Hans Centre Sydney Pty Ltd

338 Pitt St, Sydney

Acoustic SSDA Report

AC01

Issue 2 | 13 December 2019

Job number 271640-00

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Document verification

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Job title		338 Pitt St, Sydney			**Job number** 271640-00
Document title		Acoustic SSDA Report			**File reference**
Document ref		AC01			
Revision	**Date**	**Filename**	AC01_v1_Acoustic SSDA report.docx		
Draft 1	22 Nov 2019	**Description**	First draft		
			Prepared by	Checked by	Approved by
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		Signature			
Issue 2	13 Dec 2019	**Filename**	AC01_v2_Acoustic SSDA report.docx		
		Description			
			Prepared by	Checked by	Approved by
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		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document verification with document	✓

Contents

Long-term noise monitoring results

1 Introduction

Arup has been commissioned by Hans Centre Sydney Pty Ltd to prepare a noise and vibration assessment report as part of the SSDA application for the proposed mixed-use development located at 338 Pitt Street, Sydney.

Acoustic terminology used in the report is included in Appendix A.

1.1 Project Overview

This report supports a Stage Significant Development Application (SSDA) for the mixed-use redevelopment of 338 Pitt Street, Sydney, which is submitted to the City of Sydney pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act). China Centre Development Pty Ltd is the proponent of the SSDA.

The site is located at the corner of Pitt Street and Liverpool Street, within the 'Mid Town' precinct of Sydney's Central Business District (CBD) (see Figure 1). The site is approximately 150 m west of Museum Station and Hyde Park, and approximately 350 m from Town Hall Station. The site includes several allotments and constitutes nearly one third of the city block between Bathurst Street, Pitt Street and Liverpool Street. The site is an irregular shape and has a combined area of approximately 5,900 m².

The proposed development comprises of hotel, residential, commercial and retail uses and will include:

- demolition of all existing structures;
- excavation and site preparation, including any required remediation;
- construction and use of a mixed-use development, with an iconic 258 m two-tower built form above a podium and internal courtyard;
- four (4) basement levels and a lower ground level accommodating residential, retail and hotel car parking, motorcycle parking, bicycle parking, loading dock, storage and relevant building services;
- improvements to the public domain, including landscaping, pedestrian thoroughfares/connections, and landscaping; and
- augmentation and extension of utilities and services.

A detailed description of development is provided by Ethos Urban within the EIS.

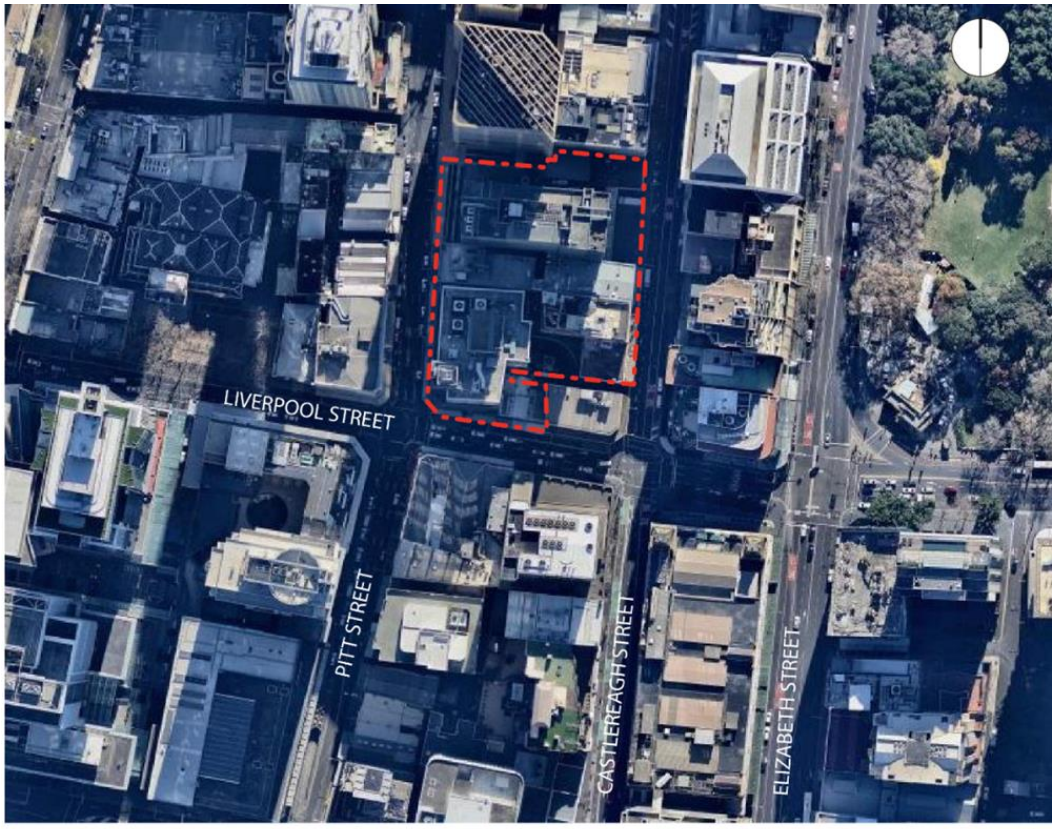

Figure 1: Site location and boundary

1.2 Project requirements

1.2.1 SEARS requirements

The acoustic assessment requirements for the SSDA are provided in the SEARs SSD-10362 dated 19/08/2019, as summarised in Table 1 below.

Table 1: Relevant SEARs requirements for acoustic assessment

Clause	Relevant requirements/policies for acoustic assessment	Acoustic assessment in this report
1. Statutory and Strategic Context	State Environmental Planning Policy (Infrastructure) 2007	Section 3
	State Environmental Planning Policy No 65 – Design Quality of Residential Development (including Apartment Design Guideline)	
	Development near Rail Corridors and Busy Roads – Interim Guideline	
	Sydney Development Control Plan 2012	
5. Amenity	The EIS include: measures to minimise potential overshadowing, **noise**, reflectivity, visual privacy, wind, daylight and view impacts.	Section 3.3.2

Clause	Relevant requirements/policies for acoustic assessment	Acoustic assessment in this report
10. Construction management	provide a Demolition and Construction Noise Vibration Management Plan in accordance with Condition 30 of the Stage 1 consent.	Section 6
Plans and Documents	Construction impacts and management plan, including a **construction noise and vibration management plan**, construction waste and recycling management plan and cumulative impact of construction activities on other nearby sites, including any impact to Rail services nearby	Section 6
	Acoustic reports regarding: Demolition and Construction Noise Vibration Management Plan in accordance with Condition 30 of the Stage 1 consent	Section 6
	Acoustic reports regarding: Noise impact assessment considering City's Acoustic Amenity requirements under DCP 2012 4.2.3.11 for residential apartments & NSW EPA Noise Policy for Industry and NSW Department of Planning Planning for Entertainment Guidelines 2009 for commercial plant and entertainment related noise associated with the proposed development	Section 3 and Section 3.3.2

1.2.2 Stage 1 DA conditions

The Stage 1 DA conditions of consent are provided in the Notice of Determination – Approval D/2016/1509 dated 28 February 2018. The relevant conditions for acoustic assessments are summarised in Table 2 below.

Table 2: Relevant Stage 1 DA conditions for acoustic assessment

No.	Condition	Where addressed in this report
SCHEDULE 1B		
30	DEMOLITION AND CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN ….Any subsequent development application for the detailed design of the building must include a Demolition and Construction Noise and Vibration Management Plan to be submitted and must include: (a) a demolition and excavation methodology report ….	Section 6
	(b) provides details about community consultation	Section 6.5.1
	(c) provides details of the complaints management system to include hotline and site manager contact numbers and which are to be distributed to the surrounding receivers and a template for a complaints register; and	Section 6.5.5

No.	Condition	Where addressed in this report
SCHEDULE 1D – SYDNEY METRO		
40 (c)	TFNSW SYDNEY METRO CONCURRENCE CONDITIONS allowances in the design, construction and maintenance of the development for the future operation of railway tunnels in the vicinity of the approved development, especially in relation to **noise, vibration**, stray electrical currents, electromagnetic fields and fire safety;	Section 3.3 Noise and vibration only.
SCHEDULE 1E – CBD RAIL LINK ZONE B-TUNNEL		
3(c)	allowances in the design, construction and maintenance of the development for the future operation of railway tunnels in the vicinity of the approved development, especially in relation to **noise, vibration**, stray electrical currents, electromagnetic fields and fire safety;	Section 3.3 Noise and vibration only.
4(c)	The acoustic assessment report is to be updated to include ground-borne noise and vibration effects from the future CBDRL rail operations to the proposed development.	Section 3.3

With regard to the Metro rail impacts, Schedule 1D refers to the future CBD metro, while Schedule 1E refers to the CBDRL and Sydney Metro City and South West (SMCSW). The location of the SMCSW is in the approximate location of the CBDRL (Halcrow Pacific Pty Ltd Drg no. 482749-310 v2 and Drg no. 482749-311 v2), being approximately 20 m below Pitt Street, and therefore assumed to be the same protection corridor. The location of the 'future CBD metro', referred in Schedule 1D is however not known and information has been requested.

2 Existing acoustic environment

2.1 Noise sensitive receivers

The development is to be located at 338 Pitt Street, Sydney, which is located at the corner between Pitt Street, Liverpool Street and Castlereagh Street. The site location and surrounding sensitive receivers type identified during site visits are shown and described below in Figure 2 and Table 3.

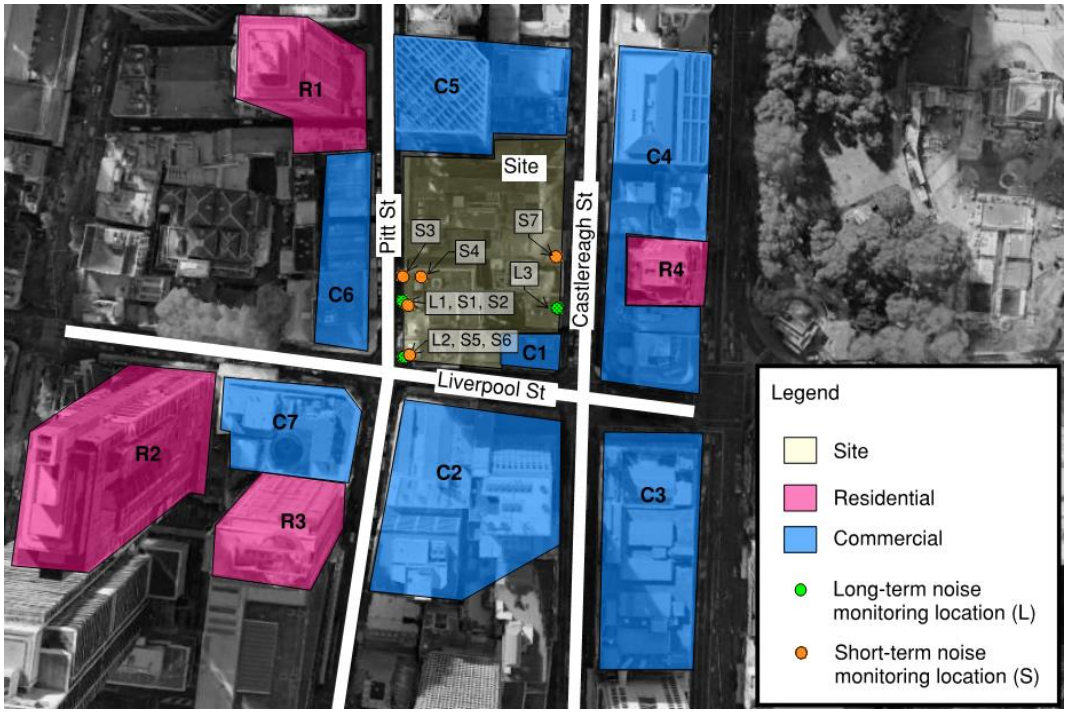

Figure 2: Site location and surrounding noise sensitive receivers

Table 3: Surrounding noise sensitive receivers

Receiver	Building/Address	Type of receiver[1]	Approximate distance to site boundary
Residential			
R1	The Regent 359-361 Pitt Street Century Tower 343-357 Pitt Street, Sydney	Mix Commercial Residential (10 Storeys) Mix Commercial Residential (52 Storeys)	19 m
R2	Hordern Towers, World square 393 Pitt Street	Mix Commercial and Residential (40 Storeys)	67 m
R3	World Tower, World square 91-95 Liverpool Street, Sydney	Mix Commercial and Residential (73 Storeys)	95 m

Receiver	Building/Address	Type of receiver[1]	Approximate distance to site boundary
Residential			
R4	Regency Hyde Park 281-285 Elizabeth Street, Sydney	Mix Commercial Residential (25 Storeys)	26 m
Commercial			
C1	134 Liverpool Street, Sydney	Commercial (5 storeys)	Adjacent to site
C2	127A and 127B Liverpool Street, Sydney 133 - 141 Liverpool Street The chambers, 370 Pitt street	Commercial (6 storeys) – Hotel Commercial (app 30 storeys) - CBA Commercial (17 storeys)	18 m
C3	Downing centre 143-147 Liverpool Street	Commercial (8 storeys)	36 m
C4	242 Castlereagh Street to 280 Castlereagh Street	Commercial (3 to 25 storeys)	18 m
C5	320 Pitt Street, Sydney 221 Castleareagh Street, Sydney	Commercial (32 Storeys) COmmerical (5 Storeys) – Bank of Sydney	Adjacent to site
C6	363 Pitt Street, Sydney to Fayworth house 379-383 Pitt Street, Sydney	Commercial (4 to 7 storeys)	17 m
C7	World Tower, world square 123 Liverpool Street	Commercial (9 storeys)	32 m

Note 1: As described in the Noise Policy for Industry

2.2 Summary of noise measurements

Unattended and attended noise measurements were conducted at the locations shown in Figure 2.

The results have been processed in accordance with:

- the Noise Policy for Industry (which will be used to derive the operational noise criteria) and,
- City of Sydney Code of Practice (which will be used to derive the construction noise criteria).

Results of the unattended noise measurements are given graphically in Figure 2 and summarised in Table 4. A summary of the attended noise results is given in Table 5.

The existing ambient noise environment in the vicinity of the site was found to be dominated by general urban hum influenced by mechanical plants, traffic and pedestrian activities.

