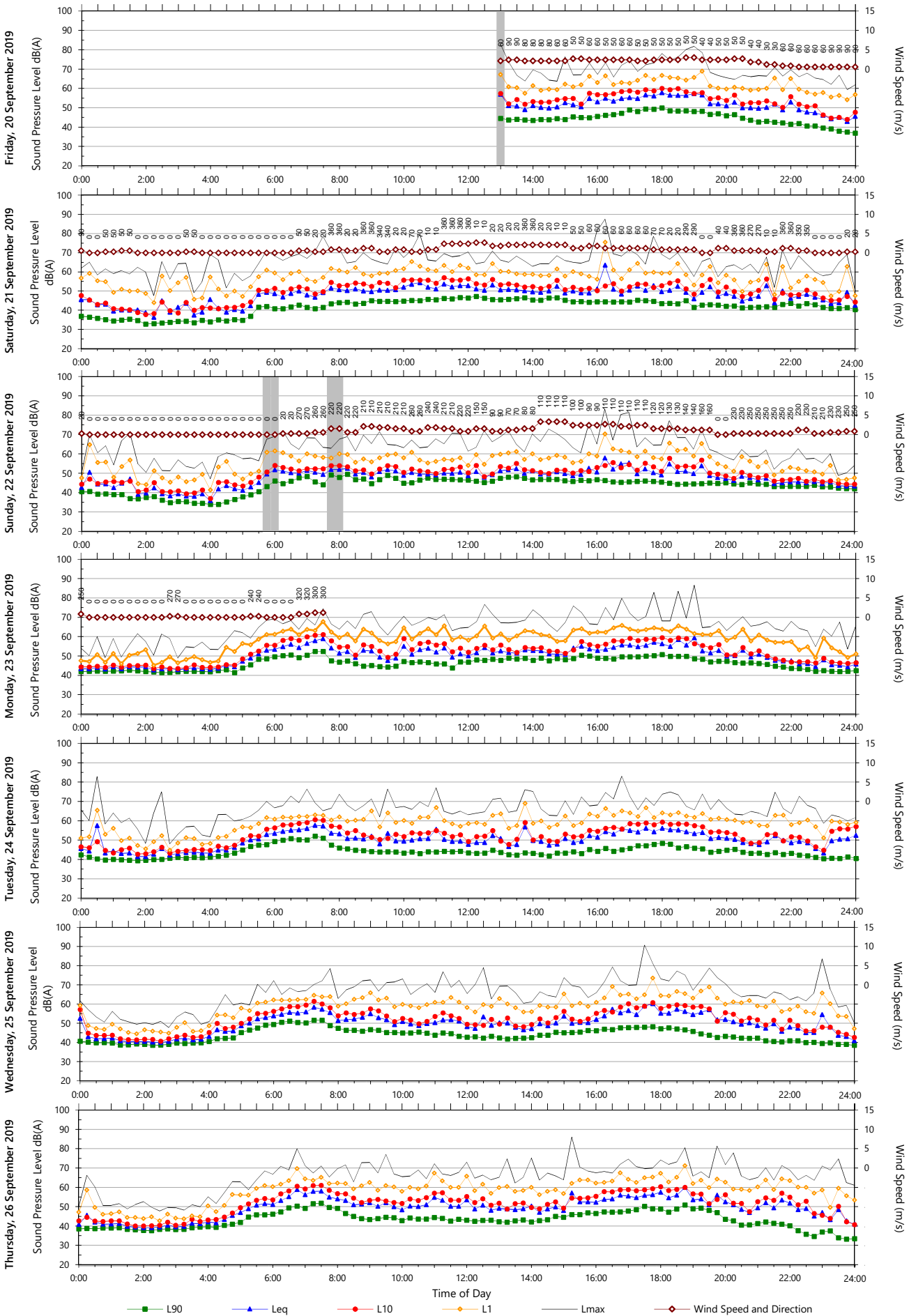
Date	L _{Aeq} Noise Levels		L _{Aeq 1hr} Noise Levels			
	Day ¹	Night ²	Day - Up ⁴	Day - Low ⁵	Night - Up ⁴	Night - Low ⁵
Friday-20-September-2019	56	48	59	53	51	43
Saturday-21-September-2019	54	48	55	52	50	42
Sunday-22-September-2019	53	51	54	51	55	46
Monday-23-September-2019	56	52	59	54	55	46
Tuesday-24-September-2019	55	52	58	52	56	43
Wednesday-25-September-2019	56	52	59	51	54	42
Thursday-26-September-2019	56	50	59	52	54	40
Friday-27-September-2019	56	-	58	53	-	-
Representative Weekday³	56	52	59	52	54	43
Representative Weekend³	54	50	55	51	53	44
Representative Week³	56	51	58	52	54	43

Notes:

