WALSH BAY ARTS AND CULTURAL PRECINCT

STATE SIGNIFICANT DEVELOPMENT APPLICATION

SSDA 8671

APPENDIX 19:

NOISE AND VIRATION IMPACT ASSESSMENT

NSW GOVERNMENT

Infrastructure New South Wales

Walsh Bay Arts and Cultural Precinct

SSDA - Noise and Vibration Impact Assessment

R06

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Contents

Appendices

1 Introduction

This report describes the outcome of a detailed investigation into the environmental noise and vibration issues associated with the proposed development of the Walsh Bay Arts and Cultural Precinct (WBACP).

Alongside the WBACP project, there are plans for major modifications to take place inside the Sydney Theatre Company (STC) facilities, located on level 1 of Wharf 4/5 of the WBACP. To limit the disruption, it is likely that the works would be done at the same time as the main WBACP project. Although these are subject to a separate planning application, the potential cumulative impacts from these works for STC have been assessed herein.

A list of referenced documents is provided in Appendix A.

A glossary of the acoustic terminology used in this report has been included in Appendix B.

1.1 The Project

The NSW Government is committed to development of a public arts and cultural precinct at Walsh Bay. Infrastructure NSW is acting on behalf of the client, Arts, Screen and Culture Division in preparing this State Significant Development Application(SSDA) for the WBACP.

This SSDA will seek approval for the construction and operation of Pier 2/3 and Wharf 4/5 for arts and cultural uses with complementary commercial and retail offerings to activate the precinct.

The site generally comprises Pier 2/3, Wharf 4/5, and Wharf 4/5 Shore Sheds. The site has a street frontage to Hickson Road as shown in Figure 1. The site is part of the Walsh Bay area, which is located adjacent to Sydney Harbour within the suburb of Dawes Point.

Figure 1: The Site

The Scope of the Project is as follows:

Pier 2/3

- The adaptive re-use providing for new arts facilities including performance venues for the Australian Chamber Orchestra (ACO), Bell Shakespeare (Bell) and Australian Theatre for Young People (ATYP);
- Retaining a large heritage commercial events/art space for events such as Sydney Writers Festival, Biennale of Sydney and a wide range of commercial and artistic events;
- A series of stairs, external lift and balconies designed as a contemporary interpretation of the original gantries reflecting the precinct's former industrial heritage
- Modifications to the roof

Wharf 4/5 (including Shore Sheds)

- Refurbishment of the ground floor arts facilities and its associated Shore Sheds for Bangarra Dance Theatre (Bangarra), Sydney Dance Company (SDC), Sydney Philharmonia, Gondwana and Song Company;
- New commercial retail opportunities; and
- A series of stairs, external lifts and balconies designed as a contemporary interpretation of the original gantries reflecting the precinct's former industrial heritage
- Modifications to the roof

1.2 Purpose of this Report

This report describes the outcomes of a construction and operational noise and vibration assessment to address the requirements for SSD 8671 application for the redevelopment of the WBACP.

Key Issue 7 of the SEARs for application SSD 8671 sets out the following requirements with regard to the assessment of noise and vibration:

> *The EIS shall include a noise and vibration assessment prepared by a suitably qualified acoustic consultant that:*
>
> - *assesses construction noise and vibration impacts. The assessment must consider cumulative noise and vibration impacts from all concurrent construction activities;*
> - *assesses operational noise from the use of the buildings and any commercial/food and drink premises;*
> - *assesses cumulative noise impacts from the operation of the development and other nearby premises*
> - *assess operational vibration from the use of the premises;*
> - *outlines reasonable and feasible measures to minimise and mitigate potential noise and vibration impacts within the precinct and to surrounding occupiers of land.*

SSD 8671 also references the following policies relevant to acoustics:

- NSW Industrial Noise Policy 2000, EPA (INP) [1]
- NSW Industrial Noise Policy – application notes 2013, EPA [2]
- Interim Construction Noise Guideline 2009, DECC (ICNG) [3]
- Assessing Vibration: A Technical Guideline 2006, DECC) [4]
- NSW Road Noise Policy 2001, DECC (RNP) [5]
- NSW Road Noise Policy – application notes 2013, EPA [6]
- Development Near Rail Corridors and Busy Roads – Interim Guideline 2008 [7]

The Development Near Rail Corridors and Busy Roads (Department of Planning, NSW) addresses noise from rail and road traffic on residential use, a place of worship, a hospital, an educational establishment or childcare centre. This document is referred to in Key Issue 2 of the SEARs; however, as these types of development are not proposed for the WBACP it is considered that the guideline is not applicable.

The Site is not located adjacent to a ‘busy road’, defined as a road with an Average Annual Daily Traffic volume of >40,000 vehicles, or a rail corridor, the assessment of the Project under this Guideline is not required.

During operator attended measurements, summarised in Table 6, it was noted that road and rail noise was noted at the nearest affected receiver locations, however noise impacts on the Precinct venues was not such that noise intrusion presented an issue, hence no further assessment of road or rail noise in accordance with the Guideline has been conducted.

Alongside the Arts Precinct project, there are plans for major modifications to take place inside the Sydney Theatre Company (STC) facilities. To limit the disruption, it is likely that the works would be done at the same time as the main Arts Precinct project. Although these are subject to a separate planning application, the potential cumulative impacts from these works for STC have been assessed herein.

1.3 Report Structure

The policies and guidelines outlined in Section 1.2 have been addressed in this report as follows:

Acoustic aspect	SEARs addressed	Policy or guideline	Report section
Construction noise & vibration	• Assesses construction noise and vibration impacts. The assessment must consider cumulative noise and vibration impacts from all concurrent construction activities	Interim Construction Noise Guideline [3] Assessing Vibration: A Technical Guideline [4]	Section 3
Operational noise & vibration from site	• Assesses operational noise from the use of the buildings and any commercial/food and drink premises • Assesses cumulative noise impacts from the operation of the development and other nearby premises • Assess operational vibration from the use of the premises	Industrial Noise Policy [1] & application notes [2]	Section 4 & 5
Operational road traffic generated on local road network		Road Noise Policy [5] & application notes [6]	Section 6
Mitigation measures	• Outlines reasonable and feasible measures to minimise and mitigate potential noise and vibration impacts within the precinct and to surrounding occupiers of land.	-	Section 7

2 Existing Conditions

2.1 Acoustic environment

Due to the waterfront location of the site, the environment is affected by a number of marine noise sources, in addition to rail and air traffic. Unusually for a central urban site, there is very little direct road traffic noise affecting the environment, however distant traffic noise from the Sydney Harbour Bridge and the Sydney CBD are audible at some locations on the site. The main noise sources are:

- Marine traffic in Sydney Harbour (noise from boat engines, party boats and occasional horns)
- Road and rail traffic on the Sydney Harbour Bridge
- Regular civilian helicopter traffic
- Occasional military helicopter traffic
- Distant aircraft noise
- General activity noise from users of the existing facilities

Most of the above sources are intermittent in nature and variable in level.

2.2 Noise sensitive receivers

The area surrounding the Project is predominantly comprised of commercial and residential receivers. A list of noise sensitive receivers is presented in Table 1, with locations presented in Figure 2.

Table 1: Noise sensitive receivers

Usage	ID	No. of floors	Name
Residential / Commercial	R1 / C1	4	Pier One Hotel Ground floor: Bar, restaurant and event venue Level 1, 2 & 3: Hotel suites
	R2 / C2	6	Shore 6/7 Ground floor: Lavana, Hickson's Bar Cycle, 17, Marie France Group Level 1, 2, 3, 4 & 5: Shore 6/7 apartments
	R3 / C3	2	18 Hickson Road Ground floor: Vacant commercial, Manage-meant Level 1: Hickson Apartments
Residential	R4	3	1-23 Lower Fort Street (North Terraces)

Usage	ID	No. of floors	Name
	R5	3	25-79 Lower Fort Street (South Terraces)
	R6	3	2-34 Pottinger Street Terraces
	R7	7	Pier 6/7 apartments
	R8	25	Blues Point Tower – 14-28 Blues Point Road, McMahons Point
	R9	4	1-9 Warung Street Residences, McMahons Point
	R10	6	1 East Crescent Street & 6-8 Henry Lawson Avenue, McMahons Point
Commercial	C4	4	View By Sydney, Simmer on the Bay
	C5	1	16 Hickson Road - Fratelli Fresh, Paradise Thai Massage, Unique Estates, Vermilion Art, Wash on the Rocks Dry Cleaning, Walsh Bay Wine Cellar, Lotus Dumpling Bar, IGA X-press
	C6	2	Roslyn Packer Theatre
Passive Recreation Area	P1	-	Blues Point Reserve

Rating Background Levels (RBLs) vary across receivers surrounding the site, due to shielding and proximity to the above noise sources. Residential receivers with similar RBLs have been grouped into Noise Catchment Areas (NCAs), also shown in Figure 2 and listed in Table 2.

Table 2: NCAs

NCA	Receivers	INP classification
NCA 1	R1	Urban
NCA 2	R3, R4, R5 & R6	Urban
NCA 3	R2 & R7	Urban
NCA 4	R8, R9 & R10	Suburban

NCA boundaries have been determined based on site observations and attended measurements, which are detailed in Table 6.

The noise sensitive receptors are shown in Figure 2 below.

Figure 2: Noise sensitive receiver locations and NCAs

2.3 Measurement of existing noise levels

Criteria for the assessment of operational and construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

2.4 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or if a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

The short-term and long-term measurement locations are outlined in Table 3 and shown in Figure 3.