Table 4: Unattended noise measurements results – Noise Policy for Industry (NPfI)

Location ID	Location [1]	Date	Logger serial number [2]	Noise Policy for Industry (NPfI)						Sydney DCP	
				Rating Background Level - dBA			L_{Aeq} Ambient Levels - dBA			$L_{Aeq,1hour}$ - dBA	
				Day [3]	Evening [3]	Night [3]	Day [3]	Evening [3]	Night [3]	Day [4]	Night [4]
L1 [5]	338 Pitt street, level 6 Balcony (Approximately 2.2m away from the façade)	Tuesday 29 October 2019 to Monday 11 November 2019	878061	63	62	56	65	65	62	66	65
L2 [5]	Corner Pitt street and Liverpool street, level 6 Balcony (Approximately 2.2m away from the façade)	Tuesday 29 October 2019 to Monday 11 November 2019	87807f	65	64	59	67	68	65	69	68
L3	249 Castleareagh Street, roof level (4 storeys), roof level	Monday 4 November 2019 to Tuesday 12 November 2019	8780D0	62	60	56	66	65	61	67	64

Notes

1. Microphones were set up a minimum of 1.2 m above ground.
2. Noise loggers carry current National Association of Testing Authorities (NATA) calibration certificate
3. The NPI defines day, evening and night time periods as:
    - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
    - Evening: the period from 6 pm to 10 pm.
    - Night: the remaining period.
4. Sydney DCP defines day, night time periods as:
    - Day: the period from 7 am to 10 pm.
    - Night: the period from 10 pm to 7 am.

Table 5: Attended noise measurements results

Location ID	Location	$L_{Aeq,15mins}$	L_{A90}	Source contributions	Notes
S1	338 Pitt street, level 6 Balcony (Approximately 2.2m away from the façade)	66	64	Mechanical services (from across the road and from 332 Pitt Street) Construction activities (sporadic) Traffic Traffic honk	Ambient dominated by mechanical services General traffic is barely audible apart from traffic honk, motorbikes
S2	338 Pitt street, ground floor (Approximately 3m away from the façade)	71	66	People talking/walking Traffic (Cars,Trucks) Mechanical Services	
S3	338 Pitt street, level 6 Balcony (Approximately 3m away from the façade, north of the site)	66	65	Mechanical services (from across the road and from 332 Pitt Street) Construction activities (sporadic) Traffic, motorbikes Helicopter	Ambient dominated by mechanical services
S4	338 Pitt street, level 6 Balcony (Approximately 3m away from the façade, north of the site, 6 m away from S3)	68	65	Mechanical services (from across the road and from 332 Pitt Street) Construction activities (sporadic) Traffic, motorbikes Helicopter	
S5	Corner Pitt street and Liverpool street, level 6 Balcony (Approximately 2.2m away from the façade)	66	65	Traffic Mechanical Services	Ambient dominated by mechanical services and traffic on Liverpool Street
S6	Corner Pitt street and Liverpool street, Ground floor (Approximately 3m away from the façade)	71	67	Traffic (Cars, trucks, ambulance, motorbikes) Crossing alarms Mechanical Services Electricity access noise when car travelling on it	Ambient dominated by mechanical services and traffic on Liverpool Street

Location ID	Location	$L_{Aeq,15mins}$	L_{A90}	Source contributions	Notes
S7	245 Castlereagh Street, roof (7 storey), Facing Castlereagh Street	64	63	Traffic Mechanical Services	Ambient dominated by mechanical services and traffic on Castlereagh St. There is a perforated steel screen (~2m) on the edge of the roof.

Note: Measurements conducted between 2pm and 5pm

3 Noise and vibration intrusion

3.1 Criteria

3.1.1 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. Relevant to the acoustic assessment are the Clause 87 *Impact of rail noise or vibration on non-rail development* and the Clause 102 *Impact of road noise or vibration on non-road development.*

The NSW Department of Planning *Development in Rail Corridors and Busy Roads – Interim Guideline* (December 2008) supplements the ISEPP. While the ISEPP applies only to roads with an AADT greater than 20,000 vehicles, the guideline is also recommended for other road traffic noise affected sites [1].

In accordance with the traffic engineer GTA Consultants, there is no AADT information available for the surrounding roads. However, based on the GTA Consultants' data collected on 25 June 2019, it suggests that on the day:

- 9,000 to 10,000 daily vehicles travelled along Liverpool Street at the site frontage
- Approximately 6,000 daily vehicles travelled along Pitt Street at the site frontage
- 5,000 to 6,000 daily vehicles travelled along Castlereagh Street at the site frontage.

Although this based on one day data collection, it indicates that the AADT is unlikely to be more than 20,000 vehicles for the surrounding roads. As such, ISEPP for busy road is not applicable. The airborne noise criteria provided in Table 6 are reference only.

The ground-borne noise criteria are established based on the recommendations of the NSW Department of Planning *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects*.

Table 6 presents the ISEPP internal noise criteria along with the equivalent external noise criteria for residential premises.

Table 6: ISEPP noise criteria for new residential development

Room	**Location**	**Airborne noise criteria***		**Ground-borne noise criteria**	
		$L_{Aeq,\ 15hr}$ Day 7am – 10pm	**$L_{Aeq\ 9hr}$ Night 10pm – 7am**	**$L_{Amax(slow)}$ Day 7am – 10pm**	**$L_{Amax(slow)}$ Night 10pm – 7am**
Living rooms	Internal, windows closed	40	40	40	35

Room	Location	Airborne noise criteria*		Ground-borne noise criteria	
		$L_{Aeq, 15hr}$ **Day** **7am – 10pm**	$L_{Aeq 9hr}$ **Night** **10pm – 7am**	$L_{Amax(slow)}$ **Day** **7am – 10pm**	$L_{Amax(slow)}$ **Night** **10pm – 7am**
	Internal, windows open	50	50		
	External free-field (allowing windows to remain open)^	60	60		
Bedrooms	Internal, windows closed	40	35		
	Internal, windows open	50	45		
	External free-field (allowing windows to remain open)^	60	55		

Notes:

* Requisite for 20,000AADT Roads only under ISEPP 2007. Based on the current traffic count provided by Traffic Engineer, the AADT for the development is unlikely to be more than 20,000. The ISEPP for road noise is considered to be not applicable.

^ 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 BCA 2011 requirements.

3.1.2 State Environmental Planning Policy 65 – Apartment Design Guide

The SEPP 65 [2] applies to the design of apartments, and *Objective 4B-1* of the Apartment Design Guideline (ADG) [3] states that "*all habitable rooms are naturally ventilated*". This is achieved by providing operable windows/doors to all rooms of at least 5% of the floor area.

It is noted that the City of Sydney's interpretation of SEPP 65 and the supporting ADG is that natural ventilation must be provided while also satisfying internal noise criteria. This requirement is not outlined in the ADG and the referred noise policy in Section 4J, refers to the NSW Development Near Rail Corridors and Busy Roads – Interim Guideline which allows for alternative mechanically supported ventilation systems in noise and pollution affected sites [4]. The City have released a Draft guideline for the assessment of natural ventilation [5], however the policy does not clarify what noise criteria is to be achieved.

Attempting to achieve concurrent compliance requires acoustically attenuated ventilation paths, that go beyond the requirements of current policy and standards, and requires complex modelling, assessment and design of bespoke, often unproven, ventilation and acoustic solutions. Also, filters for air quality are unlikely to be practicable where the system is not mechanically supported, due to their significant impact on air flow.

Further, this approach goes beyond the intent of SEPP 65, and adds additional constraint, complexity, uncertainty, negative design affects, time and cost to projects, in conflict with objectives 2(3)(g)[1] and 2(3)(h)[2] of SEPP 65. It is also noted that the ventilation rates prescribed are for adequate air quality only, rather than addressing acceptable amenity and thermal comfort.

Accordingly, where noise levels exceed those recommended with windows open, the proposed design response is to achieve satisfactory sound levels with windows closed, while providing appropriate background ventilation through mechanically supported means consistent with the National Construction Code (NCC) [6].

3.1.3 City of Sydney Development Control Plan

The Sydney Development Control Plan [7] provides a guideline of noise intrusion for residential developments in Section 4.2.3.11 (7) & (8), as summarised in Table 7.

It is noted that, Item (8) of Section 4.2.3.11 states:

'(8) where natural ventilation of a room cannot be achieved, the repeatable maximum $L_{Aeq(1hour)}$ level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:

(a) 38dB for bedrooms (10pm-7am); and

(b) 48dB for main living areas (24 hours).'

As suggested in Item 8 of Section 4.2.3.11 in Sydney DCP and discussion in Section 3.1.2, the noise intrusion target for the 'Open windows and doors' should not apply if the natural ventilation cannot be achieved due to noise and pollution affected sites.

Table 7: Noise intrusion targets in Sydney DCP

Space	**Noise intrusion targets, dB $L_{Aeq(1hour)}$**		
	Closed windows and doors	**Open windows and doors**	**Closed doors and windows. Air conditioning is operating**
Bedrooms (10pm-7am)	35	45	38
Living areas (24 hours)	45	55	48

3.1.4 Ground-borne vibration

The NSW EPA's *Assessing Vibration Guideline* (AVG) [8] provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. For intermittent sources

[1] *2(3)(d) to support housing affordability.* [14]
[2] *2(3)(h) to facilitate the timely and efficient assessment of applications for development to which this Policy applies.* [14]

(i.e. Sydney Metro train passbys in this assessment), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. While, the vibration design objectives provided in the Sydney Metro EIS are based on the maximum 1 second rms vibration level not exceeded for 95% of train passbys.

For the purpose of this assessment, to be consistent with the Sydney Metro EIS, the continuous vibration criteria recommended in AVG [8] are adopted as a conservative approach.

3.1.5 Project specific criteria

The proposed project specific criteria for the noise intrusion to the apartments are provided in Table 8, based on the requirements of Sydney DCP.

Table 8: Intrusion criteria for the development

Space	Airborne noise intrusion criteria, dB $L_{Aeq(1hour)}$			Rail ground-borne noise and vibration intrusion criteria, dB $L_{Amax(slow)}$	Rail vibration criteria, weighted root-mean-square (rms) vibration acceleration (m/s^2) 1-80 Hz
	Windows/door closed (internal)	Windows/door open			
		Internal	External [1]		
Bedrooms (10pm-7am)	35	45	55	35	0.007 - 0.014
Bedrooms (7am-10pm)	-	-	-	40	0.010 – 0.020
Living areas (10pm-7am)	45	55	65	35	0.007 - 0.014
Living areas (7am-10pm)				40	0.010 – 0.020

Note:

1. The noise reduction provided by open windows/doors is typically 10-15 dB. As a conservative approach for assessment, this screening criterion adopts 10 dB reduction of open windows/doors.

3.2 Airborne noise intrusion assessment

For the purpose of this report, the acoustic assessment for the worst noise affected apartments on Level 6 has been conducted to demonstrate the noise intrusion criteria can be achieved by appropriate building envelope design. Ambient noise levels at upper levels of the development may reduce slightly, however are difficult to predict due to environment being influence by noise from the wider city environment, not just the localised traffic and building services equipment. At this stage of the project, it is recommended to conservatively assume that similar noise levels may be experienced at all levels.

3.2.1 Ambient noise levels

The ambient noise levels used in the acoustic assessment are measured at the edge of the Level 6, which does not account for the acoustic barrier effect provided by the setback as a conservative approach. The noise spectrum from the attended measurement (Location S1) is adopted and corrected based on the long-term noise monitoring levels of $L_{Aeq,1hour}$ for day (7:00 am to 10:00 pm) and night (10:00 pm to 07:00 am) time, as provided in Table 9 below.

Table 9: Noise levels for the noise intrusion assessment

Time	**Free-field Broad band $L_{Aeq,1hour}$ [1]**	**Octave band centre frequency (Hz), dB $L_{eq,1hour}$**						
		63	**125**	**250**	**1 k**	**2 k**	**4 k**	**8 k**
Day (7:00 am to 10:00 pm)	66	70	68	65	63	62	57	52
Night (10:00 pm to 07:00 am)	65	69	67	64	62	61	56	51

Note: 1. The measured noise level and spectrum has been normalised based on the long-term noise monitoring results provided in Table 4.

3.2.2 Architectural design

As shown in the figure below, the closest apartments to streets are located on Level 6 of the north tower facing Pitt Street.

The typical building envelope design for the living area with a balcony is provided in Figure 4. It is noted that the noise reduction of the open windows provided by the design will be greater than 10 dB.

Figure 3: Level 6 apartment layout (highlighted in yellow)

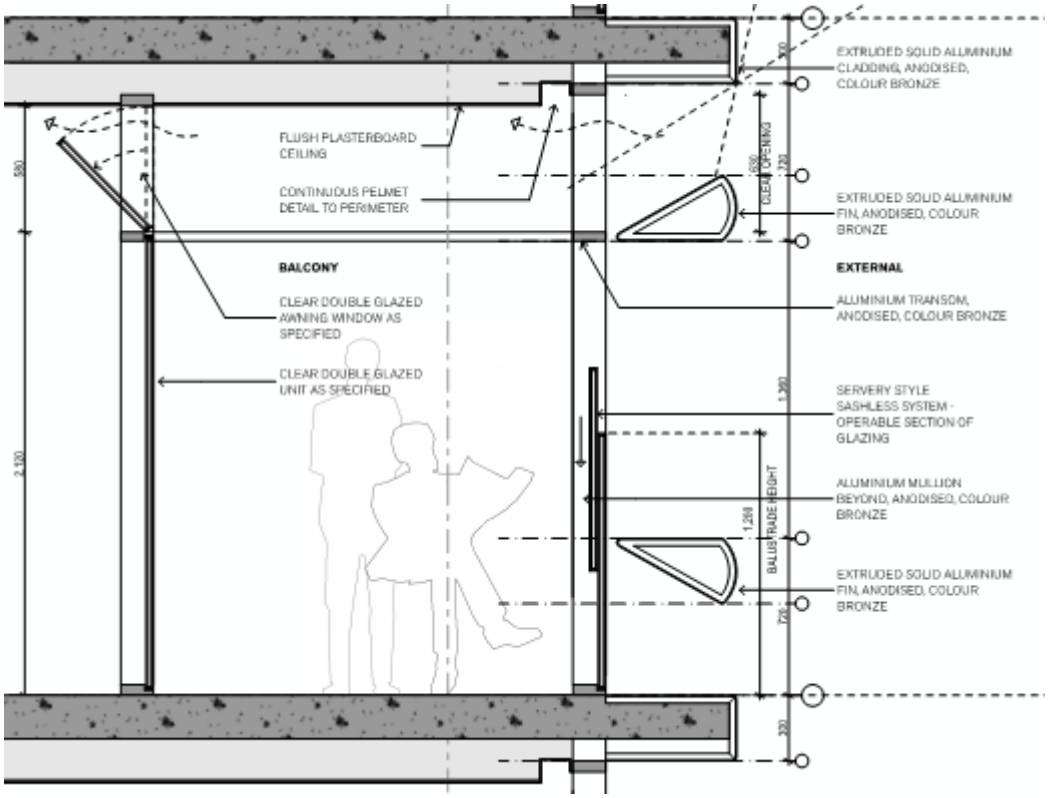

Figure 4: Typical building envelope design for living areas

3.2.3 Assessment

Based on the current apartment architectural design, the outcomes of the acoustic assessment are summarised in Table 10. As design progresses, the detailed acoustic requirements for façade will be developed.