- Day is 7:00am to 10:00pm
- Night is 10:00pm to 7:00am
- Median of daily L_{Aeq}
- Upper 10th percentile L_{Aeq 1hr}
- Lower 10th percentile L_{Aeq 1hr}
- Values are calculated at the facade. 2.5dB is added to results if logger is placed in the free field

Unattended Monitoring Results

Location: Hills Showground Masterplan - Location L4

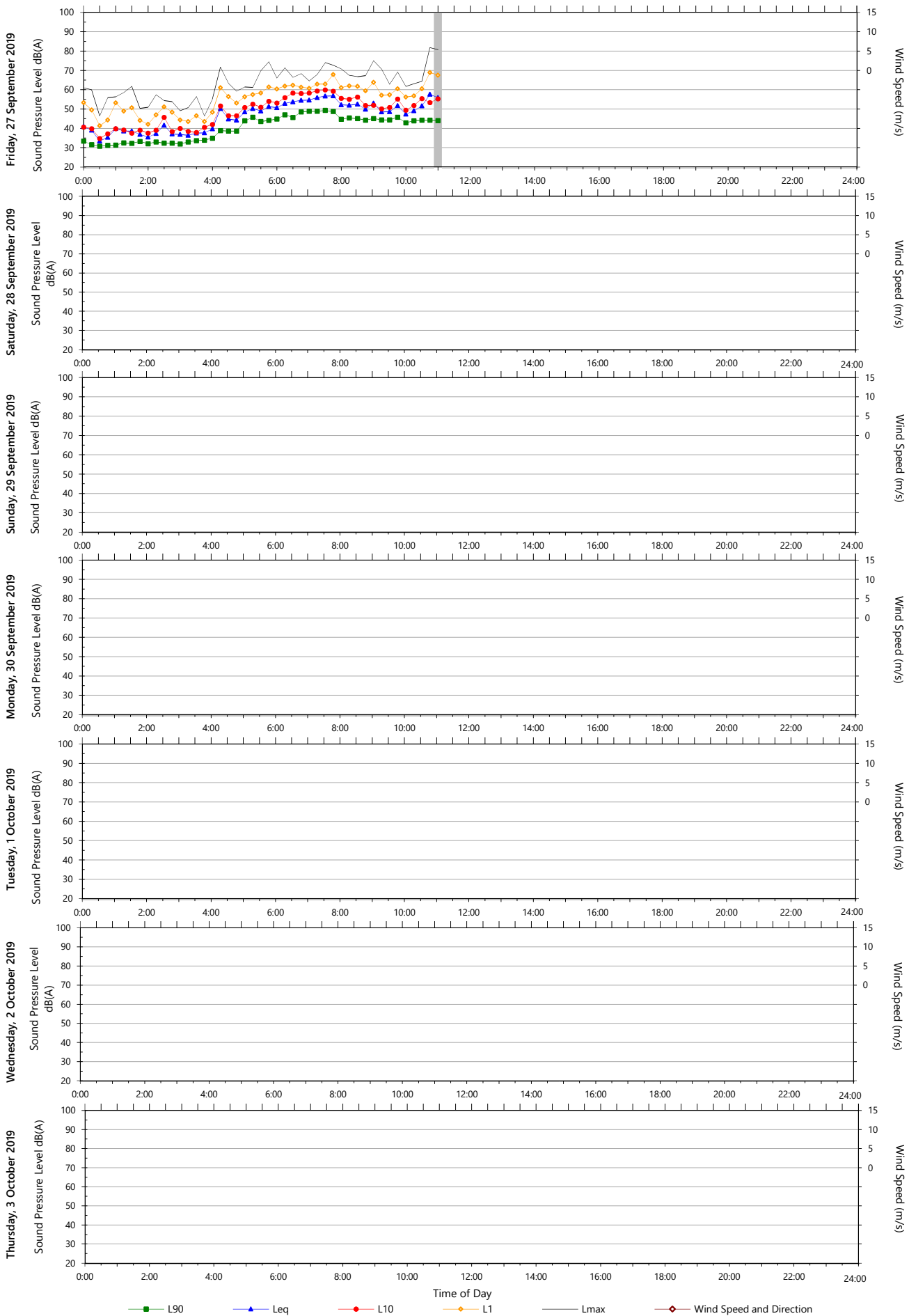


Data File: 2019-09-20_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r30)

Unattended Monitoring Results

Location: Hills Showground Masterplan - Location L4



Data File: 2019-09-20_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r30)

APPENDIX C Risk Management

C.1 Risk Management

Risk management is an integral part of good management practice. AS/NZS 4360-1999 "Risk Management" has become part of our company's culture and as a consequence it permeates all aspects of the company's work and is actively promoted to our clients.

The risk management process can be applied to any situation where an undesired or unexpected outcome could be significant or where opportunities are identified. Our clients need to know about possible outcomes and the steps that can be taken to control any adverse impact.