Table 3: Measurement summary

ID	Measurement type	Location	Purpose
Meas. 1	Short-term and long-term	Northern end of Pier One Hotel wharf	Determine RBL at northern end of NCA 1, including noise contribution from marine traffic and road and rail traffic on the Harbour Bridge. This RBL was lower than measurement 2 and hence was used conservatively as RBL for NCA 1.
Meas. 2	Short-term and long-term	Approximately 5 metres from the edge of Hickson Road on southern boundary of Pier One Hotel	Determine RBL at southern end of NCA 1, including noise contribution from Hickson Road traffic.
Meas. 3	Short-term	On footpath overlooking Hickson Road behind 19 Lower Fort Street, Dawes Point.	Confirm background noise levels are similar across NCA 2
Meas. 4	Short-term and long-term	On footpath overlooking Hickson Road behind 45A Lower Fort Street, Dawes Point.	Determine RBL in NCA 2
Meas. 5	Short-term and long-term	In front of Shore Shed 6/7 on kerb of Hickson Road.	Quantify traffic noise levels along Hickson Road
Meas. 6	Short-term and long-term	On wharf of Pier 6/7 in front of apartments.	Determine RBL in NCA 3
Meas. 7	Short-term and long-term	Blues Point Reserve	Determine RBL in NCA 4

Figure 3: Measurement locations

2.5 Long-term unattended noise measurement results

Long-term noise monitoring was carried out from Tuesday 8 August to Wednesday 23 August 2017 and Friday, 1 September to Wednesday 6 September. Monitoring was conducted in accordance with Appendix B1 of the INP. The INP separates the 24-hour day into three different time periods – day, evening and night. These time periods are detailed below in Table 4.

Table 4: Standard INP time periods

Period	Day of Week	Time period
Day	Monday-Saturday Sunday, Public Holidays	7:00 am-6:00 pm 8:00 am-6:00 pm

Period	Day of Week	Time period
Evening	Monday-Sunday	6:00 pm -10:00 pm
Night	Monday-Saturday Sunday, Public Holidays	10:00 pm -7:00 am 10:00 pm -8:00 am

The long-term noise monitoring methodology and noise level-vs-time graphs of the data are included in Appendix C.

Table 5 presents the overall single RBLs and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the INP.

Table 5: Long-term noise monitoring results

Location	Time period[1]	Rating background noise levels, dBL_{A90}	Ambient dBL_{Aeq} noise levels
Meas. 1	Day	48	57
	Evening	46	62
	Early night	46	51
	Late night	42	45
Meas. 2	Day	57	76
	Evening	54	66
	Early night	51	61
	Late night	47	50
Meas. 4	Day	53	66
	Evening	52	58
	Early night	49	54
	Late night	47	50
Meas. 5	Day	54	67
	Evening	50	65
	Early night	48	61
	Late night	45	56
Meas. 6	Day	49	56
	Evening	47	53
	Early night	44	46
	Late night	42	43
Meas. 7	Day	48	62
	Evening	44	55
	Early night	41	47
	Late night	40	42

Note: 1 – Early night defined as 10:00pm – 12:00am, late night defined as 12:00am – 7:00am

2.6 Short-term attended noise measurement results

Short-term operator attended noise measurements were conducted on 21 and 22 August 2017 at each logger location as well as a number of supplementary locations in order to identify noise sources present at each NCA, as well as confirm NCA boundary extents as outlined in Table 3 and shown in Figure 3. Noise measurements were conducted over a 15-minute period. Weather conditions were warm, still and clear during measurements.

It should be noted no industrial noise contribution was noted at any of the measurement locations.

Table 6 presents the measured L_{90} and L_{eq} noise levels for at each measurement locations, determined in accordance with the INP.

Table 6: Short-term noise monitoring results

ID	Location	Day / time	dBL$_{A90}$	dBL$_{Aeq}$	Description of noise environment
Meas. 1	North side of Pier One wharf	21/08/2017 5:06 PM	54	58	Road and rail traffic noise on Sydney Harbour Bridge Some intermittent aircraft and marine craft noise Noise from water's edge No industrial noise noted
Meas. 2	South side of Pier One wharf	21/08/2017 5:21 PM	57	65	Road and rail traffic noise on Sydney Harbour Bridge Road traffic on Hickson road Some intermittent aircraft and marine craft noise No industrial noise noted
Meas. 3	Rear of Lower Fort street residences, Eastern end	21/08/2017 4:24 PM	61	56	Road and rail traffic noise on Sydney Harbour Bridge Some Road traffic on Hickson road No industrial noise noted
Meas. 4	Rear of Lower Fort street residences, Western end	21/08/2017 4:42 PM	60	56	Some Road and rail traffic noise on Sydney Harbour Bridge Some Road traffic on Hickson road No industrial noise noted
Meas. 5	Hickson Road outside pier 6/7	21/08/2017 5:02 PM	66	56	Road traffic on Hickson road No industrial noise noted
Meas. 6	Pier 6 boardwalk outside residences	21/08/2017 4:40 PM	58	51	Some intermittent aircraft and marine craft noise Noise from water's edge Noise from marine craft moorings No industrial noise noted
Meas. 7	Blues point near water's edge	22/08/2017 2:37 PM	54	49	Some intermittent aircraft and marine craft noise Noise from water's edge No industrial noise noted

3 Construction Noise and Vibration

3.1 Overview

An Environmental, Construction and Site Management Plan (ECSMP) has been prepared by Cadence for the WBACP redevelopment. The assessment in this report supplements the ECSMP and has been used to inform the proposed work practices and management measures contained in the ECSMP. The ECSMP will be further developed as the construction methodologies and processes are confirmed during the design development process.

The control of noise affecting the community will be given a high priority and form a critical part of the eventual Contractor's scope of work. There will be a specific requirement for the Contractor to prepare a detailed Construction Noise and Vibration Management Plan as part of their appointment.

3.2 Construction noise criteria

The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all 'feasible and reasonable' work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 7 and other sensitive receivers in Table 8 below.

Table 7: Construction noise management levels at residential receivers

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Notes: 1 - Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 8: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Noise Management level $L_{Aeq(15\ min)}$ [1]
Passive recreation areas	External noise level	60 dB(A)
Commercial premises	External noise level	70 dB(A)

Notes:

1 – Noise management levels apply when properties are in use.

3.2.1 Project construction noise targets

Construction noise criteria are set based on noise catchment areas relative to proposed construction works. These catchment areas are defined for the project in Section 2.2.

Measured noise data obtained at the logger location most representative of each noise catchment area has been used to derive appropriate noise management levels for the project. These are summarised in Table 9.

Table 9: Noise Management Levels during intended working hours

Location	Time Period	RBL, dB(A)	Noise Management Level, $dBL_{Aeq\ 15minute}$	
			Noise affected	Highly noise affected
Residences				
NCA 1 – R1	Day	48	58	75
NCA 2 – R3, R4, R5, R6	Day	53	63	75
NCA 3 – R2, R7	Day	49	59	75
NCA 4 – R8, R9, R10	Day	48	58	75
Other sensitive receivers				
C1-C6	Use hours	-	70	-
P1	Use hours	-	60	-

3.3 Construction vibration criteria

3.3.1 Human comfort

The NSW EPA's Assessing Vibration Guideline 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. The weighting curves are obtained from BS 6472-1:2008 [8].

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event. Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as 'impulsive' sources for the purposes of assessment.

As noted in the Guideline, situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances, such as a construction or excavation projects. Notwithstanding, the recommended vibration limits for maintaining human comfort in residences and other relevant receiver

types are given for continuous/impulsive and intermittent vibration in Table 10 and Table 11 respectively.

Table 10: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Residences	Daytime 0700-2200h	0.010	0.0071	0.020	0.014
	Night-time 2200-0700h	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Residences	Daytime 0700-2200h	0.30	0.21	0.60	0.42
	Night-time 2200-0700h	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.64	0.46	1.28	0.92

Table 11: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime 0700-2200 h		Night-time 2200-0700 h	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

3.3.2 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with BS7385-2 [9]. BS7385-1 [10], 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 BS7385-2 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.

3.3.2.1 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 12 sets out the BS7385-2 criteria for cosmetic, minor and major damage. Regarding heritage buildings, BS7385-2 notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 12: 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

Notes:

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

Notes:

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%.

3.4 Modelling of construction noise

Noise emissions from construction and demolition activities associated with the WBACP redevelopment have been assessed to criteria outlined in Section 3.2.

Noise emissions have been modelled using SoundPlan 7.4. The model included:

- Construction noise sources listed in Section 3.5.3
- WBACP and surrounding buildings
- Receivers listed in Table 1
- Ground terrain and absorption

3.5 Noise sources

3.5.1 Demolition and construction activities

In consultation with Cadence Australia, a list of proposed construction activities and associated items of equipment has been developed along with likely staging and simultaneous operation throughout each stage of construction, based on the Walsh Bay Arts and Cultural Precinct – Environmental, Construction and Site Management Plan (ECSMP) [11].

This forms the basis of assessment of construction noise impacts. It is noted that the construction activities and appliances mentioned in this document are indicative and are provided for information only.

A large portion of the scope of works is internal demolition and fitout works which will be attenuated by the existing building envelope which significantly mitigates the negative noise impacts on the public and surrounding areas.

Storage of materials will be within the existing buildings rather than externally. This will reduce noise from material handling.

Five construction phases have been modelled to capture the significant proposed demolition and construction works. A description of the proposed works is shown in Table 13.

Table 13: Construction stages and activities

Construction works
1. Demolition and removal works
• Demolition and removal of: - stairs and landings in Shore shed 4/5 breezeway - façade elements - roof sheeting, insulation and sarking - lift in wharf 4/5
- internal partitions, stairs and various internal elements - storey posts (internal)
- concrete demolition for grease trap installation - external (some greater impact than others, some under timber decking and some under concrete)
- floors and floor coverings - nominated trusses
2. Lift, stair, balcony installation, facade modification, roof works
• Installation of external lifts to western elevation of Pier 2/3 • Façade modification including installation of glazing and other solid panels on eastern, western and northern elevations in Pier 2/3. • Relocation of stair access to the STC • New 'gantry' balconies, stairs and lifts mid-wharf and at the end of wharf 4/5 • Minor amendments to existing wharf 4/5 façade • Raising roof of Pier 2/3 to house plant room • Raising roof of workshop • Raising roof of Wharf 1 theatre • Installation of photovoltaic panels to roof of Pier 2/3
3. Structural works
• Installation of:
- concrete slabs and soffits - new steel portal frames and steel columns
- new gantry and stair structures
4. Utilities & lifts
• Installation of - lift pits in Wharf and Pier Aprons - some internal and some external. Scissor platform lift, may install them overlapping. - plant to wharf 4/5 shore sheds - plant to roof platform and plantrooms

Construction works
5. Internal works – not modelled
• Installation of - heat exchange system below wharf - internal partitions, floors, walls, lifts (including piling for lift pits) and stairs - gangways and walking plantrooms to roof structures - seating banks - timber deck in colonnade Pier 2/3

Notes: - Items shaded in grey indicate internal works within the WBACP buildings which will have less significant impacts than external works and have not been modelled.