Table 10: Acoustic performance requirements for the worst-case apartments

Scenario	Acoustic assessment and discussion	Maximum acoustic performance requirements (based on worst case of the Level 6 bedroom)
Windows, door closed	On this basis of this assessment, it is anticipated that acoustic criteria for the windows/doors closed can be achieved with appropriate and practical building envelope design. The maximum acoustic performance required for the entire building is provided in the column on the right.	R_{w+Ctr} 39 (indicative façade build-up: 8 mm laminate -16 mm air gap- 12 mm laminate)

Scenario	Acoustic assessment and discussion	Maximum acoustic performance requirements (based on worst case of the Level 6 bedroom)
Windows and doors open	**For Bedroom:** The acoustic assessment indicates that the noise intrusion criteria may not be achieved when the windows/doors are open due to the high external noise level. As such, it is recommended that mechanical ventilation is provided for the bedrooms/apartments when windows/doors are closed (refer to Section 3.1.2 for discussion). **For Living areas:** The acoustic assessment indicates that the noise criteria for open windows/doors can be achieved during the night time. There is only marginal 1 dB exceedance during the day time. However, this is assuming a conservative noise reduction by open windows/doors (i.e. 10 dB reduction). Based on typical façade design provided in Figure 4, the noise reduction of the balcony system will be greater than 10 dB. The noise criteria for the day time will be met. It is also recommended that sound absorbing soffit and walls to be incorporated for further noise control. As such, it is anticipated that the noise criteria will be achieved for living areas when windows/door are open.	-

3.3 Rail ground-borne noise and vibration

3.3.1 Basis of assessment

The acoustic assessment assumptions for the ground-borne noise and vibration from Sydney Metro City and South West (SMCSW) operation is based on the Technical Paper 2 Noise and Vibration of Sydney Metro Environmental Impact Statement dated May 2016 [9], as shown in the figure (screenshot) below. Updated information has been requested from Sydney Metro however is yet to be received.

Table 75 Reference Source Vibration Levels (Tunnel Wall at 80 km/h Reference Speed)

Track Type	Vibration Levels (dB_V re 1 nm/s) in 1/3 Octave Bands (Hz) – $L_{max,slow,95\%}$															Overall Level
	10 Hz	12 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	
Standard Attenuation	77	78	78	77	80	86	86	86	85	84	84	89	86	82	79	78	96
High Attenuation	77	79	80	80	84	88	81	77	77	77	78	84	82	78	75	74	93
Very High Attenuation	78	81	83	83	81	80	74	71	72	73	74	80	78	74	72	71	90

Figure 5: Source vibration levels on tunnel walls from Sydney Metro EIS report

Predictions have been conducted for the potential ground-borne noise and vibration impacts from the future Sydney Metro line to the bedroom of apartments on Level 6 of the North Tower. The assessed location is the apartments closest to the metro tunnel (under Pitt Street). The input speed of the train is 80 km/h based on the speed profile provided in the Figure 31 of the Technical Paper 2 Noise and Vibration of Sydney Metro Environmental Impact Statement.

Due to the complexity of ground-borne vibration and noise transmission and limited information available at this stage, the predicted results are provided as a range in Table 11.

Table 11: Predicted ground-borne noise and vibration levels – most affected bedroom

Assessment location	**Ground-borne noise criteria, $dBL_{Amax(slow)}$**	**Track type**	**Predicted sound level, $dBL_{Amax(slow)}$**	**Predicted vibration level, m/s^2**
Apartment on Level 6 of North Tower	35 (10pm-7am) 40 (7am-10pm)	Standard	35-45	0.004-0.011
		High attenuation	30-40	0.005-0.008

3.3.2 Discussion and recommendations

It should be noted that these predictions are preliminary based on the level of design detail at this stage of the project, and the data used for the predictions is the generic data provided in SMCSW EIS. Updated information has been requested from Sydney Metro however is yet to be received. Based on this preliminary prediction at the most affect apartment given in Table 11, there is a risk that the ground-borne noise criteria are not be met at the most affected apartment based on the design detail at this stage. The acoustic mitigation measures, such as building isolation, may be needed to control the ground-borne noise and vibration, subject to a detailed ground-borne noise and vibration assessment and/or modelling.

It is recommended that, when the site specific data/information from Sydney Metro will be available and progressed design, a detailed ground-borne noise and vibration assessment should be conducted during the detailed design stage.

4 Operational noise and vibration emission

4.1 Criteria

Operational noise emissions from the project have been assessed in accordance with the Noise Policy for Industry (NPI), which is primarily concerned with controlling intrusive noise impacts in the short-term for residences, and maintaining long-term noise level amenity for residences and other land uses.

Based on the background and ambient noise monitoring (refer to Appendix B), Table 12 summarises the project specific noise trigger levels derived in accordance with the NPI.

Table 12: NPI Project specific noise trigger levels

Receiver	Time Period	Project Specific Noise Levels		
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	**Project Amenity Noise Level (PANL)** $L_{Aeq,period}$	**Sleep Disturbance** $L_{AFmax(night)}$
Residential (R1-R4) [2]	Day	67	55	N/A[3]
	Evening	65	50	N/A[3]
	Night	61	46	71
Commercial (C1-C7) [4]	When in use	65	60	N/A[3]

Notes

1. The NPI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. The residential receiver criteria are based on the most affected residential receiver R4.
3. N/A Not Applicable
4. The commercial receiver criteria are based on the most affected receiver C5.

4.2 Operational noise assessment

4.2.1 Building services

At this stage in the project, details of the plant selections are not known and therefore detailed selections of noise control devices cannot be made. Space for appropriate noise and vibration control treatments will be allowed for during the early stages of the plant design and detailed noise emission prediction will be undertaken when specific plant noise data is available.

These noise and vibration control treatments are likely to include:

- Rectangular and circular attenuators to control fan noise,
- Acoustic louvres to control noise from plantroom ventilation openings,

- Cooling air and flue gas attenuators on the generator set,
- Acoustic screens around any external plant,
- Incorporation of sound absorptive treatments in plantrooms; and,
- Provision of vibration isolation devices to rotating and reciprocating plant.

The following major building services plantrooms and plants have been identified in Table 13. Acoustic mitigation measures will be designed and provided to meet the project specific criteria provide in Table 12.

Table 13: Major building services plantrooms and plant

Plantroom/Plant	Location	Potential acoustic treatments
Genset Room	Basement 1	Acoustic attenuators to air connections, and/or Cooling air and flue gas attenuators, and/or Vibration isolators
Cooling Tower	Level 4	Acoustic attenuator, and/or Vibration isolators, and/or Acoustic barrier
Plant Level	Level 31	Acoustic louvres, and/or Acoustic attenuators, and/or Acoustic lining to plantroom
Plant Level	Level 57	
Plant Level	Level 79	

4.2.2 Retail use

The preliminary acoustic assessment of potential noise impact from retail uses is summarised in Table 9. It is noted that the retail uses will be subject to separate development applications.

Table 14: Acoustic assessment for the retail uses

Space/Location	Acoustic assessment
Retail uses on Ground Floor – Level 2	Retail uses are anticipated to be located in the lower levels opening to the central courtyard area. The expected usage of these spaces is not yet known, however the acoustic impact to the external receivers is expected to be low due to their location. The building envelope of the retail uses, along with fitout and management measures will be developed to appropriately control the potential noise breakout. Further acoustic assessments will be undertaken for the respective use and tenancy DAs.
Ballroom on Level 2	The ballroom is an enclosed space located on Level 2, close to the Castlereagh Street. The building envelope, fitout design and management measures will be developed during the detailed design stage to control the potential noise breakout to the environment. There is an outdoor space around the ballroom, however, it will be used as a transient space connecting the pre-function space. Limited number of people will be occupying the space at one time. It is anticipated that the noise impact is limited.

Space/Location	Acoustic assessment
Rooftop bar on Level 4	The noise impact from the rooftop bar is anticipated to be at low risk as it is an enclosed space. The building envelope, fitout design and management measures will be developed during the detailed design stage to control the potential noise breakout to the environment. It will be subject to the tenant's acoustic assessment and DA.
Restaurant + Bar on Level 32	The noise impact from the retail uses on sky bridge is anticipated to be at low risk as they are enclosed internal spaces. The façade/building envelope will be designed to control the noise breakout from these spaces.
Swimming pool on Level 34	

4.2.3 Loading docks

The loading dock is a fully enclosed space located on the Basement 1. It is not directly adjacent to an outdoor space. No acoustic impact is anticipated from the operation of loading dock. However, the following provisional noise mitigation and management measures are considered to control the noise from loading dock operation:

- Broadband non-tonal and ambient noise sensing to control the noise of alarms for exiting of vehicles from docks and car parks, if required.
- A Management plan will be prepared detailing all relevant noise mitigation and management measures, appropriate for distribution to relevant contractors or operators.

4.2.4 Emergency equipment

Concessions are proposed for emergency equipment such as backup generators and smoke exhaust systems. The allowances of 10 dB above the normal operations criteria is adopted.

5 Traffic generation

5.1 Criteria

The RNP provides road traffic noise criteria for both residential and other non-residential noise sensitive receivers. The RNP provides both absolute noise level limits, dependent upon road category, and limits to control the relative increase in road traffic noise.

It should be noted that the road traffic noise criteria are provided as guidelines and are 'non-mandatory'. They provide target noise levels that it is desired to meet where it is *feasible and reasonable* to do so. The policy document states that in some instances this may be achievable only through long-term strategies such as improved planning; design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage. Regarding the application of the assessment, the RNP states:

> *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.*

5.2 Assessment

Based on the traffic volume information provided by the Traffic Consultant GTA, Table 15 provide a noise assessment for the traffic generation by the development. The traffic generation by the development is expected to be minor in comparison with the existing traffic volume. The predicted noise level increase is less than 2 dB which complies to the road noise assessment criteria.

Table 15: Noise assessment for the traffic generation by the development

Road	Peak hour traffic volume		Predicted noise level increase	Compliance to the criteria?
	Existing	Traffic generation by the development		
Pitt St.	574	47	0.3	YES
Liverpool St.	956	20	0.1	YES
Castlereagh St.	620	5	0	YES
Bathurst St	1416	15	0	YES

6 Demolition and construction

6.1 Stage 1 conditions

Condition 30(a) of the Stage 1 Consent required that a detailed Demolition and Excavation Methodology Report. The condition outlines highly detailed requirements, such as:

- Proposed hours and days of operation for each development stage
- Identify the specific floor and section of the building to which different methodologies may be used
- Provides a statement prepared by a Demolition Professional and Acoustic Consultant

Such detail would only be available once a contractor has been engaged for the project, which is yet to occur, and would not typically occur until project approval has been secured. It is therefore sought for this detailed assessment to be conditioned on the Stage 2 approval, as a requirement to be satisfied prior to issue of the construction certificate. Preparing such an assessment at this time is considered to provide no material benefit to management of the project.

In the conditioning of the development, reference to 'compliance' with the Noise Code [10] in Condition 30(a)(iii) and (iv)(c), should be amended to reflect the 'note' provided proceeding these clauses which highlights that the Noise Code not practicably achievable in all cases. With regard to the note, reducing hours of intrusive appliances is regularly adopted through defining of respite periods, as outlined in Condition 30(a)(vi).

A preliminary construction management plan for the demolition of existing buildings located currently onsite and for the construction of the project has nonetheless been developed for the project (Refer to Arup report, Construction Management Plan). While the Construction Management Plan identifies that detailed work methods are yet to be determined, it provides an indication of what equipment may be used.

6.2 Demolition and construction noise criteria

The demolition and construction noise criteria are established based on Construction Hours/Noise within the Central Business District [10] as required by the SEARs and Consent Condition 30 of Stage 1 DA (Refer to Section 1.2).

The Code of Practice sets noise limitations to receivers located in a proximity to a construction site. The construction noise levels allowed vary depending on the hours of work. Typical construction hours (Category 1 hours) are:

- Monday to Friday (inclusive) 07:00 to 19:00
- Saturday 07:00 to 17:00

The Code of Practice places limits on three items:

- Noise at Nominated Affected Occupancy
- Appliance noise levels (e.g. individual pieces of construction equipment)
- Noise at site boundary from Appliances

While the Noise Code implies hard limits for construction noise, the Stage 1 approval, Condition 30 clarifies that the limits are not always practicably met, and therefore considered targets:

> *Generally, it is required that demolition and construction noise and vibration is managed to ensure compliance with the noise criteria stated in the City of Sydney Construction Hours/Noise Code of Practice 1992. Often this is difficult to achieve in practice due to the intrusive nature of the equipment being operated and the proximity of adjoining properties. In these instances therefore, a more satisfactory outcome may be to formally reduce the approved hours within which high noise intrusive appliances can be operated thereby ensuring that occupiers of neighbouring residential and commercial property are not subject to long sustained periods of highly intrusive noise*

The following additional guidelines should also be adhered to where possible:

- Australian Standard 2436:2010 – Guide to Noise Control on Construction, Maintenance and Demolition Sites
- DECCW Interim Construction Noise Guideline [11]
- BS 5228:2009 Noise and Vibration Control on Construction and Open Sites

6.2.1 Noise at Nominated Affected Occupancy

In the first instance, the applicant must identify the nominated hours of work. Code of Practice Construction Hours of works and applicable noise criteria are reproduced below in Table 16.

Table 16 Categories of working hours, and noise criteria (Noise Code, Table 1 [10])

DAY	TIME ZONE	CATEGORY	NOISE CRITERIA (which must not be exceeded)
Monday to Friday	00.00 - 07.00	4	Background + 0 dBA
	07.00 - 08.00	1	Background + 5 dBA
	08.00 - 19.00	1	Background + 5 dBA + 5 dBA to be determined on a site basis
	19.00 - 23.00	2	Background + 3 dBA
	23.00 - 24.00	4	Background + 0 dBA
Saturday	00.00 - 07.00	4	Background + 0 dBA
	07.00 - 08.00	1	Background + 5 dBA
	08.00 - 17.00	1	Background + 5 dBA + 5 dBA to be determined on a site basis
	17.00 - 23.00	2	Background + 3 dBA
	23.00 - 24.00	4	Background + 0 dBA
Sundays and Public Holidays	00.00 - 07.00	4	Background + 0 dBA
	07.00 - 17.00	3	Background + 3 dBA
	17.00 - 24.00	4	Background + 0 dBA

1. All noise levels to be $L_{A\ av\ max}$ (15 minute) measured at the nearest Nominated Occupancy.

2. The permissible noise level is to be complied with during each fifteen (15) minute period during the relevant Category of Hours.

3. The guidelines for control of construction noise as outlined in AS2436 shall be applied, where appropriate.

4. Background is "Background Noise Level" as defined in para 18.j (page 5).

6.2.2 Appliance noise levels

Paragraph 49 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992, presents maximum allowable sound levels measured at a distance of 7 m for particular types of equipment and divides them into Groups A through to F, with A being the loudest. Relevant section of the City of Sydney, Code of Practice has been reproduced in Table 17.