There is an opportunity in the design process for the client to actively participate in risk management by providing input into risk reduction strategy. For example, the client may need to know that some aspects of risk reduction could involve passing those risks on to other entities in a better position to treat those risks. Some aspects of risk reduction may involve additional cost or time consequences. On the other hand, there may also be opportunities to avoid or avert risk at no cost to the client by rescheduling processes so that key information becomes available at a critical time.

When the client is properly informed, this supports better decision making by contributing a greater insight into risks and their impacts.

For this project, there are inherent risks in the design process and in the final outcome where the designer is not in control of all processes. Accordingly, the Risk Assessment Table included in the appendices of this report identifies those risks, analyses the consequences, assesses the levels of risk and advises on the action taken or recommended to minimise them.

E TABLE E1 - RISK ANALYSIS – ROAD TRAFFIC NOISE (PLANNING INVESTIGATION STAGE) NSW						
No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recom- mended	Used on this Project
	The design offered in this report assumes a number of factors which are outside the control of the designer:	The client should be aware that the design tolerance and noise mitigation measures chosen may not be adequate and some additional noise mitigation measures may be required including, for example, increasing the height of the noise barriers and increasing the number of dwellings requiring architectural treatment.		In order to reduce the risk of noise levels not complying with the design criteria, the following risk-reducing measures have been implemented or are recommended:		
1.	Traffic noise modelling	The accuracy of traffic noise modelling predictions are based on the reliability of many modelling input parameters, including design assumptions relating to topography, road vertical and horizontal alignment, cutting and embankment details, road gradients, noise barrier locations, and noise receptor locations. Differences between model inputs and actual conditions in the field, can affect traffic noise model predictions.	MED	Perform more noise measurements and traffic counting of existing conditions at commencement of detailed design phase, to improve the validation and calibration of the traffic noise model. This involves inputting the required parameters (eg. topography, road design, traffic volumes, etc) into the traffic noise model, comparing the modelled noise levels with the measured noise levels and calibrating the model to account for any differences. Then apply a design tolerance of at least one standard deviation to the predicted noise results to achieve an 84% confidence interval in the predictions. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance.	Calibrate model + add design tolerance (min. one standard deviation) = 84% confidence interval	Calibrated model + nil design tolerance
2.	Topographic data of land surrounding the road project	No topographic data (ie assumed flat terrain) or coarse topographic data (ie >2m contour intervals) provides inaccurate ground levels, particularly for undulating land.	MED	Obtain better topographic data, ideally to 0.5m or 1m contour intervals.	See 'Treat Risk'	>2m contour intervals
3.	Building information	Assumptions made in relation to the location of buildings, in particular residential dwellings, and their associated ground levels and heights. Exact locations and heights may be incorrect, which may result in under or over predicting the level of noise mitigation.	LOW	Obtain more accurate building information through more detailed surveying of buildings. Building survey information can be obtained from photogrammetry techniques, although land-based surveying provides better accuracy.	See 'Treat Risk'	Estimated visually from photos and buildings modelled as blocks with a flat 5m height

E TABLE E1 - RISK ANALYSIS – ROAD TRAFFIC NOISE (PLANNING INVESTIGATION STAGE) NSW						
No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recom- mended	Used on this Project
4.	Traffic volume and composition data	Inaccurate traffic volume and composition information may cause over or under prediction of noise levels and consequently over or under design of noise mitigation.	LOW	Client to confirm that the traffic data used in the noise model is correct and is likely not to be exceeded throughout the year.	See 'Treat Risk'	Traffic data provided by client
5.	Road alignment	Changes to road alignment details between the planning, concept, tender and detail design phases (eg vertical/ horizontal alignment, pavement, cuttings, embankments, gradients etc) may change noise impacts at sensitive receiver locations, which may result in under or over predicting the level of noise mitigation.	LOW	Obtain the latest road design electronic files and use these to carry out traffic noise modelling for the detailed design phase.	See 'Treat Risk'	Tender Design model provided by client
6.	Noise barriers (mounds, walls etc)	Noise barrier heights, lengths and types may change from those tendered, for all the reasons described herein and because of road alignment and design changes.	MED	Conduct more detailed and refined noise modelling during the detailed design phase taking into account the Project's final design, specific criteria, and reasonableness/ feasibility of using noise barriers to mitigate traffic noise in lieu of other mitigation methods.	See 'Treat Risk'	Design and cost provisions explained to client
7.	Property / at-building treatment	The properties selected for at-building mitigation treatment, may change from those tendered, for all the reasons described above and because of project design changes.	LOW	Conduct more detailed and refined noise modelling during the detailed design phase taking into account the Project's final design, specific criteria, and reasonableness/ feasibility of implementing architectural / at-house mitigation treatment in lieu of other mitigation methods.	See 'Treat Risk'	Design, cost and time provisions for extra noise mitigation, where necessary
8.	Noise receptor locations greater than 300m from road corridor	Traffic noise models tend to have a reasonable level of accuracy within 300m from the road. Beyond 300m the accuracy of any traffic noise model is questionable.	LOW	Client to commit to the implementation of reasonable/feasible noise mitigation measures where post-commissioning noise monitoring identifies a significant [>2dB(A)] exceedance of traffic noise criteria at noise sensitive receivers located beyond 300m from the Project.	See 'Treat Risk'	Design, cost and time provisions for extra noise mitigation, where necessary