Regarding internal construction works, impacts to external receivers are not expected to be significant due to the attenuation from the building façade, as well as the typically lower noise emissions of the proposed internal works. Receivers within the precinct, namely C4 - View By Sydney, Simmer on the Bay, may be affected by works taking place in adjacent venues, namely the Bell Studio in Pier 2/3. Noise management measures to minimise these impacts are provided in Section 3.8.

3.5.2 Hours of construction

General demolition and construction works will be undertaken within the hours outlined in Table 14.

Table 14: Preferred Hours of Construction

Day	Proposed construction hours
Monday to Friday	7.00 am to 6.00 pm
Saturdays	8.00 am to 1.00 pm
Sundays or Public Holidays	No construction

In some cases, after-hours permits will be sought from the relevant authorities where special requirements exist, for example oversized deliveries.

3.5.3 Construction equipment

Assumed construction equipment to be used for redevelopment works are provided in Table 15 as approved by Cadence Australia.

The sound power levels of the proposed appliances have been derived with reference to the AS2436 [12], DEFRA [13] documents and Arup's measurement database. The equipment below has been assumed to operate externally and concurrently (a worst case assumption).

The locations of equipment have been based on the locations of the demolition and construction works around the precinct.

Table 15: Construction equipment usage and associated sound power levels

Construction equipment	Sound power level, dB(A)	Construction stage				
		1. Demolition and removal works	2. Lift, stair, balcony installation, facade modification, roof works	3. Structural works	4. Utilities & lifts	5. Internal works
		Number of equipment modelled in 15-minute period				
Tower crane	105	1	1	1	1	1
Franna crane	107	1	1	1	1	1
Manitou	103	1	1	1	1	1
Trucks	105	2	2		1	1
Rock breakers	111	1				
Hand tools	95	2	2		2	2
Light vehicles	80	2				
Jackhammers	113	1				
Chainsaws	114	1				
Concrete saws	105	1				
Welding	95		1	1		1
Concrete truck	108			1		
Concrete vibrator	105			1		
Electric winch	95		1	1	1	1

3.5.4 Sydney Theatre Company

There is potentially some work for STC taking place at the same time as the works for the rest of WBACP. This work is effectively 'fit out' and is primarily taking place internally within the existing STC facilities. The potential STC works would take place from July 2018 to December 2019.

There will be some additional deliveries associated with their works but these are not expected to result in a significant increase in traffic noise within Hickson Road.

A major part of the STC work is the installation of noise sound insulating provisions for the envelope of the building. This will help reduce any noise breakout from the internal construction works such that there would be a minimal additional external noise from the STC works.

The STC works would include:

- A mobile barge crane will be used at a location where necessary to remove and install plant and other materials associated with the development. The worst case location within line of sight of residential receivers (location R1) has been assumed.
- Trucks will be used to remove demolition and construction waste from the site, using the ramp on at the Pottinger Street level for access. Truck movements will be restricted to daytime periods only.
- Some vehicle movements will take place on the side of the Wharf building furthest from other neighbouring wharf residences.
- Much of the construction work will be done internally and will therefore be screened by the existing building envelope. The heritage nature of the development means that many of the existing elements are being retained and the works will primarily involve the construction of new internal partitions and modifications to the roof.
- No piling works are anticipated in this contract.
- Site offices will be accommodated within the existing building structure.
- There will be some concrete removal work required, involving 3 tonne excavators and pulverisers. The equipment used for this will be selected to be as quiet as is reasonably practicable.
- Some remedial works to the heritage façade will be carried out using hand tools.

Demolition and constructions works will be limited to daytime hours only.

3.6 Results

Predicted construction noise impact levels are presented in Table 16, along with the relevant NML, derived in Table 9.

Table 16: Predicted construction noise levels, dB(A)

Receiver	***NML***	**Construction stage**			
		1. Demolition and removal works	**2. Lift, stair, balcony installation, facade modification, roof works**	**3. Structural works**	**4. Utilities & lifts**
		Highest predicted noise level, dB(A)			
R1 - Pier One Hotel suites	***58***	69	59	56	45
R2 - Shore 6/7 apartments	***59***	62	54	57	52

Receiver	*NML*	Construction stage			
		1. Demolition and removal works	2. Lift, stair, balcony installation, facade modification, roof works	3. Structural works	4. Utilities & lifts
		Highest predicted noise level, dB(A)			
R3 - 18 Hickson Road Hickson Apartments	***63***	46	40	41	38
R4 - Lower Fort Street North Terraces	***63***	63	54	53	56
R5 - Lower Fort Street South Terraces	***63***	56	52	53	54
R6 - Pottinger Street Terraces	***63***	52	48	49	48
R7 - Pier 6/7 apartments	***59***	63	61	64	59
R8 - Blues Point Tower	***58***	50	44	47	44
R9 - Warung Street Residences	***58***	47	41	41	42
R10 - East Crescent Street Residences	***58***	47	41	41	42
C1 - Pier One Hotel Bar & Restaurant	***70***	66	56	54	43
C2 - Shore 6/7 ground floor commercial	***70***	59	51	54	50
C3 - 18 Hickson Road commercial	***70***	44	38	39	36
C4 - View By Sydney, Simmer on the Bay	***70***	72	67	71	63
C5 - 16 Hickson Road commercial	***70***	55	50	51	50
C6 - Roslyn Packer Theatre	***70***	42	35	37	35
P1 - Blues Point Reserve	***60***	50	44	46	45

Notes: Levels shaded in grey indicate a notional exceedance of NMLs based on the worst case assumptions noted above.

Results show some exceedances of up to 11 dB are predicted at both R1 - Pier One Hotel suites and R7 - Pier 6/7 apartments. The highest noise impacts are predicted during demolition stage, where the use of equipment such as chainsaws, concrete saws and jackhammers are likely to result in adverse noise affects to directly exposed receivers and exceedances of NMLs. These items are typically used over short durations and the noise levels predicted in Table 16, representing the worst case 15 minute periods of each construction stage.

Receivers located north of the harbour and east of the precinct beyond Hickson Road are not predicted to experience noise levels above NMLs due to proximity to the site and shielding from the precinct buildings themselves.

It should be noted, no residences are predicted to be ‘highly affected’, i.e. experience noise levels of 75 dB(A) or above.

Noise impacts at commercial premises directly exposed to construction works, namely C4 - View By Sydney, Simmer on the Bay are predicted to exceed NMLs by 2 dB, representing a 'minor' exceedance.

3.7 Construction Traffic

Trucks will be used to remove demolition and construction waste from the site, with the ramp at Wharf 4/5 proposed for access.

Construction works will generate vehicle trips primarily along Hickson Road. Construction works are anticipated to generate 80 trucks per day during four months out of the 24 month construction program, and 30 trucks a day in the remaining 20 months. In light of the existing traffic numbers and the small number of construction generated vehicles, the additional construction traffic created by construction works is considered an insignificant additional contribution to the ambient noise environment.

3.8 Recommendations

The contractor will have a key role in managing the noise and vibration levels during the works so as to reduce noise and vibration as far as is reasonably practicable. This will include:

3.8.1 Noise and vibration management plan

The contractor will be required to prepare a noise management and vibration plan as soon as they are appointed. This will specify the actual plant to be used and will include updated estimates of the likely levels of noise and the scheduling of activities.

3.8.2 Staffing

- Appointing a named member of the site staff who will act as the Responsible Person with respect to noise and vibration.
- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Ensuring good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable.
- Avoid the use of radios or stereos outdoors.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.

3.8.3 Plant and Equipment

- Turn off all vehicles, plant and equipment when not in use.
- Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable

- Reinforcing to be cut by bolt cutter
- Quiet hoist to be used.

3.8.4 Scheduling

- Ensuring that the Responsible Person controls the working hours on site to ensure that work is only done during the acceptable periods as defined in the ICNG (7am to 6pm on weekdays and 8am to 1pm on Saturdays. No work on Sundays or public holidays).
- Upgrades to partitions separating existing spaces will be undertaken early in the construction schedule in order to minimise on-going noise impacts. This is primarily in reference to the common partition wall between C4 - View By Sydney, Simmer on the Bay and the proposed Bell Studio in Pier 2/3.

3.8.5 Noise Logging

- A noise logger will be installed and maintained which can be interrogated remotely by precinct management staff as well as the Contractor. The logger will also be required to automatically send a text message to the Responsible Person on site once the 'warning' threshold (5 dB below the noise management threshold set out in Table 9 above) has been breached.
- The Precinct Management representative will also be copied in with the warning texts.
- The data from the noise logger will be used to inform the Contractor on the noise levels being generated so that particularly noisy activities can be identified and practicable options investigated to reduce noise levels further.

3.8.6 Community liaison

- Ensure Responsible Person periodically (i.e. once per week) checks the commercial tenants around the site and nearby residences for noise problems so that solutions can be quickly applied.
- Ensuring that the Responsible Person keeps the precinct (and local community) advised on expected activities and coordinates scheduling and locations of noisy works around any critical user events where practicable. This shall include face to face meetings with tenants if requested and a letter box drop.
- Maintaining appropriate records of complaints to include timing, reported issues, actions taken and measures to be included for on-going works. The complaints log will need to be filed with the Precinct Management.
- Liaison with receivers within the WBACP, namely C4 - View By Sydney, Simmer on the Bay, should be on-going in order to advise of upcoming noisy demolition works or internal works to common partition walls.

3.8.7 Respite

It is likely that noise levels during most of the construction will be below the "highly noise affected" NMLs in the ICNG for most of the construction period. As such, no respite periods are expected to be strictly necessary. In any event, the introduction of respite periods would not reduce the overall long term 'noise dose' given that it would just extend the programme.

The potential for construction work to impact on the existing uses of the WBACP and surrounds is recognised. The Contractor will be required to liaise with the Precinct Management so that noise from construction does not impact on any critical events taking place within the existing accommodation.

3.9 Vibration management

The following guidance provides recommended minimum working distances for vibration intensive plant. These are based on international standards and guidance and reproduced in Table 17 below for reference.