Table 17: City of Sydney Code of Practice - Appliances and allowable noise levels [10]

Allowable Noise Levels, $L_{A10,\ 1minute}$ at 7m from the point nearest to an Appliance					
Group A (A certificate of Acoustic performance is required)	**Group B 90 dBA**	**Group C 85 dBA**	**Group D 80 dBA**	**Group E 75 dBA**	**Group F 70 dBA**
Pile drivers Hydraulic hammers Machine mounted rock breakers Sand blasters Steam cleaners Mole borers	Earthmoving equipment of engine capacity above 200 kW net engine power (NEP) Warning Sirens (measured at site boundary) Reversing alarms (must not exceed background levels by more than 10 dB) Trucks	Impulsive tools – air, electric or hydraulic Earthmoving equipment of engine capacity between 100 kW and 200 kW NEP Explosive power tools Impact wrenches Refuse chutes (measured at site boundary) Scabblers Chainsaws Rock drills	Concrete agitators Concrete pumps Concrete saws Cranes (fixed and mobile) Earthmoving equipment up to and including engine capacities of 100 kW NEP Concrete vibrators Portable hand tools Vibratory compacters	Air compressors above 170 L/s capacity Construction dumpers over 1m3 capacity Public address system (must not exceed background levels by more than 10 dB) Internal combustion or electrically driven equipment (unless grouped elsewhere) over 14 kW NEP	Air compressors up to 170 L/s capacity Fluid pumps Internal combustion or electrically driven equipment (unless grouped elsewhere) up to 14 kW NEP

6.2.3 Noise at site boundary from Appliances

Furthermore, Paragraph 50 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 192, states the following:

*The $L_{A\ av\ max}$ noise level emitted from all appliances in use at any time on the construction site, as measured over any **15 minute period**, shall not exceed a level of **85 dB(A)** at any point on the Construction Site boundary.*

6.2.4 Criteria

The descriptor of the noise criterion used by the policy is "$L_{A\ av\ max}$" which is deemed to be equivalent to L_{A10} as mentioned in 'Part 1 Paragraph 18 Item g". For

acoustic assessment purposes, the L_{A10}, instead of $L_{A\ av\ max}$, is adopted in this assessment.

Measured noise data obtained at the logger locations most representative of the ambient noise environment in the vicinity of the project have been used to derive appropriate noise criteria for the project. City of Sydney criteria are summarised in Table 18.

Table 18: Construction noise limiting criterion

Receiver [1]	**Representative logger location**	**Background level (Daytime $L_{A90(15min)}$ Background level)**	**Noise criteria $L_{A10(15minute)}$**		
			Monday to Friday 07.00-08.00 Saturday 07.00-08.00	**Monday to Friday 08.00-19.00 Saturday 08.00-17.00**	**Monday to Friday 19.00-23.00 Saturday 17.00-23.00**
R1	L1	63	68	73	66
R2	L2	65	70	75	68
R3	L2	65	70	75	68
R4	L3	62	67	72	65
C1	L3	62	67	72	65
C2	L2	65	70	75	68
C3	L2	65	70	75	68
C4	L3	62	67	72	65
C5	L1	63	68	73	66
C6	L1	63	68	73	66
C7	L2	65	70	75	68

Note 1: As per Table 4

6.3 Vibration criteria

The Stage 1 approval refers only to the Noise Code for construction noise and vibration assessment. The Noise Code however does not include criteria for vibration assessment. Relevant Standards commonly adopted for assessment in NSW are discussed below.

6.3.1 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 and/or German Standard DIN4150-3. British Standard 7385 Part 1: 1990, defines different levels of structural damage as:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*

- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

Table 1 of British Standard 7385 Part 2 (1993) sets limits for the protection against cosmetic damage, however the following guidance on minor and major damage is provided in Section 7.4.2 of the Standard:

> 7.4.2 Guide values for transient vibration relating to cosmetic damage
>
> Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.
>
> Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

> "that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if
>
> - cracks form in plastered surfaces of walls;
> - existing cracks in the building are enlarged;
> - partitions become detached from loadbearing walls or floors.
>
> These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)

While the DIN Standard defines the above damage as 'minor', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures.

6.3.2 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 19 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 (1993, p.5) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 19: BS 7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

1 - Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

2 - Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

6.3.3 Vibration to Sydney Metro

The demolition and construction vibration criteria to the Sydney Metro is recommended in the TfNSW *Sydney Metro Underground Corridor Protection Technical Guidelines* dated 16 October 2017 [12].

Any development that occurs within a screening distance of 25 m horizontally from first reserve must consider the vibration on the metro infrastructure with the following assessment criteria of maximum peak particle velocity (PPV):

- 15 mm/s for tunnel and cavern cast insitu concrete linings that are in good condition.
- 20 mm/s at the running tunnels supported using a precast concrete segment lining.

6.4 Assessment

A construction management plan for the demolition of existing buildings located currently onsite and for the construction of the project has been developed for the project (Refer to Arup report, Construction Management Plan)

While the Arup Construction Management Plan identifies that detailed work methods are yet to be determined, it provides an indication of what equipment are likely to be used.

6.4.1 Anticipated hours of construction

Preferred construction hours are typically as follow and correspond to Category 1 of the City of Sydney, Code of Practice:

- Monday to Friday (inclusive) 07:00 to 19:00
- Saturday 07:00 to 17:00
- No work on Sundays and Public Holidays

6.4.2 Construction activities

While this is early stage and detail construction methods, activities and plant and equipment required are not fully known.

For reference and indicative purposes, Table 20 provides a list of potential construction activities and equipment may be carried out for a typical demolition and construction process.

Table 20: Construction activities and associated plant and equipment

Construction Activities/Scenarios	Scenario number	Description	Typical plant and equipment required
Site establishment	Sc 1	Installation of hoarding	Hiab Trucks Hand tools
Demolition of existing buildings	Sc 2.1	General demolition	Small excavators Pneumatic hammers Concrete Saws Hand tools Cranes Trucks
	Sc 2.2	Retaining wall	Smooth drum Roller
Excavation works	Sc 3	Excavation works	8T – 13T Excavator Hammer Roller Trucks
Construction – structure works	Sc 4.1	Construction – structure works	Tower cranes Pile drivers
	Sc4.2	Construction – structure works	Concrete trucks Concrete pumps Builders lifts

6.4.3 Construction noise impact assessment

Prediction of noise levels generated by different items of equipment have been carried out based on the equipment noise groups contained in the code of as summarised in Table 17.

Note that predicted levels in Table 21 have been based on one appliance operating at the closest point near the sensitive receiver.

Table 21: Predicted levels at nearest sensitive receivers

Sensitive receiver	Distance from closest site boundary	Predicted noise level $L_{A10(15\ min)}$, dB					
		Group A	Group B	Group C	Group D	Group E	Group F
R1	19 m	75	70	65	60	56	52
R2	67 m	64	59	54	49	45	41
R3	95 m	61	56	51	46	42	38
R4	26 m	72	67	62	57	53	49
C1	Adjacent to site	100	95	90	85	81	77
C2	18 m	75	70	65	60	56	52
C3	36 m	69	64	59	54	50	46
C4	18 m	75	70	65	60	56	52
C5	Adjacent to site	100	95	90	85	81	77
C6	17 m	75	70	65	60	57	53
C7	32 m	70	65	60	55	51	47
Note: Number in red indicate exceedance of criteria for hours of Catalogue 1 (exclude 07.00-08.00). Number in amber indicate exceedance of criteria for 07.00-08.00 (Monday – Saturday)							

6.4.3.1 Discussion

Table 21 indicate that exceedances of criteria are predicted when equipment from Group A is used such as during Sc 2.1 and Sc 3 demolition and excavation works when using excavator hammers and during Sc 4.1 during construction structure works if using pile drivers at nearest receivers (R1, R2, R4, R6, R7).

Exceedances are predicted at nearest receivers R1 and R9 when using any equipment from Group A to Group F due to the proximity of the sites.

Note that cumulative impacts due to activities conducted concurrently or equipment operated concurrently has not been included as specific number of equipment is currently not know. Should concurrent activities occur, or plant and equipment to be operated concurrently, there is potential that receivers may be exposed to higher construction noise levels.

An analysis of potential cumulative impacts due to concurrent construction of other nearby development has not been included. Should concurrent construction activities there is a potential that receivers may be exposed to higher cumulative construction noise levels. In these instances, consultation with relevant development shall be conducted.

Note that no barriers have been considered in the prediction in Table 21. Temporary barriers and screens may provide up to 5 dB reduction to the predicted levels at the sensitive receivers when located in close proximity to the noise source.

Noise mitigation and management measures identified in Section 6.5 shall be considered for these works to limit noise impacts on nearest sensitive receivers.

6.4.4 Construction traffic impact assessment

The construction of the project will generate an increase in vehicle movements within the project site area and around the surrounding road network. Additional vehicle movements will be generated by:

- The arrival and departure of construction plant, equipment and vehicles; this may require off-peak movement of construction plant and equipment to/from work areas
- The haulage and delivery of road work materials, and removal of waste to and from the construction zones
- The arrival and departure of construction workers at the start and end of each work day, which will result in an increased traffic demand and turning manoeuvres to and from the construction site access.

Impact from construction traffic travelling to and from the site and within the site is to be mitigated by applying the management measures listed in Section 6.5 such as accessing site during daytime hours and limiting speed.

A.1.1 Construction vibration impact assessment

The NSW Construction Noise and Vibration Guideline provides, as a guide, minimum working distances from sensitive receivers for typical items of vibration intensive plant. The minimum working distances are reproduced in Table 22. The table has been supplemented with Arup's data.

Table 22: CNVG recommended minimum working distances for vibration intensive plant

Plant Item	**Rating/Description**	**Safe Working Distance**	
		Cosmetic Damage (BS 7385)	**Human Response (NSW EPA Vibration Guideline)**
Vibratory Roller	< 50 kN (Typically 1-2t)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4t)	6 m	20 m
	< 200 kN (Typically 4-6t)	12 m	40 m
	< 300 kN (Typically 7-13t)	15 m	100 m
	> 300 kN (Typically 13-18t)	20 m	100 m
	> 300 kN (Typically > 18t)	25 m	100 m
Small Hydraulic Hammer	300 kg - 5 to 12t excavator	2 m	7 m
Medium Hydraulic Hammer	900 kg - 12 to 18t excavator	7 m	23 m
Large Hydraulic Hammer	1600 kg - 18 to 34t excavator	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (NSW EPA Vibration Guideline)
Heavy Site Traffic		2m	2m
Road Saw[1]		2m	10m
Jumping Jack and plate compactor[2]		5m	55m
Trench Roller		5m	15m

Note 1: Assuming rock saw with 1mm/s vibration and 10m (CASB project report reference)

Note 2: Reference Vibration Source: hhtp://epubs.scu.edu.au/acmsm23/112/

The minimum working distances are indicative only and will vary depending on the item of plant and local geotechnical conditions. Accordingly, vibration monitoring shall be conducted to confirm the minimum working distances at specific sites with specific geotechnical conditions.

In relation to human comfort (response), the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason higher vibration levels, occurring over shorter periods are considered allowable.

Mitigation shall be considered where sensitive receivers are located within the minimum working distances. Monitoring is proposed where works are identified within the minimum working distances for cosmetic damages such as R1 and R6.

Vibration monitoring and careful selection of plant is required as described in Section 6.5.

6.5 Noise and vibration management

Any work that is carried out shall be done in such as way as to reduce the noise levels generated and comply with the noise limiting criterion.

Management measures have been described in the Construction Management Plan.

6.5.1 Pre-Lodgement consultation

China Centre Development engaged Ethos Urban to provide communication and stakeholder engagement services for the project. The consultation program included engagement and collaboration with the local community, neighbours, key stakeholders, and government authorities and agencies to present an overview of the SSDA and gather feedback during the preparation of the SSDA.

The consultation completed prior to the lodgement of this SSDA is detailed in the Consultation Outcomes Report prepared by Ethos Urban and submitted with the Environmental Impact Statement.

A variety of engagement tools and activities were used as part of these consultation exercises. These included:

- letterbox drop to 13,800 local properties providing an overview of the proposed development and invited them to attend a community information session;
- letters were sent to local landowners in potentially impacted properties;
- a community drop-in session was held for members of the community, residents and businesses;
- meetings with community stakeholders were held as requested; and
- meetings with government agencies were held as requested

China Centre Development has also consulted with all agencies referred to in the SEARs, being:

- City of Sydney Council
- Government Architect of NSW
- Sydney Coordination Office within Transport for NSW;
- Transport for NSW (Roads and Maritime Services);
- Sydney Trains;
- Sydney Metro; and
- Sydney Airport/CASA.

Consultation outcomes

Community feedback has been largely inquisitive in nature with a common understanding that this project will become a landmark feature of the Sydney CBD and changing to the existing landscape of the 'midtown' precinct.

Most members of the community that have engaged in the process have described the existing public domain and streetscape in the area as uninviting. As a result many people were enthusiastic to see a transformation proposed towards revitalising the area through better public domain activation and new retail and dining opportunities.

People were also attracted by the architectural features of the project including the skybridge, ground plane plaza and through-site links.

Many questions were raised in relation to the timings of the project delivery as well as the land uses and built form.

Some concerns were raised in relation to the perceived overshadowing effects and traffic congestion, however these were not serious issues as they did not oppose the project.

6.5.2 Training

All employees, contractors and utility staff working on site will undergo site induction training that includes construction noise and vibration management issues. The induction training will address elements related to noise and vibration management as described in Construction Management Plan Section 3.9 and including:

- All relevant project specific and standard noise and vibration management measures
- Permissible hours of work (Refer to Section 5.1 of Construction Management Plan)
- Any limitations on high noise generating activities
- Location of nearest sensitive receivers
- Construction employee parking areas
- Designated loading/unloading areas and procedures
- Site opening/closing times (including deliveries)
- Complaints reporting

6.5.3 Management measures

Management measures to limit noise and vibration impacts onto nearby receivers are listed in Table 23.