E TABLE E1 - RISK ANALYSIS – ROAD TRAFFIC NOISE (PLANNING INVESTIGATION STAGE) NSW						
No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recom- mended	Used on this Project
9.	Adverse meteorological effects (temperature inversions / wind)	Regions which are subject to adverse meteorological effects, such as moderate or greater temperature inversions at night and in the early morning periods and slight breezes (<3m/s), can significantly increase traffic noise levels at distant noise receptor locations. Traffic noise modelling does not account for adverse meteorological effects.	LOW	Client to commit to the implementation of feasible and reasonable noise mitigation measures where post-commissioning noise monitoring identifies repeatable and significant exceedance of traffic noise criteria at distant noise sensitive receivers, due to meteorological effects.	See 'Treat Risk'	Design, cost and time provisions for extra noise mitigation, where necessary

EXPLANATION OF TABLE

The designs offered in this report assume a number of factors which are outside the control of Renzo Tonin & Associates.

The client accepts the risks identified in this document and is encouraged to minimize those risks by the methods described above.

The column marked "Level" identifies the level of risk as HIGH, MED, LOW or N/A. Where the risk is HIGH, the client is advised that if the design does not comply with the selected standards then the client may experience significant additional costs and delays in rectification works. Where the risk is MED, the client is advised that if the design does not comply with the selected standards then the client may experience some additional costs and/or delays in the rectification works. Where the risk is LOW, the client is advised that if the design does not comply with the selected standards then the client may experience delays in the rectification works. Where N/A is indicated, this means the item is not applicable to the project.

E TABLE E2 - RISK ANALYSIS – FACADE DESIGN FOR NOISE INGRESS						
No	Item of Risk	Analyse Risk	Level	Treat Risk	Risk Allowance	
					Recom- mended	Used on this Project
	The design offered in this report assumes a number of factors which are outside the control of the designer:	The client should be aware that the design tolerance chosen may not be adequate and some remedial measures may be required including, for example, increasing the height of the noise barriers or the provision of additional treatment.	MED	In order to reduce the risk of noise levels not complying with the design criteria, the following risk-reducing measures have been implemented or are recommended:		
1.	Engineering Design	Modelling and calculating sound levels contain inaccuracies, for example, design assumptions relating to sound propagation on the site (including reflections from nearby buildings and surfaces).		A design tolerance of 3dB(A) is allowed in the final calculated sound level. The client may instruct Renzo Tonin & Associates to adopt a higher or lower design tolerance.	3	0
2.	Construction of the Works	Construction involves many processes which are beyond the control of Renzo Tonin & Associates. Even when forms of construction have laboratory certification, the final installed product may not achieve the assumed design noise reduction.		<p>We recommend acoustic testing prior to construction of any works.</p> <p>We recommend the client allocates sufficient time for pre-testing programs.</p> <p>We recommend the client approves a rigorous inspection regime.</p> <p>We recommend the client allocates a budget for add-on options.</p> <p>We recommend the client allows for changes impacting on other areas, for example, detailing at window mullions and dimensional changes to built-in furniture.</p>	See 'Treat Risk'	See 'Treat Risk'
3.	Background/ Ambient Noise Levels	Assumptions made in relation to the background/ ambient noise level adopted which cannot practically be determined with absolute certainty from a limited sample only.		Undertake further background/ ambient noise level measurements to confirm the noise goals.	See 'Treat Risk'	See 'Treat Risk'

EXPLANATION OF TABLE

The designs offered in this report assume a number of factors which are outside the control of Renzo Tonin & Associates.

The client accepts the risks identified in this document and is encouraged to minimize those risks by the methods described above.

The column marked "Level" identifies the level of risk as HIGH, MED, LOW or N/A. Where the risk is HIGH, the client is advised that if the design does not comply with the selected standards then the client may experience significant additional costs and delays in rectification works. Where the risk is MED, the client is advised that if the design does not comply with the selected standards then the client may experience some additional costs and/or delays in the rectification works. Where the risk is LOW, the client is advised that if the design does not comply with the selected standards then the client may experience delays in the rectification works. Where N/A is indicated, this means the item is not applicable to the project.

(This page is intentionally blank)