Table 17: Recommended minimum working distances for vibration intensive plant

Plant Item	**Rating / Description**	**Minimum working distance**	
		Cosmetic damage (BS 7385)	**Human response (OH&E Vibration Guideline)**
Small rock breaker	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium rock breaker	(900 kg – 12 to 18t excavator)	7 m	23 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

Mitigation will therefore need to be considered where sensitive receivers are located closer to the construction work zone than these 'safe working distances'. It is noted that focus is on mitigating cosmetic damage.

The contractor will be required to manage vibration as well as noise and make use of best practice in the management of vibration using simple and practicable techniques such as avoiding dropping heavy items.

Where vibration intensive works are required within the minimum working distances outlined in Table 17, vibration monitoring at the nearest potential affected building should be considered, where real-time alerts can be generated when measured vibration levels exceed criteria.

4 Operational Noise – Excluding Events

4.1 Overview

4.1.1 Noise sources

The primary operational noise sources with the potential to impact upon surrounding noise sensitive receivers include:

- Mechanical plant and equipment serving the various uses
- Patrons and staff occupying precinct venues excluding coordinated precinct-wide events (See Section 5 for event noise assessment).
- Set building activities within the Bell Shakespeare and ATYP.
- Loading dock operations & waste and recycling collection

4.1.2 Sydney Theatre Company

The STC have plans for an upgrade to their facilities which is likely to take place at the same time as the works covered by this report. The potential additive effect of operational noise from the STC development is assessed in this application.

In practice, the event noise from STC will be minimal because of the very high standards of sound insulation provided within the building envelope of the STC facilities. This is necessary to control both noise intrusion and noise breakout and for adherence to any existing noise management plan.

Noise from mechanical plant servicing STC has been included in the mechanical plant noise model (Section 4.3.1.1), and venue patron noise from the operation of the STC (Section 4.3.1.2) have been included in this assessment.

4.2 Criteria

4.2.1 NSW Industrial Noise Policy (INP)

Operational noise emission from the project has been assessed in accordance with the INP, 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.

The INP states that background noise levels should be determined over the “days and times of operation of the project”. When setting criteria, only the measured data from the hours of operation of the project should be included.

Noise limits are set based on land use in the area and existing background noise levels. Compliance is achieved if the adjusted L_{Aeq} noise level at sensitive receivers affected by noise from the facility is below the noise limit. The adjusted L_{Aeq} is determined by applying corrections for such noise characteristics as duration, intermittency, tonality, and impulsiveness.

The assessment of noise emission under the INP is based on the calculation of a noise limit at a receiver position, taking into account the land-use in the surrounding area and the existing background noise level.

The INP provides guidance on acceptable noise levels from the introduction of new industrial noise sources to an area, as well as a process for assessing and managing noise from a partially upgraded site. Where this occurs the usual process involves the measurement of existing noise levels from the source in question. Existing source levels should then be taken into consideration when determining feasible and reasonable mitigation strategies.

Outside of precinct-wide events, such as the Sydney Writer's Festival and the Biennale, existing noise from the operation of the site, including mechanical noise and venue operational noise, is largely inaudible at nearby receivers. The use of the venues as function spaces is new, and therefore has been assessed as a new development under the INP, however the existing use of the precinct for large events such as the Sydney Writer's Festival and the Biennale should be considered in the assessment of 'event' noise, provided in Section 5.

The assessment procedure for industrial noise sources has two components:

- Controlling intrusive noise impacts in the short term for residences; and
- Protecting noise level amenity for particular land uses such as residences, recreation areas and commercial offices etc.

4.2.1.1 Intrusive noise criteria

The intrusiveness criteria are applicable to residential premises only. The intrusiveness criterion is summarised as follows:

- $L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5 dB

As the intrusiveness criteria is established from the prevailing background noise levels at the residential receiver locations, the rating background noise level is required to be quantified in order to establish Project noise goals.

4.2.1.2 Amenity noise criteria

The INP amenity criteria are for the purpose of maintaining noise amenity, for which the INP recommends 'acceptable' and 'recommended maximum' cumulative noise levels for all industrial noise at different receiver types, including residential, commercial and other sensitive receivers.

Table 18: INP Amenity Criteria - Recommended L_{Aeq} noise levels from industrial noise sources (NSW INP Table 2.1)

Type of receiver	Indicative Noise Amenity Area	Time of day	Recommended L_{Aeq} (Period) noise level, dB(A)	
			Acceptable	Recommended maximum
Residence	Urban	Day	60	65

Type of receiver	Indicative Noise Amenity Area	Time of day	Recommended L_{Aeq} (Period) noise level, dB(A)	
			Acceptable	Recommended maximum
		Evening	50	55
		Night	45	50
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Commercial premises	All	When in use	65	70

Reference should be made to the INP for full assessment procedures and application, including modifying factor adjustments, background measurement procedures, adverse meteorological effects as well as assessment of sleep disturbance.

4.2.1.3 Project specific noise criteria

Based on the background and ambient noise monitoring, Table 19 summarises the derived project noise criteria based on the INP.

Table 19: INP project noise goals

Receiver	Time period	Existing noise levels[1], dB(A)		Project goals, dB(A)		
		RBL	Industry[2] L_{Aeq}	Intrusive	Amenity	Project Specific Noise Goals[3]
Residential receivers						
NCA 1 – R1	Day	48	-	53	60	53
	Evening	46	-	51	50	50
	Early night	46	-	51	47[4]	47
	Late night	42	-	47	45	45
NCA 2 – R3, R4, R5, R6	Day	53	-	58	60	58
	Evening	52	-	57	50	50
	Early night	49	-	54	47[4]	47
	Late night	47	-	52	45	45
NCA 3 – R2, R7	Day	49	-	54	60	54
	Evening	47	-	52	50	50
	Early night	44	-	49	45	45
	Late night	42	-	47	47[4]	47

Receiver	Time period	Existing noise levels[1], dB(A)		Project goals, dB(A)		
		RBL	Industry[2] L_{Aeq}	Intrusive	Amenity	Project Specific Noise Goals[3]
NCA 4 – R8, R9, R10	Day	48	-	53	55	53
	Evening	44	-	49	45	45
	Early night	41	-	46	42[4]	42
	Late night	40	-	45	40	40
Other sensitive receivers						
C1-C6	Use hours	-	-	-	65	65
P1	Use hours	-	-	-	50	50

Notes:
1 – Free-field noise levels
2 – No significant existing industrial noise contributions were identified at the measurement location, see Table 6.
3 – Project Specific Noise Goals taken as the lower of the intrusive and amenity criteria
4 - Shoulder period amenity goals taken as mid-point between evening and night time in accordance with INP. This follows the observation of the logger graphs (Appendix C) that the background L_{90} noise levels for the period from 10:00 pm – 12:00 am are noticeably higher than those from 12:00 am – 7:00 am.

4.2.2 Sleep disturbance

Noise emanating from the project has been assessed for its potential to disturb sleep. The NSW EPA has conducted research with respect to sleep disturbance and has made the following policy statement:

> *From the research, the EPA recognised that the current sleep disturbance criterion of an LA1, (1 minute) not exceeding the LA90, (15 minute) by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, the EPA will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*

In summary, the sleep disturbance criteria of $L_{A1(1min)} \leq L_{A90(15min)} + 15dB(A)$ is to be used for initial assessment. The L_{Amax} may be used as an alternative to the $L_{A1(1min)}$. It is noted that the background $L_{A90(15minute)}$ noise level used for establishing the sleep disturbance criteria includes all background noise including noise from the project.

The sleep disturbance criteria for the project are presented in Table 20.

Table 20: Sleep disturbance criteria

Noise Catchment Area	**Sleep disturbance criteria, 10pm - 12am, $L_{A1,1min}$ (or L_{Amax}), dB(A)**
	$L_{A90(15min)}$ + 15
NCA 1 – R1	61
NCA 2 – R3, R4, R5, R6	64
NCA 3 – R2, R7	59
NCA 4 – R8, R9, R10	56

4.2.3 Emergency equipment

The INP allows increases to the environmental noise limits for events of short durations where no more than one event occurs in any 24-hour period. This is to allow for short and intermittent operation of equipment during testing and/or emergencies such as stair pressurisation fans. The allowances are summarised in Table 21.

Table 21: Adjustments to environmental noise limits for duration

Duration of Noise (one event in any 24-hour period)	**Increase in acceptable noise level at receptor, dB(A)**	
	Daytime and Evening (7am-10pm)	**Night 10pm-7am**
1-2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
less than 1.5 minutes	20	10

For the purposes of design, it is assumed that smoke exhaust fan tests would fall in the 15 minutes to 1 hour band during the daytime, and thus attract an allowable increase of 5 dB(A) to the limiting noise criteria for typical building daytime operation.

The scheduled testing of smoke exhaust fans would also be limited to occur on Saturdays during the daytime hours to avoid disruption to occupants within the building.

4.3 Modelling of operational noise

Noise emissions from mechanical services within the WBACP have been assessed to criteria outlined in Section 4.2.

Noise emissions have been modelled using SoundPlan 7.4. The model included:

- Operational noise sources listed in Section 4.3.1
- WBACP and surrounding buildings
- Receivers listed in Table 1
- Ground terrain and absorption

4.3.1 Noise sources

4.3.1.1 Mechanical plant

An assessment of noise emissions from the WBACP was conducted based on mechanical services drawings listed in Appendix D.

The preliminary mechanical plant selections along with modelled sound power levels are listed in Table 22. Only significant mechanical noise sources over 70 dB(A) sound power level have been included in the model.