Table 23 Noise and vibration management measures summary

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
Community Consultation			
Community engagement prior to works	A suite of communication tools and activities will be utilised as required to target the sensitive receivers based on the nature of works and the potential impacts to provide clear, effective and timely information. Ongoing consultation in accordance with the Communication Plan (once developed) will assist to identify sensitive receivers and manage noise and vibration impacts.		Communication Manager
	A consultation meeting will be conducted with relevant stakeholders and surrounding tenants.	Pre-construction Fortnightly meetings throughout.	Communication Manager
	Develop a communication plan. The communication plan is based on on-going collaborative communication between the stakeholders/tenants and the contractors.	Pre-construction To be implemented during construction	Communication Manager
	Disruption notice to be communicated to the stakeholders/tenants to communicate	To be communicated 10 days prior to any (significant) disruption	Communication Manager
	Contact potentially noise affected neighbours (receivers identified in Section 2.1) at the earliest possible time before any site work begins and keep up to date with works progress	Pre-construction	Communication Manager

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
	Periodic notifications – These include regular newsletters, letterbox drops or advertisements in local papers to provide an overview of current and upcoming works and other topics of interest. Email distribution list is recommended to be provided (used to disseminate project information to interested stakeholders) Signage shall be provided to notify stakeholders of project details and project emergency or enquiry information Specific notifications – Specific notifications would be letterbox dropped or hand distributed to the nearby residences and other sensitive receptors no later than seven days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications, or to advertise unscheduled works.	Pre-construction assessment. To be implemented during construction	Communication Manager
	The Contractor will maintain records of community engagements at the site office throughout construction	Throughout construction.	Communication Manager
	The Communications Manager must record all complaints on the stakeholder database, Consultation Manager, and register complaints on the Complaints spreadsheet if Consultation Manager is unavailable.	Throughout construction.	Communication Manager
Register Noise Sensitive Receivers	The Contractor shall register all noise and vibration sensitive receivers (NSRs) and the register shall be kept on site. The register shall include the following details for each NSR: Address of receiver Category of receiver (e.g Residential, Commercial etc.) Contact name and phone number.	Pre-construction	Communication Manager
Programming – for emergency work	On becoming aware of the need for emergency construction works, the noise sensitive receiver shall be notified of the need for those activities or works. Best endeavours to notify all affected sensitive receivers of the likely impact and duration of those works shall be carried out. It is anticipated that letter box drops, emails and phone calls will be used as a minimum.	During construction	Project Manager Communication Manager
Works and Site Planning			
Develop and Update the CNVMP	The CNVMP must be regularly updated to account for changes in noise and vibration management issues and strategies. A weekly review of any monitoring, complaints and incidents register shall be carried out to inform necessary changes to the plan.	Weekly review	Project Manager

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
Construction hours and scheduling	Where feasible and reasonable, construction shall be carried out during the standard daytime working hours. Work that is considered high impact noise and/or high impact vibration levels, shall be scheduled after 8 am. Work that is considered high impact noise and/or high impact vibration levels, shall be scheduled during a time that will reduce the impact on sensitive receivers when possible.	Pre-construction assessment. To be implemented during construction	Project Manager
Respite periods	High noise and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) shall only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. (Note: "Continuous" includes any period during which there is less than a 60 minutes respite between ceasing and recommencing any of the work). Where other equipment is utilised, timing can vary, but must accord with the 3 hours on / 1 hour off respite and be coordinated with other work in the Area.	Pre-construction assessment. To be implemented during construction	Project Engineer
Vehicle movements	Where possible, heavy vehicle movements shall be limited to standard construction hours.	Pre-construction assessment. To be implemented during construction	Contractor Foreman
Traffic and loading areas	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements and idling traffic within the site. Vehicles, shall not queue idling in front of residential apartments to await entry into the site	Pre-construction assessment and to be implemented during construction	Contractor Foreman
	Select site access points and roads as far as possible away from Noise Sensitive Receivers (NSRs) Dedicated loading/unloading areas to be shielded if close to NSRs Delivery vehicles to be fitted with straps rather than chains for unloading, wherever feasible and reasonable Reduce construction traffic if available to do so	Pre-construction assessment and to be implemented during construction	Superintendent
Delivery vehicles	Loading and unloading of materials/deliveries is to occur as far as possible from NSRs. Vehicles being loaded/unloaded shall have engines switched off where practicable.	Pre-construction assessment. To be implemented during construction	Superintendent Contractor Foreman

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
Use and siting of plant	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant and equipment used intermittently is to be throttled down or shut down. Noise-emitting plant is to be directed away from sensitive receivers. Only have necessary equipment onsite	Pre-construction assessment. To be implemented during construction	Contractor Foreman
Boundary screening and hoarding	Hoardings will be installed in accordance with the City of Sydney guidelines.	N/A	Superintendent
Shielding by Site Sheds or other structures	Structures such as site sheds shall be positioned to further shield sensitive and residential receivers from works activities. Conduct work behind temporary hoardings/screens wherever possible	Pre-construction assessment. To be implemented during construction/demolition.	Project Engineer
Shield stationary noise sources	Sources such as pumps, compressors, fans etc: Stationary noise sources would be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained.	To be implemented during construction.	Superintendent
Work practices			
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. Refer to Section 6.5.1 of this document.	Pre-construction and to be implemented during construction	Environmental Manager
Toolbox talks	During toolbox talks, site and works specific noise and vibration requirements shall be included, including: Hours of work Scheduled respites Review of Work Practices measures Current monitoring in vicinity of works.	To be implemented during construction	Contractor Foreman

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios onsite. No dropping of materials from height, throwing of metal items and slamming of doors Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise. Consideration shall be given to driver behaviours	To be implemented during construction	The Contractor, Associates and Subcontractors
Site review	The foreman shall carry out daily review of works practices to ensure the compliance with this Construction Noise and Vibration Management Plan.	To be implemented during construction Daily	Contractor Foreman
Simultaneous operation of noisy plant	Simultaneous operation of noisy plant near sensitive receptors shall be avoided (where possible). Plant and equipment used intermittently is to be throttled down or shut down.	To be implemented during construction	Contractor Foreman
Activity and Equipment Selection			
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable. Examples of alternative techniques are listed below: **Demolition:** • Section, slab and wall sawing • Diamond tipped wire sawing • Bursting, splitting, fracturing etc • Portable or excavator assisted crushing methods **Excavation** • During excavation: low vibration techniques such as saw cutting or ripping shall be the preferred option than the use of rock hammers. **Piling** • When piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.	Pre-construction assessment. To be implemented during construction	Superintendent

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
Equipment maintenance	Ensure plant is regularly maintained, and repair or replace equipment that becomes noisy. For permanent equipment, utilised for longer than two months, conduct compliance checks for noise emissions from all plant and machinery used to indicate whether noise emissions from plant items are higher than predicted and to identify defective silencing equipment on the items of plants.	To be conducted during construction For equipment utilised for longer than 2 months on site	Environmental Manager
Reduced equipment power	Use only the necessary size and power of equipment.	To be conducted during construction	Contractor Foreman
Non-tonal and ambient sensitive reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used onsite and for any out-of-hours work. Factoring in the potential for use of hearing protection by workers, consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level whilst ensuring that the occupational health and safety of workers is maintained.	Pre-construction assessment. To be conducted during construction.	Environmental Manager
Silencers on Mobile Plant	Where possible reduce noise from mobile plant through additional fittings including: Residential grade mufflers Damped hammers such as “City” Model Rammer Hammers	Pre-construction assessment. To be conducted during construction.	Contractor Foreman
Rental plant and equipment	The noise levels of plant and equipment items are to be considered in rental decisions	Pre-construction assessment. To be conducted during construction.	Contractor Foreman
Vibration intensive activities	Piling activities that affect sensitive receivers must be undertaken using quieter alternative methods than impact or percussion piling, such as bored piles or vibrated piles, where practicable. In general, mitigation and management measures that would be considered include: • Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment. • Use lower vibration generating items of excavation plant and equipment (e.g. smaller capacity rock breaker hammers), particularly at lower levels of demolition and excavation. • Minimise consecutive works in the same locality (if applicable). • Use dampened rock breakers to minimise the impacts associated with rock breaking works.	Pre-construction assessment and to be implemented during construction	Senior Project Engineer

Management Measure Requirement	Details	Timing/ Frequency	Responsibility
Monitoring and inspection			
Structural surveys	Pre-construction surveys of the structural integrity of vibration sensitive buildings have been identified. Refer to Section 6.5.4	Pre-construction assessment.	Environmental Manager
Attended Vibration Monitoring	Attended vibration measurements are required at the commencement of vibration generating activities that are proposed within the Cosmetic Damage minimum working distances, identified in Table 22 Monitoring will be used to established if alternative works procedures are required. Follow vibration measurement procedure in Section 6.5.6	To be implemented during construction. Refer to Section 6.5.6	Subcontractor
Extended Vibration Monitoring	If vibration intensive works are required within the minimum working distances in Table 22, and attended vibration monitoring has established risk of exceedance, extended monitoring will be carried out. See Section 6.5.6 for detail.	To be implemented during construction. Refer to Section 6.5.6	Environmental Coordinator Subcontractor
Noise Monitoring	A noise monitoring program is to be carried out for the duration of the works in accordance with this Construction Noise and Vibration Management Plan. The monitoring program is outlined in Section 6.5.6	To be implemented during construction.	Environmental Manager Subcontractor
	Ongoing noise monitoring during construction at sensitive receptors during critical periods shall be used to identify and assist in managing high risk noise events. Monitoring of noise shall also be carried out in response to complaints. All noise monitoring shall be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, who is familiar with the requirements of the relevant standards and procedures.	Pre-construction assessment and to be implemented during construction	Subcontractor

6.5.4 Dilapidation surveys

As per Construction Management Plan Section 4.1.

6.5.5 Community engagement and complaints management process

As per Construction Management Plan Section 4.2 and 4.3.

The complaints management process will be detailed in the Communication Plan and will sets out the projects' approach to handling complaints.

6.5.6 Monitoring

If required, noise and vibration monitoring can be conducted. .

Table 24 outlines the construction noise and vibration monitoring procedures.

Table 24 : Construction noise monitoring procedure

Item	Details
General requirements:	Environmental audits (which include noise monitoring) must be conducted in accordance with AS/NZS ISO 19011. All noise monitoring would be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, who is familiar with the requirements of the relevant standards and procedures.
Baseline Data	Baseline data has been conducted and is outlined in Appendix B. Additional baseline is not deemed to be required.
Monitoring to be undertaken	Generally short-term attended monitoring is response to specific complaint should it be required to quantify noise levels and compliance with relevant criteria. Generally, response would be based on application of mitigation and management measures.
Noise Monitor requirements Parameters to be monitored	Attended: Comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or 2. Allow averaging and storing data for standard 15-minute measurement period. Measurements to be carried out in accordance with AS 1055 Plant specific noise measurements shall be carried out in accordance with AS2012.1. Noise parameters recorded are L_{max}, L_1, L_{10}, L_{90} and L_{Aeq}.

Item	Details
When to monitor:	At commencement of activities Where construction is undertaken at sensitive receptors during critical periods, use monitoring to identify and assist in managing high risk noise events. For any alternative equipment or processes expected to be significantly louder (>5 dB) than those listed in this CNVMP Representative of typical worst-case activities, with at least one survey during high-noise activities, or During period when a complaint has been received. An acoustic engineer is recommended for any complex monitoring, such as after a complaint, or at the start of a particular noisy activity.
Locations:	At specified sensitive receiver location or suitable representative location (Sensitive receivers are identified in Section 2.1). Microphone minimum 1.2 m above the ground level in the free-field, away from reflecting surfaces (> 3 m)
Reporting	Plant specific noise measurements shall be carried out in accordance with AS2012.1 with results compared to standard published noise levels for that equipment/ activity. The monitoring data will inform construction scheduling, the level of impacts and whether additional mitigation is required. Monitoring report/s will be provided by email. Monitoring report/s shall include noise investigations, calculations and mitigation measures and additional noise surveys undertaken if any. Monitoring report will be provided within 5 working days within completion of the monitoring/ survey.

Table 25 : Construction vibration monitoring procedure

Item	Details
General requirements:	Environmental audits (which include noise monitoring) must be conducted in accordance with AS/NZS ISO 19011. All vibration monitoring would be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, who is familiar with the requirements of the relevant standards and procedures.
Baseline Data	Baseline data is not specifically required for the vibration monitoring program.
Monitoring to be undertaken	Generally short-term attended monitoring when required. Long-term unattended monitoring (24/7 monitoring) will be carried out where short-term monitoring indicates works is close to or at risk of exceeding vibration criteria for cosmetic damage.

Item	Details
Parameters to be monitored	Peak Particle Velocity (PPV) – for the assessment of cosmetic damage The long-term monitoring system will have the following features: • Continuous vibration monitoring system with notification trigger levels • Ability to send notification emails/SMS messages when the prescribed trigger levels are exceeded. • Ability to monitor and trigger notifications on peak particle velocity (PPV) and 3rd Octave Band RMS velocities. • Recorded vibration time history data for a minimum of 1 minute following a trigger event • Proposed equipment shall be reviewed by the vibration consultant to ensure the results obtained are readily comparable with criteria and any previous testing results • Capability for online access to monitored data.
When to monitor:	Use of vibration generating equipment within the safe working distance for cosmetic damage listed in Table 22 Monitor in response to complaint. If vibration intensive works are required within the minimum working distances, vibration monitoring or attended vibration trials would be carried out to ensure that levels remain below the cosmetic damage criterion.
Locations:	At specified sensitive receiver location or suitable representative location, preferable connected to the building foundation or structure. Alternatively located immediately adjacent to building structure, with appropriate mounting to couple with the ground (e.g. stake/spike). (Sensitive receivers are identified in Section 2.1) The vibration monitor(s) will be relocated as required during the works such that it/they are located at a representative distance from the works to the nearest sensitive structures and locations. Monitoring for the establishment of minimum working distances shall be carried out away from sensitive structures, or commence with plant operating well outside the anticipated minimum working distances.
Reporting	Vibration monitoring and inspection reporting shall outline the results and summary of vibration impacts including any exceedances of related limits/criteria. The results of any vibration monitoring shall be provided as requested and to assist in addressing complaints, where required. The monitoring report/s shall include vibration investigations, calculations and management and mitigation measure and additional vibration surveys undertaken if any. The report will aim to be provided within 5 working days within completion of the monitoring/ survey. Monitoring report/s will be provided by email.

Item	Details
Procedures to identify and implement additional management and mitigation measures	Where exceedance is identified (when an sms alert has been sent as per section "Vibration Monitor Requirements"), review equipment usage, mitigation and management measures. Short term testing can be used to reduce or increase the required minimum working distances between the construction activity and sensitive receivers to ensure vibration criteria are not breached whilst proceeding with construction works with maximum possible efficiency. If vibration levels are repeatedly exceeding the criteria levels, then work shall be stopped, and appropriate action taken such as: • Modifications to construction equipment used • Modifications to methods of construction

6.5.7 Review and improvement

Improvements of this Construction Noise and Vibration Management Plan will be conducted when specific details regarding methods of construction/demolition and plant and equipment to be used are known.

In addition, continuous improvement of the Construction Noise and Vibration Management Plan will be conducted to:

- Identify areas of opportunity for improvement
- Determine the cause or causes of non-conformances and deficiencies
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies
- Verify the effectiveness of the corrective and preventative actions
- Document any changes in procedures resulting from process improvement
- Make comparisons with objectives and targets. The Contractor will implement a continuous improvement system to address any non-compliances.

7 Conclusion

Acoustic assessments have been carried out in accordance with SEARs requirements, such as the noise intrusion, rail ground-borne noise and vibration intrusion, noise emission and noise from traffic generation.

The findings of the report indicate that, although detailed acoustic mitigation measures will need to be further developed as design progresses, the development is feasible to comply with relevant acoustic policies and standards with appropriate acoustic design.

Acoustic mitigation measures to control the rail ground-borne noise from Sydney Metro may be required. However, this prediction is conservative and based on preliminary information available at the current stage of design. As such, it is recommended that further detailed assessment/modelling is required during the detailed design stage when the building design progressed and updated information is provided by Sydney Metro.

Preliminary demolition and construction noise and vibration management plan has been prepared in accordance with Construction Hours/Noise within the Central Business District [9].

On the basis of the information above, it is concluded that the proposed development can operate successfully within the City of Sydney and the NSW state guidelines

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Appendix A

Acoustic Terminology

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / min$L_{A90,1hour}$)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB L_{Aeq}. Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

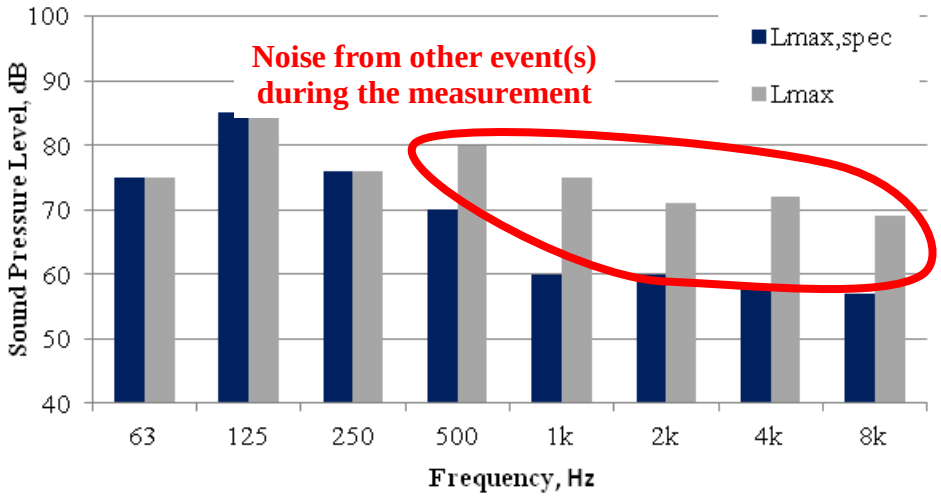
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

$L_{max\ spec}$

$L_{max\ spec}$ is another representation of the highest noise or vibration levels during the measurement period.

$L_{max\ spec}$ is the spectrum of the event that caused the highest overall sound or vibration level during the measurement period is denoted by dB $L_{max\ spec}$. An example of the relationship between dB L_{max} and dB $L_{max\ spec}$ is shown below.



L_{max} (see definition above), when measured on an octave band or 1/3 octave band meter, is the spectrum obtained by recording the highest measured value in each band. However, the highest measured values in each band may occur at different times.

Hence, $L_{max\ spec}$ represents a real event, while L_{max} is often the mathematical addition of frequency band values from different times and often does not represent a real-world event.

Since $L_{max\ spec}$ is caused by an instantaneous event, $L_{max\ spec}$ levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as “pitch”. Sounds towards the lower end of the human hearing frequency range are perceived as “bass” or “low-pitched” and sounds with a higher frequency are perceived as “treble” or “high pitched”.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a

source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, R_w, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

Spectrum Adaptation Terms (C and C_{tr})

The terms C and C_{tr} are spectrum adaptation terms (in dB) that are added to the R_w or D_w value of a partition in order to determine the overall sound insulation rating of a partition for various conditions. The overall performance of the partition is quoted as the sum of the Rw value and the spectrum adaptation terms, e.g. D_w + C 55 dB; R_w + C_{tr} 60 dB.

C is a spectrum adaptation term used to measure the performance of a partition for medium to high-frequency noise sources, such as speech.

C_{tr} is a spectrum adaptation term used to measure the performance of a partition for low-frequency noise sources such as traffic noise.

The values of C and C_{tr} are dependent on the construction of the partition. Because C and C_{tr} are (usually) negative quantities, they typically increase the Rw requirement of a partition (eg if C_{tr} is -6 dB, an R_w of 56 dB is required to achieve a rating of R_w + C_{tr} 50 dB).

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they

can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

Long-term noise monitoring results

B.1 Noise monitoring equipment

Unattended monitoring was carried out using the following equipment:

Measurement location	Equipment/model	Serial No.	SLM Type
338 Pitt street, level 6 Balcony (Approximately 2.2m away from the façade)	ARL Ngara	878061	Class 1
Corner Pitt street and Liverpool street, level 6 Balcony (Approximately 2.2m away from the façade)		87807f	
249 Castleareagh Street, roof level (4 storeys), roof level		8780D0	

Notes:

All meters comply with AS IEC 61672.1 2013 “Electroacoustics - Sound Level Meters” and designated either Class 1 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed.

B.2 Extraneous/weather affected data

Measurement samples affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the procedures outlined in Fact Sheet A of the NSW Noise Policy for Industry (NPI).

Data provided by the Bureau of Meteorology (BOM), for the nearest representative weather station to noise monitoring location(s). Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B.3 Logger graphs

The following noise level vs time graphs present overall dB(A) levels recorded by the unattended logger(s) for a range of noise descriptors, including L_{Aeq}, L_{A90}, L_{A10} and L_{Amax}, while line graphs are presented, sampling is at 15 minute intervals.

Wind speeds are also show where relevant, and periods of excluded data are shaded grey.

ARUP

L2 - Pitt Street (Facade)

Additional detail:

Background and ambient noise monitoring results - NSW 'Noise Policy for Industry', 2017

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Tuesday-29-October-2019		62	57		64	61
Wednesday-30-October-2019	63	62	56	66	66	61
Thursday-31-October-2019	64	62	57	67	65	63
Friday-01-November-2019	64	63	57	67	66	64
Saturday-02-November-2019	61	62		64	65	
Sunday-03-November-2019		62	56		66	62
Monday-04-November-2019	63	61	56	66	65	62
Tuesday-05-November-2019	63	62	56	66	65	61
Wednesday-06-November-2019	63	62	56	66	68	62
Thursday-07-November-2019	63	62	57	66	65	62
Friday-08-November-2019	63	63	57	66	66	64
Saturday-09-November-2019	61	62	58	64	65	62
Sunday-10-November-2019	60	61	56	62	63	61
Monday-11-November-2019						
Representative Week[5]	**63**	**62**	**56**	**66**	**65**	**62**

Notes:

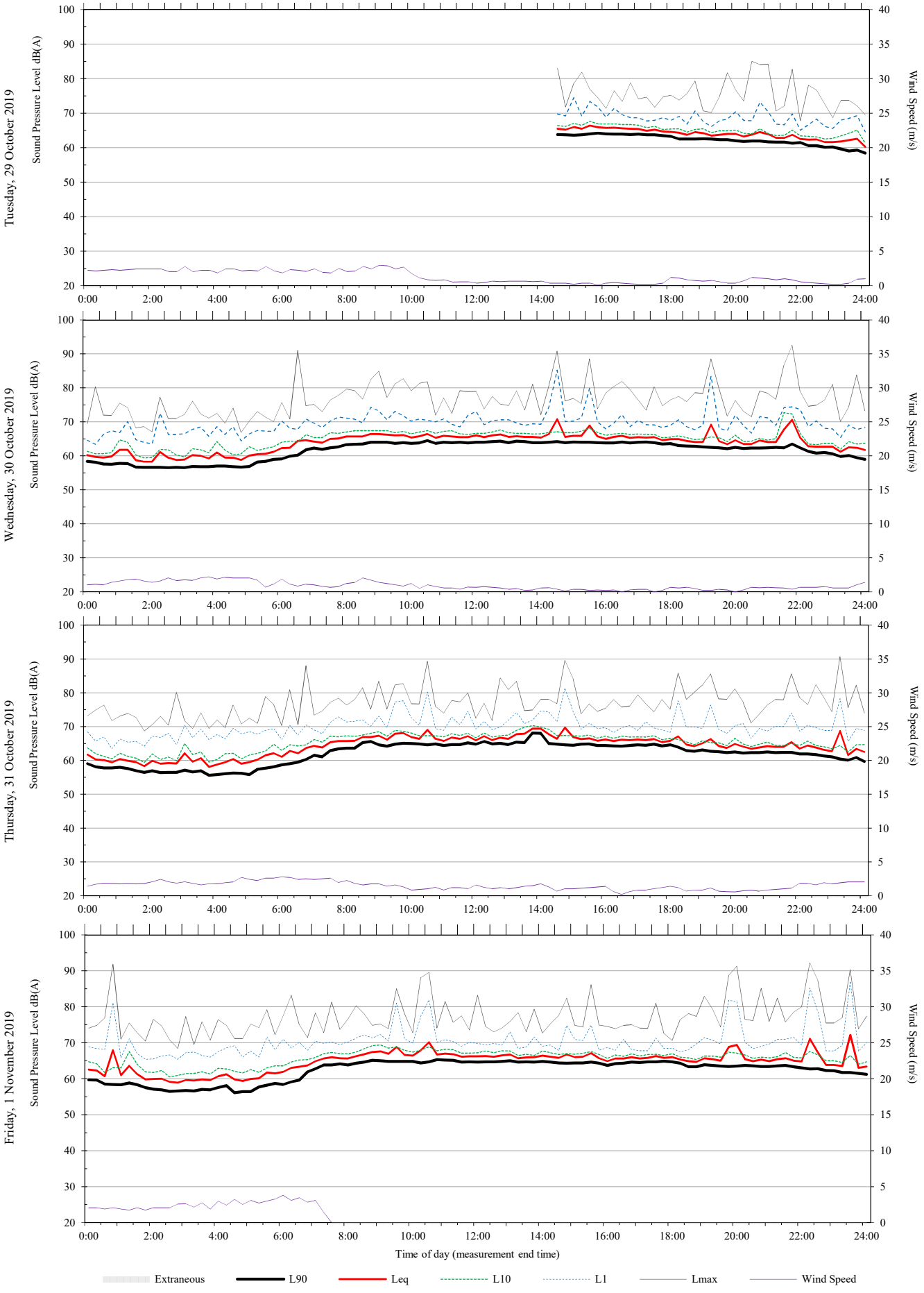
1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Road noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Tuesday-29-October-2019	65	61	66	64
Wednesday-30-October-2019	66	61	68	63
Thursday-31-October-2019	66	63	68	65
Friday-01-November-2019	66	64	68	68
Saturday-02-November-2019	64	63	65	66
Sunday-03-November-2019	66	62	69	66
Monday-04-November-2019	66	62	68	66
Tuesday-05-November-2019	66	61	66	63
Wednesday-06-November-2019	66	62	68	64
Thursday-07-November-2019	66	62	0	63
Friday-08-November-2019	66	64	67	67
Saturday-09-November-2019	64	62	66	65
Sunday-10-November-2019	63	61	63	64
Monday-11-November-2019	66		66	
Representative Week[3]	**66**	**62**	**67**	**65**

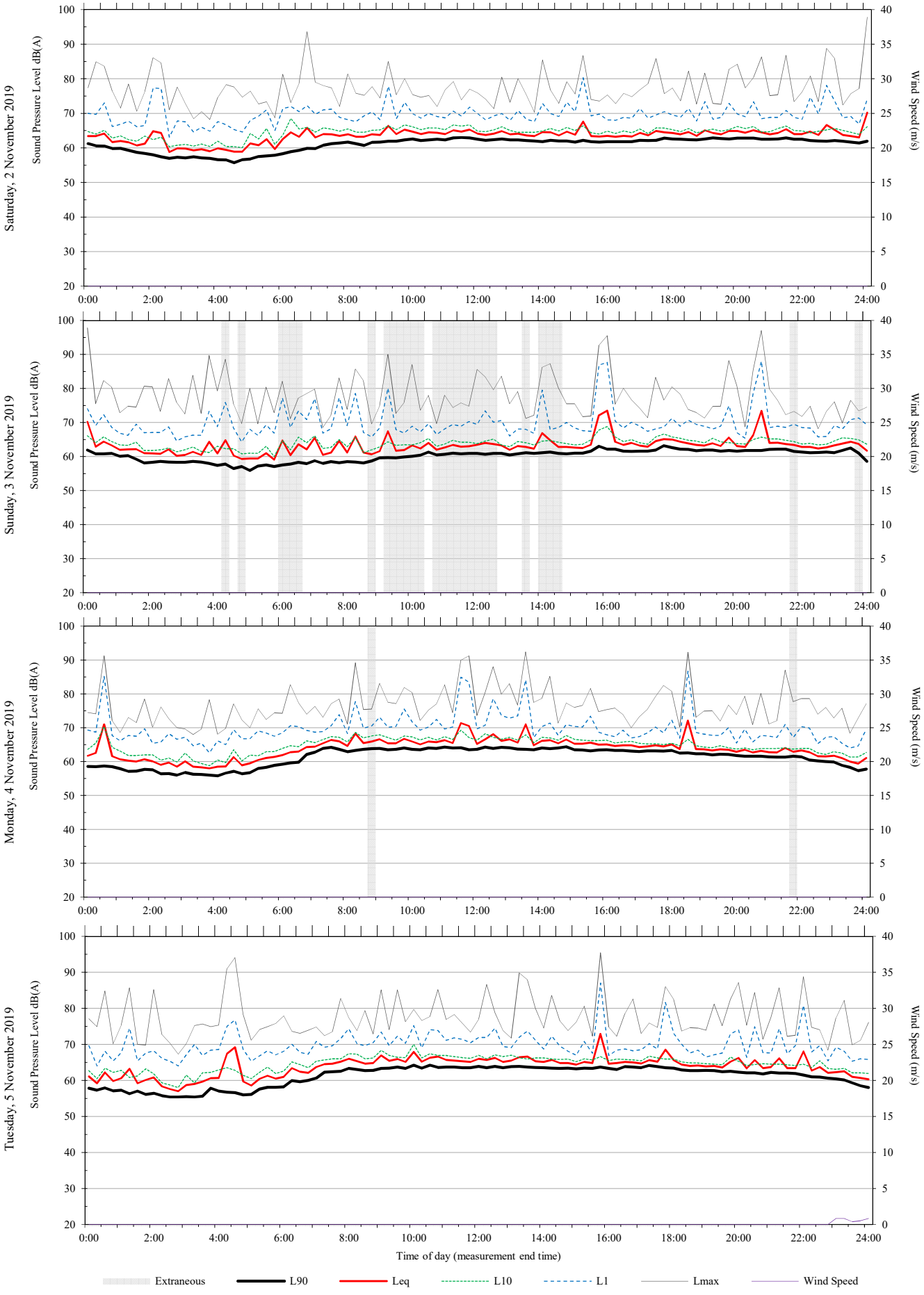
Unattended monitoring: L2 - Pitt Street (Facade)