Table 22: Noise source levels - Preliminary mechanical plant selections

Unit	Description[1]	Overall dB(A)	Octave Band Centre Frequency, Hz							
			63	125	250	500	1k	2k	4k	8k
			Sound power level, dB							
Air handling units										
AHU_2.3_02_01	Unit Breakout	67	73	76	66	65	62	50	45	27
AHU_2.3_02_02	Unit Breakout	73	74	77	68	73	68	59	50	35
AHU_2.3_02_03	Unit Breakout	70	87	78	72	67	61	46	39	22
AHU_2.3_02_04	Unit Breakout	74	78	81	73	74	68	58	49	32
AHU_2.3_02_05	Unit Breakout	69	72	74	70	67	64	51	47	32
AHU_4.5_0M_01	Unit Breakout	70	87	78	72	67	61	50	39	22
Chillers										
CH_CP_B1_01	Unit Breakout	77	-	67	71	81	73	68	66	56
CH_CP_B1_02/03	Unit Breakout	80	-	69	82	78	80	73	63	56
Condensers										
CON_2.3_00_01 to CON_2.3_03_13	Unit Breakout	70	74	74	71	68	64	61	58	50

Unit	Description[1]	Overall dB(A)	Octave Band Centre Frequency, Hz							
			63	125	250	500	1k	2k	4k	8k
			Sound power level, dB							
Fans - General										
GEF_2.3_02_16	Unit Breakout	55	59	56	57	54	50	43	38	28
GEF_2.3_02_19	Unit Breakout	55	59	56	57	54	50	43	38	28
KEF_4.5_02_01	Fan Outlet	101	89	86	92	94	95	93	90	83
KEF_SS_02_02	Fan Outlet	101	89	86	92	94	95	93	90	83
KEF_2.3_02_01	Fan Outlet	101	89	86	92	94	95	93	90	83
KEF_2.3_02_02	Fan Outlet	101	89	86	92	94	95	93	90	83
Fans - Relief										
RAF_2.3_02_01	Fan Outlet	84	77	79	82	82	79	74	72	67
	Unit Breakout	73	77	79	77	72	64	54	50	42
RAF_2.3_02_02	Fan Outlet	84	77	79	82	82	79	74	72	67
	Unit Breakout	73	77	79	77	72	64	54	50	42
RAF_2.3_02_03	Unit Breakout	90	83	81	79	83	92	82	81	76
	Fan Outlet	78	83	81	74	73	77	62	59	51
RAF_2.3_02_04	Fan Outlet	75	68	76	63	64	67	67	63	58
	Unit Breakout	62	68	76	58	54	52	47	41	33
RAF_2.3_02_05	Unit Breakout	84	77	79	82	82	79	74	72	67
	Fan Outlet	78	71	73	76	76	73	68	66	61
Exhaust fans - Emergency										
Smoke exhaust fan	Fan Inlet	103	96	87	93	96	98	96	91	83
	Fan outlet	106	97	92	95	98	100	99	92	84

Notes:
1 – Where only unit breakout data is provided, unit inlets and outlets are ducted to floors below, and inlet and outlet noise is expected to be insignificant. Where inlet or outlet sound power data is provided, some significant in-duct noise emissions are expected and have been modelled.

4.3.1.2 Venue patron noise

In order to predict noise impacts generated by patrons and staff occupying the venues during general operation of the WBACP, three scenarios have been modelled:

1. Normal operating scenario - This scenario is expected to represent the majority of the calendar year
2. Peak operating scenario - This scenario is expected to represent a realistic maximum population of the WBACP

3. Logistics activity / patrons leaving scenario – This scenario represents patrons leaving the venues after an event and some internal back of house logistical activities taking place.

Details of the numbers of patrons in the different venues are presented in Appendix E.

The venues modelled as operating in each scenario are listed in Table 23 with normal and peak scenarios based on the same venues at different percent capacities.

Table 23: Modelled venues for operational scenarios

Modelled operating venues	
• Pier 2/3 Function • Commercial 2 • Commercial 3 • Commercial 4 • Choirs • Bell rehearsal 1&2 • Sydney Theatre Company	• AYTP Theatre • ACO Auditorium • Bangarra Function Space • Bangarra Studios • Sydney Dance Company • ACO Event space

During normal and peak scenarios, patrons have been modelled both inside the venues and outside where venues contain outdoor spill areas. During logistics activities / patrons leaving scenario, only outdoor patrons have been modelled, with no noisy internal activities taking place as venues will not be operational between 12:00am – 7:00am.

Modelled patron numbers are presented in Appendix E and were based on patron numbers provided by the client.

Outdoor patron noise

Noise levels from patrons standing outside venues have been predicted using a formula established in Hayne et al. [14], being:

$$L_{WAeq} = 15 \times \log_{10}(Crowd\ size) + 64\ dB(A)$$

The formulas assume that people are not adversely affected by alcohol, and have a random orientation. Spectra have been based on Cushing et al. [15] using an energy average of the male and female raised voice spectrum presented in Table 24.

Table 24: Vocal sound pressure spectrum

Description	**dB(A)**	**Octave band sound pressure level, dB**						
		125	**250**	**500**	**1 k**	**2 k**	**4 k**	**8 k**
Vocal spectrum (raised voices) at 1m	65	53	61	64	61	57	51	44

The vocal spectrum has been normalised to the calculated sound power levels for the assessment using the formula above and outdoor patron numbers, presented in Appendix E.

In order to determine L_{Wmax} levels for outdoor patrons, 8 dB has been added to L_{Weq} levels, based on crowd measurements previously conducted by Arup.

Indoor noise

In order to represent a worst case scenario of noise emissions from the WBACP, the following indoor venue noise sources have been modelled:

- Performances – characterised by amplified foreground music
- Large functions – characterised by a crowded room of people talking

Modelled noise source levels are shown in Table 25. These levels are considered conservative and represent a worst case scenario given the intended usage.

Table 25: Indoor venue sound pressure levels

Source	Descriptor	Overall sound pressure level, dB(A)	Octave band centre frequency, Hz							
			63	125	250	500	1k	2k	4k	8k
			Sound pressure level, dBL_{eq}							
Normal scenario										
Amplified foreground music	L_{eq}	90	90	90	87	78	82	86	83	77
Patrons talking		80	81	81	82	78	75	69	62	55
Peak scenario										
Amplified foreground music	L_{eq}	90	90	90	87	78	82	86	83	77
	L_{max}	98	98	98	95	86	90	94	91	85
Patrons talking	L_{eq}	85	86	86	87	83	80	74	67	60
	L_{max}	93	94	94	95	91	88	82	75	68
Logistics activities / patrons leaving scenario										
Some internal back of house logistics, no significant noisy activities										

A sound pressure level of L_{eq} 85 dB(A) for patrons talking in a cocktail party scenario for the peak scenario was based of measurements undertaken by Arup of similar use.

The sound pressure level of the normal scenario was factored down based on the precinct population in accordance with a crowd noise level formula established in Rindel [16].

The amplified foreground music level was based on measurements undertaken by Arup for similar uses. ‘Foreground music’ is assumed to be clearly audible performances but not at ‘concert levels’ which are often over 100 dB(A).

The noise sources in Table 25 were assigned to each venue listed in Table 26. Every venue has been modelled as operating concurrently in order to represent a worst case scenario, although the likelihood of this occurring is low.

Table 26: Venue internal noise sources

Venue	Internal noise source[1]	Ventilation
Pier 2/3 Function	Patrons talking	Natural ventilation
Commercial 2	Patrons talking	Air conditioned
Commercial 3	Patrons talking	Air conditioned
Commercial 4	Patrons talking	Air conditioned
Choirs	Amplified foreground music	Air conditioned
Bell rehearsal 1&2	Amplified foreground music	Air conditioned
ATYP Theatre	Amplified foreground music	Air conditioned
ATYP Workshop	Patrons talking	Natural ventilation
ACO Auditorium	Amplified foreground music	Air conditioned
Bangarra Function Space	Patrons talking	Natural ventilation
Bangarra Studios	Amplified foreground music	Air conditioned
SDC studio 1 - 4	Amplified foreground music	Natural ventilation
SDC studio 5	Amplified foreground music	Air conditioned
ACO Function space	Patrons talking	Natural ventilation
Sydney Theatre Company	Amplified foreground music	Air conditioned – see below

Notes: 1 – Refer to Table 25 for associated noise levels

The acoustic performances of the venues external facades were based on in-situ partition tests conducted by Arup at the Pier 2/3 Function space. The use of these test results to represent the facades of all venues within the WBACP was considered to be conservative as the acoustic insulation of this space was particularly low, with visible gaps noted within the tested façade.

In addition, all natural ventilation openings were modelled in an *open* configuration, i.e. all louvered windows and doors in an open configuration. Noise breakout from these sealed and fully air conditioned spaces is predicted to be very low relative to that from the naturally ventilated spaces.

The level of noise breakout for the STC facilities, not part of this SSDA, has been assessed by Charcoal Blue, and is shown below in terms of the expected maximum sound pressure level at 1 m from the façade. These assessments are based on an assumed worst-case noise level in the performance venues of 94 dBL_{Aeq}.

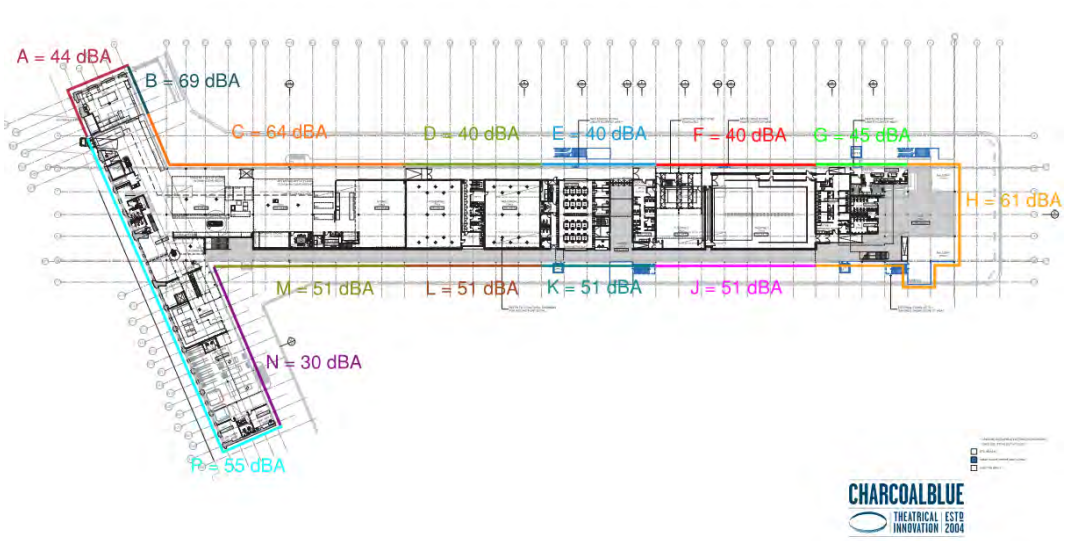

Figure 4: Sound pressure level at 1m from facade of STC facilities (image courtesy of Charcoal Blue)