ARUP



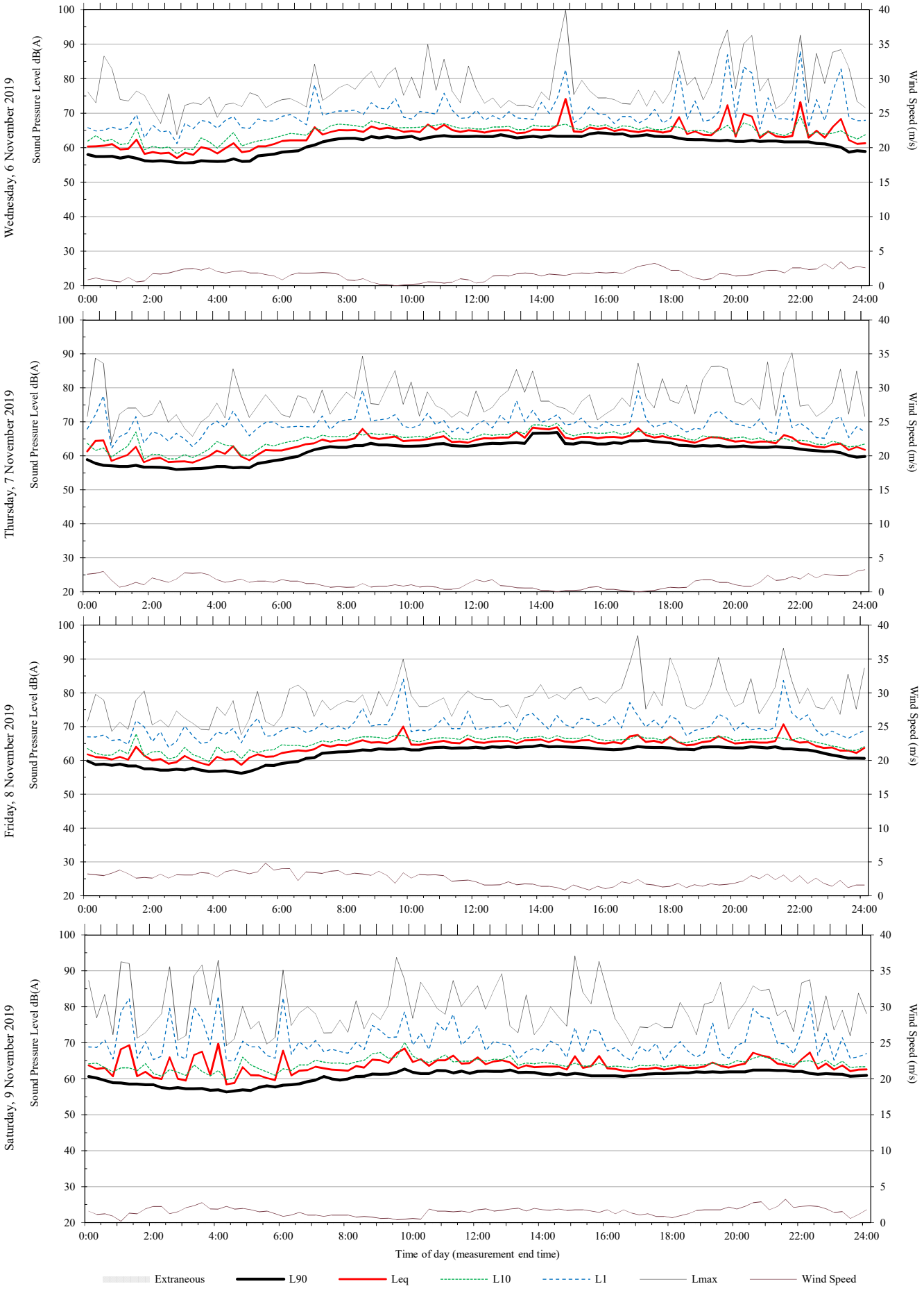
Unattended monitoring: L2 - Pitt Street (Facade)

ARUP



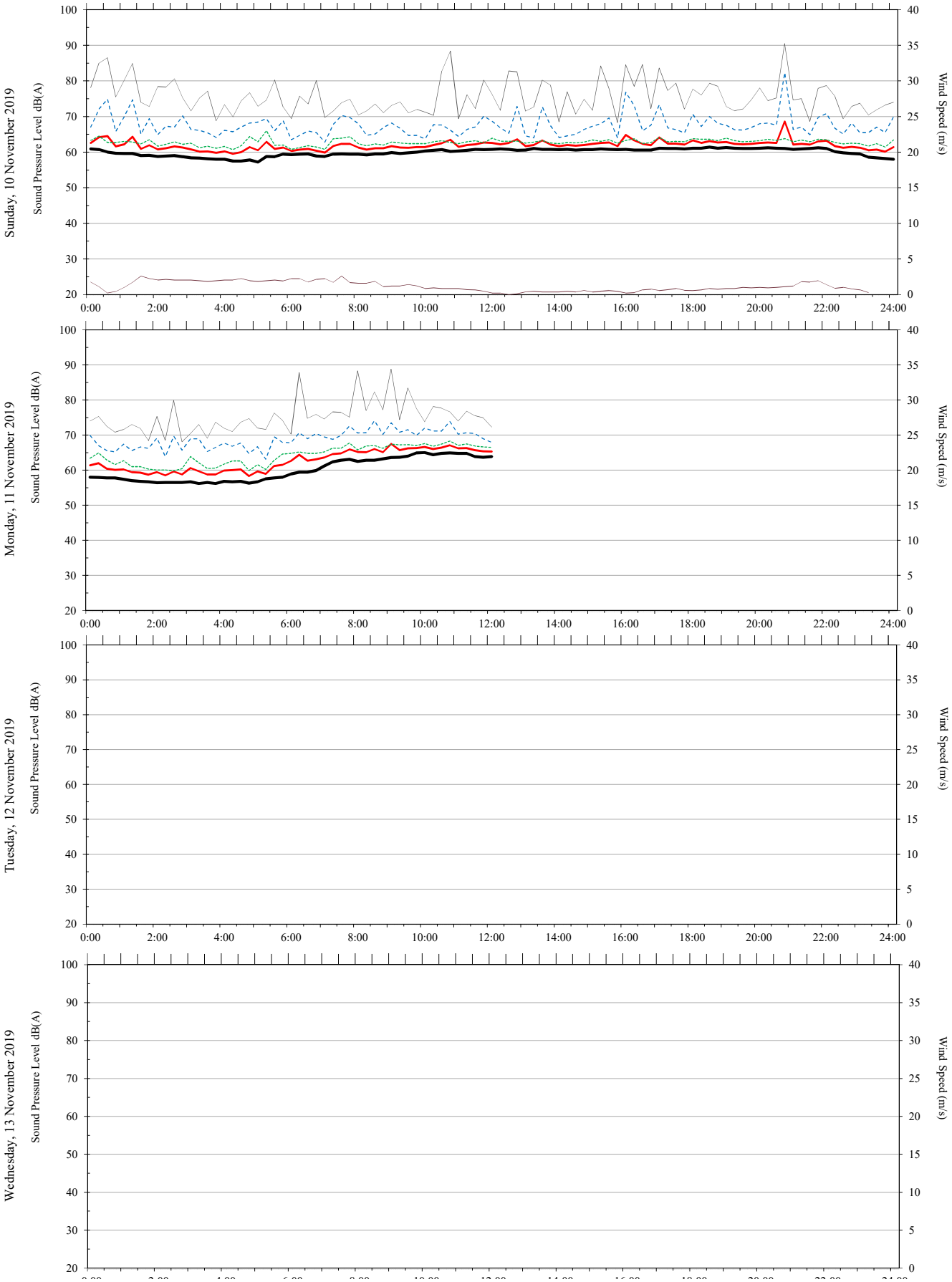
Unattended monitoring: L2 - Pitt Street (Facade)

ARUP



Unattended monitoring: L2 - Pitt Street (Facade)

ARUP



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L1 - Corner Pitt Street/Liverpool Street (Facade)

Additional detail:

Background and ambient noise monitoring results - NSW 'Noise Policy for Industry', 2017

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Tuesday-29-October-2019		64	59		67	64
Wednesday-30-October-2019	65	65	59	68	70	64
Thursday-31-October-2019	65	65	59	68	68	65
Friday-01-November-2019	65	65	59	68	69	68
Saturday-02-November-2019	63	65		67	67	
Sunday-03-November-2019		64	59		68	65
Monday-04-November-2019	65	64	58	69	68	65
Tuesday-05-November-2019	65	64	59	68	67	64
Wednesday-06-November-2019	65	64	59	68	70	66
Thursday-07-November-2019	64	64	59	67	67	64
Friday-08-November-2019	65	65	59	68	69	68
Saturday-09-November-2019	62	64	60	67	67	65
Sunday-10-November-2019	62	63	59	66	66	64
Monday-11-November-2019						
Representative Week[5]	**65**	**64**	**59**	**68**	**68**	**65**

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 L_{A90} and logarithmic average for L_{Aeq}

Road noise monitoring results

	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Tuesday-29-October-2019	67	64	68	66
Wednesday-30-October-2019	69	64	71	66
Thursday-31-October-2019	68	65	68	69
Friday-01-November-2019	68	68	70	72
Saturday-02-November-2019	67	67	68	69
Sunday-03-November-2019	68	65	70	69
Monday-04-November-2019	69	65	72	68
Tuesday-05-November-2019	68	64	69	66
Wednesday-06-November-2019	69	66	71	70
Thursday-07-November-2019	67	64	0	66
Friday-08-November-2019	68	68	70	71
Saturday-09-November-2019	67	66	69	68
Sunday-10-November-2019	66	64	68	67
Monday-11-November-2019	68		68	
Representative Week[3]	**68**	**65**	**69**	**69**

Notes:

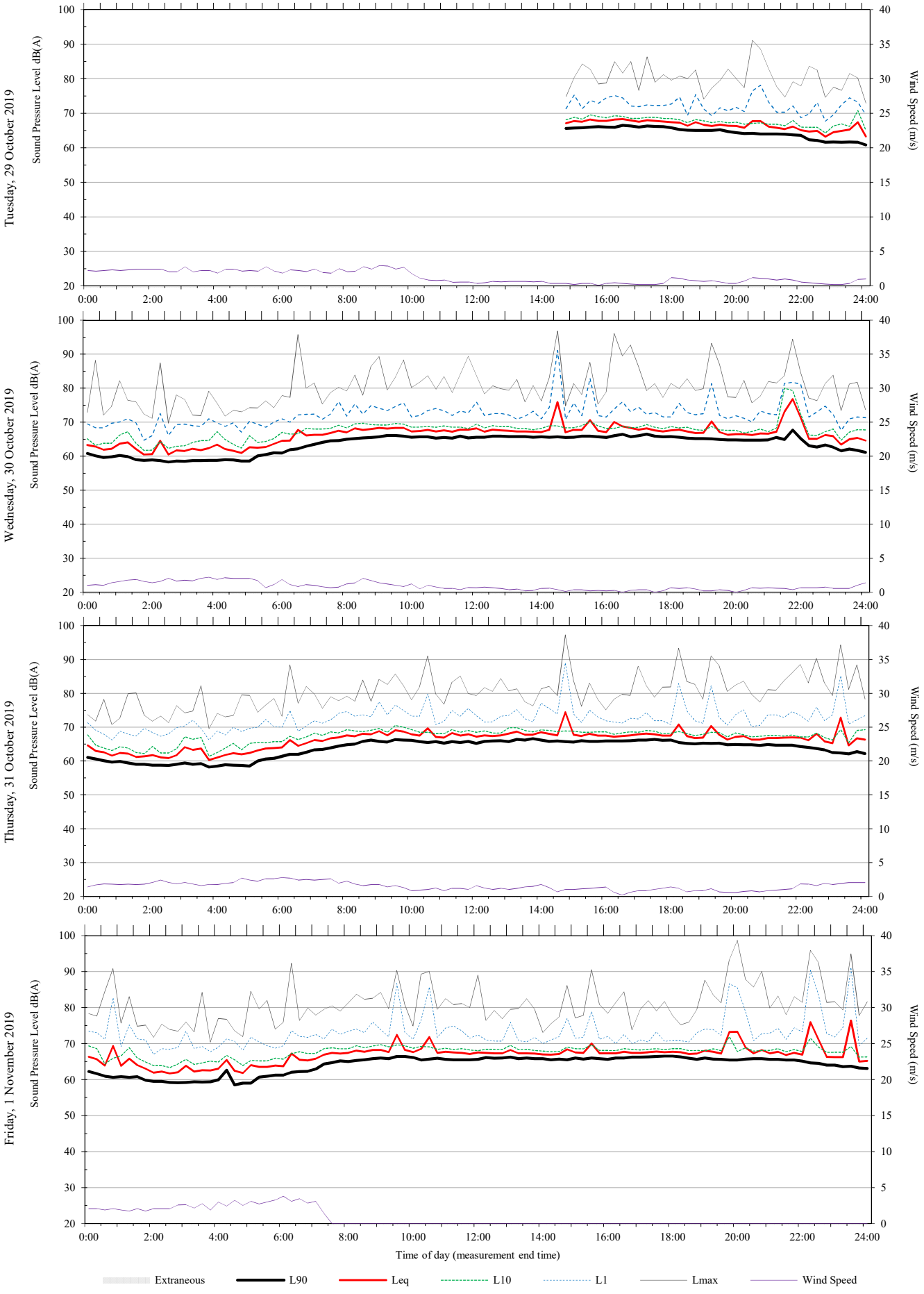
1. Day is 7:00am to 10:00pm

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

3. Logarithmic average of daily L_{Aeq}

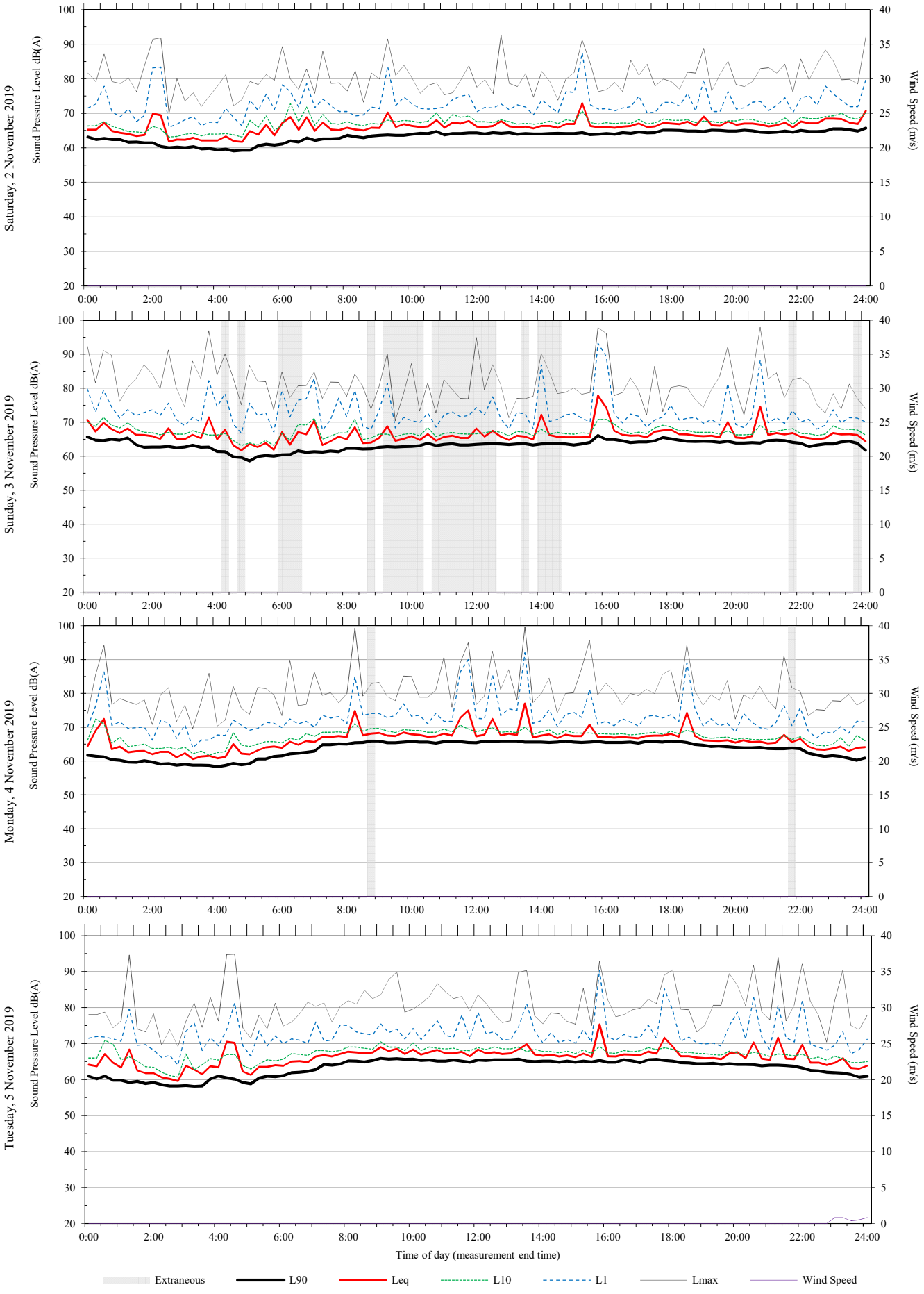
Unattended monitoring: L1 - Corner Pitt Street/Liverpool Street (Facade)