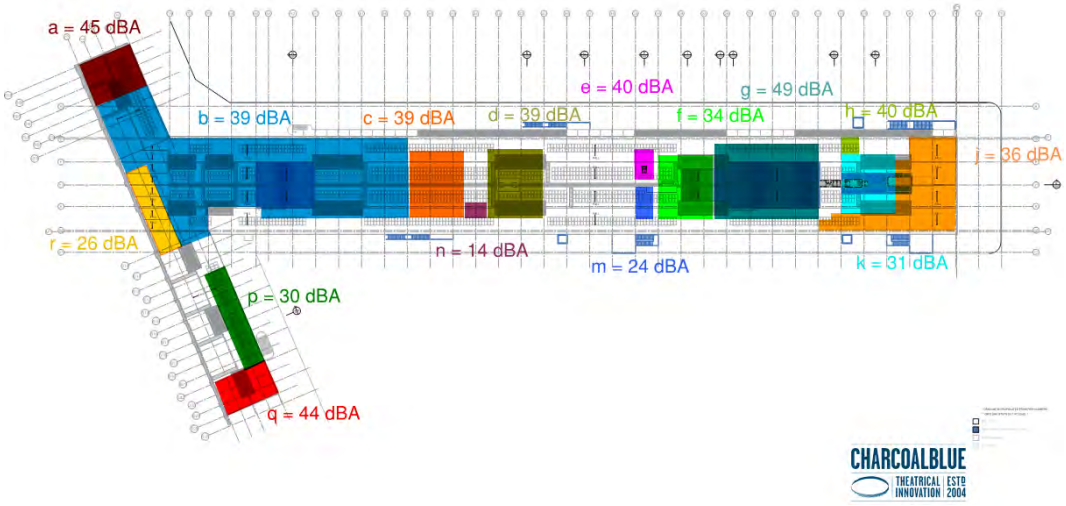

Figure 5: Sound pressure level at 1m from roof of STC facilities (image courtesy of Charcoal Blue)

As can be seen from the above, breakout noise levels even local to the façade and roof of the acoustically insulated spaces are significantly below the NSW INP targets for noise to atmosphere, and contributions from the STC to noise levels at nearby receivers is insignificant in relation to noise emissions from the operation of other precinct venues.

Mitigation measures to reduce these impacts are presented in Section 4.7.

4.3.2 Loading dock activities and waste and recycling removal

Noise from loading dock activities and waste and recycling removal have been modelled to determine impacts at nearby receivers. These activities have been

modelled as potentially taking place between 10:00pm and 12:00am. There will be a requirement for delivery vehicles to use specific routes for gaining access to the precinct, for both safety and noise mitigation reasons.

There will be a system for vehicles to flow through the Public Domain without needing to reverse (thus avoiding noise from reversing alarms). Vehicles moving along the piers will be required to turn only at the ends of the piers or within their tenancies and not allowed to drive in reverse at any other location. Again, this will avoid the need for reversing alarms outside noise sensitive premises.

The noise from loading and unloading activities has been estimated based on Arup's project experience and measurement database, and shown in Table 27.

Table 27: Noise source levels – loading dock activities and waste and recycling removal

Noise Source	**Descriptor**	**Sound power level, dB(A)**
Heavy Rigid Vehicle (HRV), 14.5 Tonne (TARE) waste removal truck driving forward at low speed	L_{Aeq}	92
Heavy Rigid Vehicle (HRV), 14.5 Tonne (TARE) waste removal truck lifting and compacting operations	L_{Aeq}	95
Loading dock activities – Use of pallet jack	L_{Amax}	114
Bottles being collected in hopper	L_{Amax}	114

Loading and unloading activities are expected to occur before or after performances at the precinct venues, therefore are not expected to occur during peak operational times of the venues, i.e. evenings, therefore have not been included in the worst case operational noise scenario.

Loading and unloading activities are not to take place between 10:00pm and 7:00am, therefore have not been assessed for sleep disturbance.

4.3.2.1 Set-building work

The Bell Shakespeare and ATYP tenancy will include some set building facilities. Noise from this activity has been measured by Arup in a theatre set workshop. The measurements covered all the major noise-generating power tools although these items would not be expected to operate continually or concurrently.

A summary of the noise measurements is provided in Table 28 below.

Table 28: Noise source levels - Set workshop building activities

Noise source	**Overall sound power level, dB(A)**		**Octave Band Centre Frequency, Hz**							
			63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
			Sound power level, dB							
Unknown saw type (dremel-like)	L_{max}	110	80	86	97	108	105	103	100	91
	L_{10}	105	74	77	94	102	97	99	97	89
Carba-Tec Thicknesser	L_{max}	118	88	92	99	104	111	113	113	101
	L_{10}	114	84	88	96	101	101	106	111	97

Noise source		Overall sound power level, dB(A)	Octave Band Centre Frequency, Hz							
			63	125	250	500	1k	2k	4k	8k
			Sound power level, dB							
Band saw (sawing timber)	L_{max}	115	91	94	100	104	105	106	109	110
	L_{10}	111	80	75	77	88	95	102	107	107
Band saw (sawing aluminium)	L_{max}	123	91	91	95	100	100	111	117	122
	L_{10}	114	80	82	89	97	98	105	110	109
Table saw	L_{max}	109	92	95	99	103	106	101	98	91
	L_{10}	103	89	91	90	96	98	97	94	90
Nail gun	L_{max}	106	89	95	99	100	100	100	98	98
	L_{10}	98	86	90	91	92	91	92	91	90
Angle grinder	L_{max}	105	84	86	84	90	94	98	101	100
	L_{10}	100	81	82	80	85	91	94	95	94

The noise levels measured in Table 28 will assist in the building façade and internal wall/floor partition design to ensure noise break-out is controlled to meet noise limits at the nearest sensitive receiver locations. The theatre tenants will be required to keep doors and windows shut to protect the local environment when particularly noisy work is being undertaken.

As there are regular set-building activities currently undertaken at the precinct, without noise issues, it is reasonable to assume that this can continue.

4.3.3 Cumulative noise from other external events

The noise emissions from occasional *external* events other than patrons in outdoor spill areas are not included in the scope of this SSDA. In practice, it is unlikely that there would be a cumulative noise impact on the community from both external *and* internal events concurrently. This is because such events would interfere with each other and would therefore have to be programmed such that there is no mutual disruption.

4.4 Results

The results of noise modelling for the normal and peak scenarios are presented in Table 29 and Table 30. Noise impacts have been predicted under neutral weather conditions (no wind) and worst case weather conditions (3 m/s source to receiver winds).

Noise contour maps of the normal and peak operational scenarios under worst case weather conditions are presented in Appendix F.

The modelling worst case scenario assumes all mechanical services are operational including those servicing STC, as presented in Section 4.3.1.1, as well as venue patron noise, presented in 4.3.1.2.

The tables include the Project Specific Noise Goals (PSNG) from Table 19 for reference.

Table 29: Operational noise impacts – Normal scenario

Receiver	Predicted noise level, dB(A)								
	Day			Evening			Early night		
	PSNG	Neut.	Worst	*PSNG*	Neut.	Worst	*PSNG*	Neut.	Worst
R1 - Pier One Hotel suites	***53***	46	46	***50***	46	46	***47***	46	46
R2 - Shore 6/7 apartments	***54***	47	48	***50***	43	44	***47***	42	43
R3 - 18 Hickson Road Hickson Apartments	***58***	31	32	***50***	31	32	***47***	31	32
R4 - Lower Fort Street North Terraces	***58***	43	44	***50***	43	44	***47***	42	43
R5 - Lower Fort Street South Terraces	***58***	40	41	***50***	40	41	***47***	40	41
R6 - Pottinger Street Terraces	***58***	37	37	***50***	37	38	***47***	37	37
R7 - Pier 6/7 apartments	***54***	46	46	***50***	45	46	***47***	45	46
R8 - Blues Point Tower	***53***	32	32	***45***	32	32	***42***	30	30
R9 - Warung Street Residences	***53***	28	31	***45***	28	31	***42***	27	30
R10 - East Crescent Street Residences	***53***	29	31	***45***	29	31	***42***	28	30
C1 - Pier One Hotel Bar & Restaurant	***65***	45	46	***65***	45	46	***65***	45	46
C2 - Shore 6/7 ground floor commercial	***65***	47	48	***65***	42	43	***65***	41	42
C3 - 18 Hickson Road commercial	***65***	28	29	***65***	28	29	***65***	28	29
C4 - View By Sydney, Simmer on the Bay	***65***	53	53	***65***	53	53	***65***	50	51
C5 - 16 Hickson Road commercial	***65***	39	39	***65***	39	39	***65***	39	39
C6 - Roslyn Packer Theatre	***65***	24	25	***65***	24	25	***65***	24	25
P1 - Blues Point Reserve	***50***	31	34	***50***	31	34	***50***	30	32

Notes: Levels shaded in grey indicate an exceedance of PSNG.

Table 30: Operational noise impacts – Peak scenario

Receiver	Predicted noise level, dB(A)								
	Day			Evening			Early night		
	PSNG	Neut.	Worst	*PSNG*	Neut.	Worst	*PSNG*	Neut.	Worst
R1 - Pier One Hotel suites	***53***	48	48	***50***	48	48	***47***	48	48
R2 - Shore 6/7 apartments	***54***	52	52	***50***	47	47	***47***	46	47
R3 - 18 Hickson Road Hickson Apartments	***58***	36	36	***50***	36	36	***47***	36	36
R4 - Lower Fort Street North Terraces	***58***	46	47	***50***	46	47	***47***	46	46
R5 - Lower Fort Street South Terraces	***58***	44	44	***50***	44	44	***47***	44	44

Receiver	Predicted noise level, dB(A)								
	Day			Evening			Early night		
	PSNG	Neut.	Worst	*PSNG*	Neut.	Worst	*PSNG*	Neut.	Worst
R6 - Pottinger Street Terraces	***58***	41	41	***50***	41	41	***47***	41	41
R7 - Pier 6/7 apartments	***54***	49	49	***50***	48	48	***47***	47	48
R8 - Blues Point Tower	***53***	36	36	***45***	36	36	***42***	33	33
R9 - Warung Street Residences	***53***	32	35	***45***	32	35	***42***	31	33
R10 - East Crescent Street Residences	***53***	33	35	***45***	33	35	***42***	31	33
C1 - Pier One Hotel Bar & Restaurant	***65***	47	48	***65***	47	48	***65***	47	48
C2 - Shore 6/7 ground floor commercial	***65***	52	52	***65***	47	47	***65***	44	45
C3 - 18 Hickson Road commercial	***65***	33	33	***65***	33	33	***65***	33	33
C4 - View By Sydney, Simmer on the Bay	***65***	56	57	***65***	56	57	***65***	53	53
C5 - 16 Hickson Road commercial	***65***	44	44	***65***	44	44	***65***	43	44
C6 - Roslyn Packer Theatre	***65***	29	29	***65***	29	29	***65***	28	29
P1 - Blues Point Reserve	***50***	35	38	***50***	35	38	***50***	33	35

Notes: Levels shaded in grey indicate an exceedance of PSNG.

Table 31: Operational noise impacts – Logistics activities / patrons leaving scenario

Receiver	Predicted noise level, dB(A)		
	Late night		
	PSNG	Neut.	Worst
R1 - Pier One Hotel suites	***45***	42	42
R2 - Shore 6/7 apartments	***47***	42	42
R3 - 18 Hickson Road Hickson Apartments	***45***	35	36
R4 - Lower Fort Street North Terraces	***45***	43	43
R5 - Lower Fort Street South Terraces	***45***	43	43
R6 - Pottinger Street Terraces	***45***	40	40
R7 - Pier 6/7 apartments	***47***	43	44
R8 - Blues Point Tower	***40***	31	31
R9 - Warung Street Residences	***40***	28	29
R10 - East Crescent Street Residences	***40***	28	29
C1 - Pier One Hotel Bar & Restaurant	***65***	40	41
C2 - Shore 6/7 ground floor commercial	***65***	39	39
C3 - 18 Hickson Road commercial	***65***	32	33

Receiver	Predicted noise level, dB(A)		
	Late night		
	PSNG	Neut.	Worst
C4 - View By Sydney, Simmer on the Bay	***65***	49	49
C5 - 16 Hickson Road commercial	***65***	43	43
C6 - Roslyn Packer Theatre	***65***	28	28
P1 - Blues Point Reserve	***50***	31	33

Results show during the normal scenario, representative of the majority of WBACP operations, no exceedances are predicted at any receivers during any period of the day.

During peak scenario representative of the realistic highest population of the precinct, a minimal exceedance of 1 dB is predicted at night during worst case weather conditions at R1 - Pier One Hotel suites and R7 – Pier 6/7 apartments. This result is not considered to result in significant community disturbance, and a 1 dB difference in noise levels is considered barely perceptible to the average person.

During late night hours when no venues are operational, with only patrons leaving and some internal logistics activities taking place, no exceedances are predicted.

These three scenarios represent the realistic typical and worst case scenarios to occur at the WBACP during the day, evening, early and late night periods, and are not expected to result in significant noise issues. It should be noted, these scenarios conservatively assume all mechanical plant is operational, and noise levels in venues are as indicated in Table 25, which are considered high for the type of events to be expected.

4.5 Sleep disturbance

The loudest activities which may take place during the night time hours of 10:00pm to 12:00am are associated with noise from the large crowds and music noise, whereas the loudest activities occurring between 12:00am and 7:00am are associated with patrons leaving.

In order to determine L_{Wmax} levels for outdoor patrons, 8 dB has been added to L_{Weq} levels, based on crowd measurements previously conducted by Arup. The determination of L_{Weq} levels are presented in Section 4.3.1.2.

Results are presented in Table 32.

Table 32: Sleep disturbance assessment, L_{max} dB(A)

Receiver	Night, 10:00pm – 12:00am		Night, 12:00am – 7:00am	
	Sleep disturbance criteria	**Predicted noise level**	***Sleep disturbance criteria***	**Predicted noise level**
R1 - Pier One Hotel suites	***61***	56	***61***	50
R2 - Shore 6/7 apartments	***59***	55	***59***	50
R3 - 18 Hickson Road Hickson Apartments	***64***	44	***64***	44
R4 - Lower Fort Street North Terraces	***64***	54	***64***	51
R5 - Lower Fort Street South Terraces	***64***	52	***64***	51
R6 - Pottinger Street Terraces	***64***	49	***64***	48
R7 - Pier 6/7 apartments	***59***	56	***59***	52
R8 - Blues Point Tower	***56***	41	***56***	39
R9 - Warung Street Residences	***56***	41	***56***	37
R10 - East Crescent Street Residences	***56***	41	***56***	37

Notes: Levels shaded in grey indicate an exceedance of NMLs.

Results show no exceedances of sleep disturbance criteria are predicted.

4.6 Operational vibration impacts

The intended use of the precinct is not expected to result in any significant vibration. All plant will need to be carefully vibration isolated to control structure-borne vibration and regenerated noise.

The overall sensitivity of the development itself to noise and vibration (because of the arts uses) will mean that there will be tight control of any future vibration generating activities.

4.7 Recommendations

4.7.1 Mechanical services

Calculations based on preliminary plant selections show that acceptable noise levels can be achieved. Most of the plant is serving low-noise internal areas and this requires the selection of inherently quiet plant.

The noise control treatments are likely to include:

- Specification of maximum sound power levels for all items of plant as part of the project documentation
- Rectangular and circular attenuators to control fan noise
- Acoustic louvres to control noise from plantroom ventilation openings
- Vibration isolators to reduce vibration input to the building structure

- Acoustic screens around any external plant
- Incorporation of sound absorptive treatments in plantroom spaces where needed
- Kitchen exhausts with discharge attenuators (treated against kitchen grease)

It is expected that the project will make use of seawater cooling. This is intrinsically quieter than many of the alternatives (i.e. cooling towers or air cooled condensers). The seawater cooling plant will be enclosed in a plantroom.

Current plant proposals do not include generator sets, thereby further lowering the potential for noise impacts.

4.7.2 Venue noise

Results show that noise from typical and worst case scenarios for venue operation are predicted to comply with project specific noise goals at all receivers.

Noisy activities within each venue should be limited to those listed in Table 25 and Table 26, and the use of amplified music within function spaces where patron noise has been assigned should be limited so that the total noise levels (including music and patron noise) do not exceed those that have been assumed in the assessment. There will necessarily be requirements to control internal noise levels in spaces because of the potential disturbance to the noise-sensitive arts tenants within the precinct through party walls and party floors. The need to control noise will be part of the agreements with hirers of the function spaces.

Due to the low modelled performance of the external façade of the venues, the closing of doors and louvres to venues does not result in significant noise reductions at nearby receivers. Similarly, the contribution of noise from outdoor patrons relative to noise breaking out of the venues hosting cocktail parties or performances is small, hence the restriction of patrons to indoor areas does not significantly reduce noise emissions from the precinct.

The heritage nature of the doors means that it would not be practicable to seal the doors to obtain very high levels of sound insulation.

The limited internal sound insulation *within* the piers means that is not possible to have amplified music at a ‘concert’ level (i.e. ~105 dB(A) within the venue) as this would disturb adjoining tenants, as well as resulting in excessive noise leaving the development. The need to control noise will be part of the agreements with hirers of the function spaces.

4.7.3 Loading dock and waste and recycling removal

In order to minimise sleep disturbance to these residences, loading dock activities and waste and recycling removal should be scheduled outside of night-time hours, i.e. before 10:00pm or after 7:00am.

4.7.4 Patrons leaving the precinct

In order to minimise the risk of sleep disturbance to surrounding residences while patrons are leaving the WBACP, patrons will be directed to leave via the aprons on the inside of the precinct, i.e. west of Pier 2/3 and the east of Pier 4/5. This will maximise the shielding of the residences to the west and east of the precinct by the precinct buildings.

Precinct staff will also be directing patrons to keep noise to a minimum when leaving in order to reduce shouting or unnecessary loud conversations between leaving the venues and leaving the precinct.

5 Event Noise

5.1 Overview

The principles for a curatorial framework for events to be hosted at the WBACP have been developed that provides less emphasis on "traditional" programmed events such as concerts and large festivals. Instead, there is a focus on low impact, intimate entertainment and passive and immersive activation to guide the development of events held within the WBACP.

It should be noted that this section addresses 'event' generated noise referring to the following coordinated precinct-wide events:

- Sydney Writer's Festival
- Biennale

The everyday operation of individual venues is assessed under operational noise in Section 4.

Given the nature of the events and the intended audience, it is expected that most would take place primarily outside normal 'office hours', although some setup would take place during the normal working day.

5.2 Noise criteria

For precinct-wide events including Sydney Writer's Festival and the Biennale, an absolute criterion is proposed based on common practice in Sydney.

The noise limits in Table 33 are proposed for occasional coordinated precinct-wide events at the WBACP. These noise limits are based on noise limits outlined in the 2017 Consent Conditions for the Sydney Writer's Festival (Application no: D/2017/178). They cover noise from setup and take down as well as noise generated by the event itself.

Whilst the dB(A) metric is commonly used to assess most types of noise, an additional requirement using the dB(C) metric is sometimes used in Sydney to take account of the low frequency content.

Table 33: Noise criteria for events

Activity	**Early morning (0700h to 1000h)**	**Daytime & evening (1000 to 2200h)**	**Night (2200h to 2400h)**
Any noise sensitive residential or commercial receiver external to the operational area of the event[1]			
Setup / takedown	$L_{Aeq,15m}$ <50	$L_{Aeq,15m}$ <55	$L_{Aeq,15m}$ <50
Event including sound check	None allowed	$L_{Aeq,15m}$ <55 $L_{Ceq,15m}$ <70	$L_{Aeq,15m}$ <50 $L_{Ceq,15m}$ <65

Notes:

Free-field noise criteria to be met at any residential boundary

1 – As prescribed in current Sydney Writer's Festival Consent Conditions

The above criteria apply for any one single day during the duration of a multi-day event. For the rest of the days of the event, INP noise criteria apply.

5.3 Modelled event scenario

In order to predict noise impacts generated by occasional events at the WBACP, an event scenario has been modelled to represent the Sydney Writer's Festival and the Biennale.

As activities taking place during these type of events are largely spoken word, no significant noise breakout from the venues is expected. The dominant noise source during these events is anticipated to be noise from patrons talking on the precinct aprons.

Noise levels from patrons standing outside venues have been predicted using a formula established in Hayne et al. [14], being:

$$L_{WAeq} = 15 \times \log_{10}(Crowd\ size) + 64\ dB(A)$$

The vocal spectrum used is presented in Table 24. This has been normalised to the calculated sound power level. Event outdoor patron numbers are presented in Appendix E.