ARUP



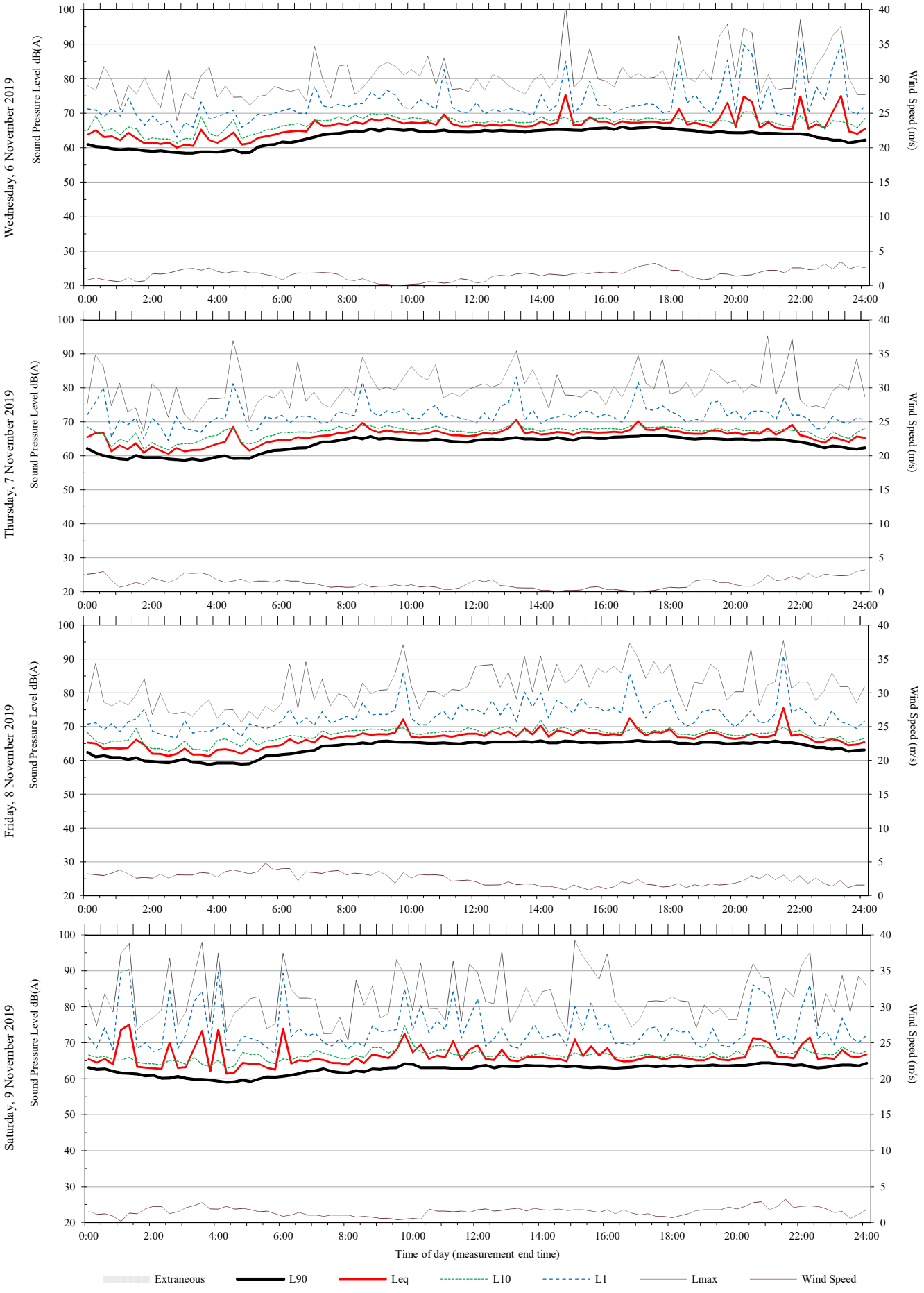
Unattended monitoring: L1 - Corner Pitt Street/Liverpool Street (Facade)

ARUP



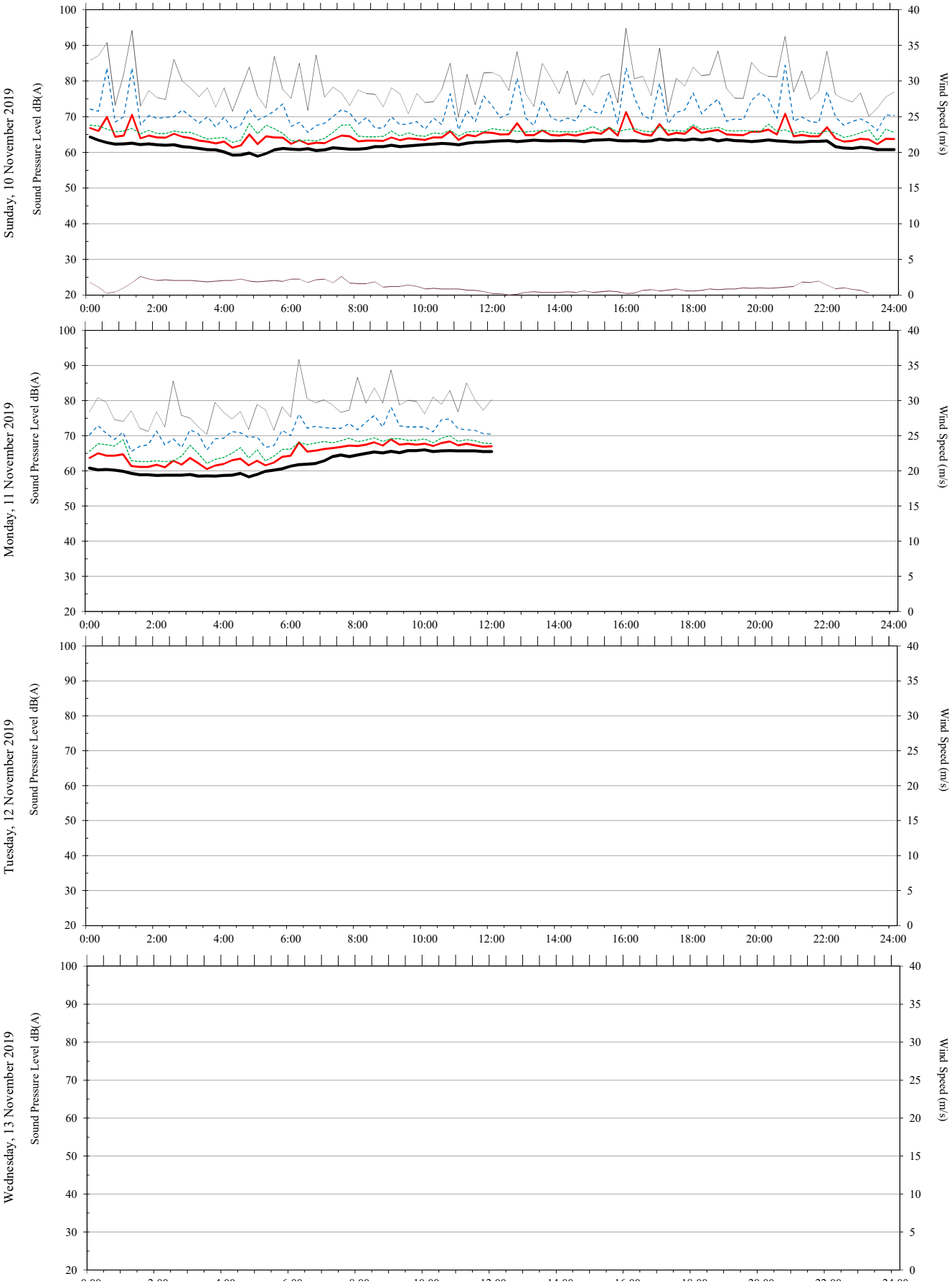
Unattended monitoring: L1 - Corner Pitt Street/Liverpool Street (Facade)

ARUP



Unattended monitoring: L1 - Corner Pitt Street/Liverpool Street (Facade)

ARUP



ARUP

L3: Facing Castlereagh St. Level 4 (Free Field)

Additional detail:

Background and ambient noise monitoring results - NSW 'Noise Policy for Industry', 2017

	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Monday-04-November-2019		60	56		64	61
Tuesday-05-November-2019	62	60	55	66	65	60
Wednesday-06-November-2019	62	60	57	66	65	62
Thursday-07-November-2019	63	60	56	66	64	61
Friday-08-November-2019	63	61	56	66	66	62
Saturday-09-November-2019	58	59	56	63	63	62
Sunday-10-November-2019						
Representative Week[5]	**62**	**60**	**56**	**66**	**65**	**61**

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 L_{A90} and logarithmic average for L_{Aeq}

Road noise monitoring periods

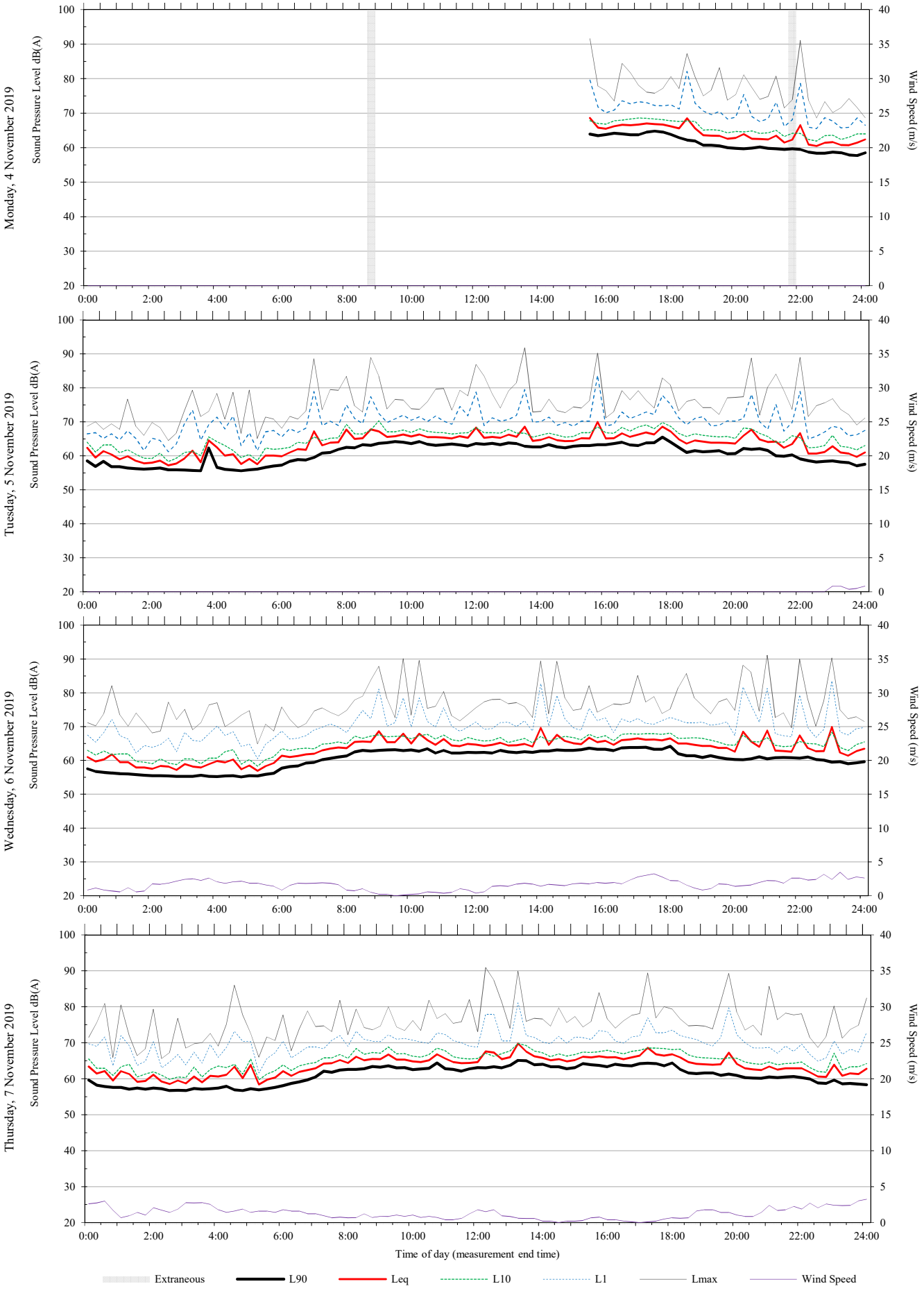
	L_{Aeq} Noise levels		$L_{Aeq\ 1hr}$ Noise levels (upper 10th percentile)	
Date	**Day[1]**	**Night[2]**	**Day**	**Night**
Monday-04-November-2019	66	61	67	64
Tuesday-05-November-2019	66	60	67	62
Wednesday-06-November-2019	66	62	67	66
Thursday-07-November-2019	66	61	67	62
Friday-08-November-2019	66	62	68	64
Saturday-09-November-2019	63	62	65	66
Sunday-10-November-2019	62		65	
Representative Week[3]	**65**	**61**	**67**	**64**

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}

Unattended monitoring: L3: Facing Castlereagh St. Level 4 (Free Field)

ARUP



Unattended monitoring: L3: Facing Castlereagh St. Level 4 (Free Field)

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