5.4 Results

The results of noise modelling for coordinated precinct-wide events are presented in Table 34. Noise impacts have been predicted under neutral weather conditions (no wind) and worst case weather conditions (3 m/s source to receiver winds).

The tables include the event criteria from Table 33 for reference.

Table 34: Event noise impacts

Receiver	Predicted noise level, $dBL_{Aeq,\ 15\ min}$					
	Day			Night		
	Criteria	Neut.	Worst	*Criteria*	Neut.	Worst
R1 - Pier One Hotel suites	***55***	43	43	***50***	34	34
R2 - Shore 6/7 apartments	***55***	43	43	***50***	34	34
R3 - 18 Hickson Road Hickson Apartments	***55***	36	37	***50***	27	28
R4 - Lower Fort Street North Terraces	***55***	45	47	***50***	36	38
R5 - Lower Fort Street South Terraces	***55***	45	47	***50***	36	38
R6 - Pottinger Street Terraces	***55***	41	42	***50***	32	33
R7 - Pier 6/7 apartments	***55***	44	45	***50***	35	36
R8 - Blues Point Tower	***55***	36	40	***50***	27	31
R9 - Warung Street Residences	***55***	35	39	***50***	26	30
R10 - East Crescent Street Residences	***55***	34	39	***50***	25	30
C1 - Pier One Hotel Bar & Restaurant	***55***	41	42	***50***	32	33

Receiver	Predicted noise level, $dBL_{Aeq, 15\ min}$					
	Day			Night		
	Criteria	Neut.	Worst	*Criteria*	Neut.	Worst
C2 - Shore 6/7 ground floor commercial	***55***	39	40	***50***	30	31
C3 - 18 Hickson Road commercial	***55***	33	34	***50***	24	25
C4 - View By Sydney, Simmer on the Bay	***- [1]***	71	71	***- [1]***	62	62
C5 - 16 Hickson Road commercial	***55***	44	45	***50***	35	36
C6 - Roslyn Packer Theatre	***- [1]***	29	30	***- [1]***	20	21
P1 - Blues Point Reserve	***55***	38	42	***50***	29	33

Notes: 1 – No criteria set for receivers within the operational area of the event in accordance with current Sydney Writer's Festival Consent Conditions

Results show no exceedances of event noise criteria are predicted under neutral or worst case weather conditions. No noise limits have been applied at receivers within the operational area of the event, therefore no exceedances are predicted at these receivers.

Noise from outdoor patrons are largely shielded from surrounding receivers by the precinct buildings, which is reflected by the low noise levels predicted at surrounding receivers but higher noise levels predicted at C4 - View By Sydney, Simmer on the Bay.

As the noise generated from events will be largely vocal noise from patrons, which is characterised as mid to high frequency noise, there is a low risk of adverse low-frequency noise issues. The C-weighted event noise criteria in Table 33 is proposed to control low-frequency noise impacts from music. These limits are unlikely to be exceeded, due to the nature of vocal noise.

No significant noise issues due to precinct-wide event activities is expected to the surrounding community, however, an Operational Noise Management Plan shall be implemented for these events.

It should be noted that the Sydney Writer's Festival and Biennale are existing annual events. It is understood that no noise complaints have been made regarding these events by surrounding commercial or residential receivers.

6 Operational Traffic Noise

Operational traffic generated by the redeveloped WBACP has the potential to increase traffic noise levels at nearby residential receivers. The potential worst affected residential receivers by traffic generated by the WBACP have been identified as those along Hickson Road, namely 17 Hickson Road and 18 Hickson Road. Traffic noise levels have been assessed to these locations.

6.1 Noise criteria

Increased traffic generated on the surrounding road network due to either construction activities or by the operation of the WBACP is assessed in accordance with the RNP. Table 3 of the NSW Road Noise Policy (RNP) which sets out the assessment criteria for particular types of project, road category and land use.

Table 35: Road traffic criteria for traffic generating development - residential receivers

Road category	**Type of project / land use**	**Assessment criteria – dB(A)**	
		Day (7:00am-10:00pm)	**Night (10:00pm-7:00am)**
Freeway/arterial/sub-arterial roads - Hickson Road	Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq,(15\ hour)}$ 60 (external)	$L_{Aeq,(9\ hour)}$ 55 (external)

Notes: These criteria are for assessment against façade corrected noise levels when measured in front of a building façade.

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.*

6.2 Generated traffic noise impacts

Traffic counts were conducted along Hickson Road adjacent to Pier 4 were conducted by Matrix Traffic and Transport Data on 27 August 2016. A summary of traffic counts are provided in Table 36.

Additional traffic generated by the operation of the WBACP were provided by GTA Consultants, and were estimated at 150 vehicle movements arriving or leaving before 10:00 pm at the WBACP and 150 movements leaving after 10:00 pm. These vehicle movements would include taxis, ride sharing, loading vehicles and private vehicles.

The predicted increase in noise as a result of the traffic generated by the WBACP are presented in Table 36.

Table 36: Operational generated traffic noise impacts – Hickson Road

	Day (7:00am-10:00pm)	**Night (10:00pm-7:00am)**
Existing traffic volumes along Hickson Road	5549 vehicles	967 vehicles
Traffic generated by operation of WBACP	150 vehicles	150 vehicles
Increase in traffic noise as a result of WBACP operation	0.1 dB	0.6 dB

Results show noise impacts as a result of the generated traffic are predicted to increase road traffic noise levels by less than 1 dB under the worst case scenario of 150 vehicles leaving after 10pm, representing a minimal impact considered barely perceptible to the average person.

No mitigation of road traffic noise is therefore considered necessary.

7 Summary of Mitigation Measures

A summary of mitigation measures proposed in this report are presented in Table 37.

Table 37: Summary of mitigation measures

Mitigation Measure	Responsibility	Timing
Appoint a construction staff member responsible for construction noise and vibration management on site. Ensure construction staff are trained in ways to minimise noise during work, eg. Minimise dropping items, avoiding the use of stereos outdoors, avoiding shouting, slamming doors.	Construction contractor & Responsible Member for construction noise	During construction
Turn off construction equipment when not in use. Maintain equipment and use quiet equipment where possible.	Construction contractor, Responsible Member & construction staff	During construction
Ensure construction only occurs between 7am to 6pm on weekdays and 8am to 1pm on Saturdays. No work on Sundays or public holidays. Undertake internal works in the proposed Bell Studio early in the construction schedule to minimise disturbance to adjacent tenants.	Construction contractor & Responsible Member	During construction
Undertake construction noise monitoring to alert the Contractor and Precinct Management of potential exceedances of Noise Management Levels.	Construction contractor & Responsible Member	During construction
Maintain open communication channels with nearby receivers, including commercial tenants and residents. Maintain a complaints log including timing, issues, immediate and on-going actions.	Construction contractor & Responsible Member	During construction
Endeavour to schedule construction works around noise sensitive events occurring within or near the Precinct.	Construction contractor & Responsible Member	During construction
Maintain minimum working distances for vibration intensive plant. Where this is not possible, vibration monitoring with real-time alerts should be considered.	Construction contractor & Responsible Member	During construction
Mechanical services acoustic treatment will be finalised at the detailed design stage. Standard noise control measures may be required, including quiet plant selection, attenuators, acoustic louvres, vibration isolators, screening and absorptive lining.	Detailed design team	Detailed design stage

Mitigation Measure	Responsibility	Timing
Internal noise sources within non-acoustically treated venues shall be limited to patrons talking and foreground music, representative of cocktail party functions and performances. Amplified music at 'concert' levels (i.e. ~105 dB(A)) is not permitted.	Operators	During operation
Loading dock activities and waste and recycling removal should be scheduled outside of night-time hours, i.e. before 10:00pm or after 7:00am.	Proponent & operators	During operation
Direct patrons out of the precinct via the aprons along the west of Pier 2/3 and east of Pier 4/5.	Proponent & operators	During operation
Precinct staff to direct patrons to keep noise to a minimum when leaving the precinct.	Proponent & operators	During operation
Management of the precinct shall undertake implement an Operational Noise Management Plan for events at the WBACP	Proponent & precinct management	During operation

8 Conclusion

Based on the assessments detailed above, it is concluded that the development will not have a significant impact on the environment around the development site, or to existing tenants within the development area. The noise assessment has included a complete set of noise surveys to update assumptions regarding the existing noise climate.

The assessment has covered the following issues and concluded:

8.1 Construction noise

Predictions have been made of noise generated from the various activities during the construction stage. This has been informed by guidance from the project Construction Consultant. Much of the work will be undertaken internally and so will be attenuated by the envelope of the building.

Some work does have to be done externally and will involve the removal of some existing concrete and timber. Noise from this work will be carefully managed to limit noise generation as far as is reasonably practicable. Detailed recommendations are given for the control of construction noise for the limited periods when a small excess of the relevant Noise Management Levels.

8.2 Operational noise

Operation noise assessments have looked at various population scenarios and types of activities. The assessment has combined noise from plant as well as patron noise (internal and external) and noise from performances. Reference has also been made to the proposed STC project.

Under the ‘normal’ scenario, no exceedances of noise criteria are predicted based on worst case assumptions. For the ‘peak’ scenario, a notional 1 dB excess is estimated, also on worst case assumptions. These are considered acceptable but measures will be taken to monitor and manage noise levels if conditions are thought likely to result in a noise exceedance. During late night activities including patrons leaving and internal logistical activities, no exceedances are predicted.

A sleep disturbance assessment of venue operations during night time hours shows predicted noise levels comply with sleep disturbance criteria. Recommendations are also given to limit noise emissions at night.

8.3 Noise from occasional coordinated events

Predictions have been made for noise from the Sydney Writer’s Festival and Biennale. An ‘event’ scenario has been modelled to represent a these events, based on the scenario detailed in Section 5.3.

The limited space available for external activities means that any large event is likely to require most of the participants to be indoors and the majority of internal performance activities are anticipated to be spoken word. It is proposed that the management of the precinct implement an Operational Noise Management Plan for events at the WBACP.

Appendix A

References

References

[1] NSW Environmental Protection Authority, "NSW Industrial Noise Policy," NSW Environmental Protection Authority, Sydney, 1999.

[2] NSW Environmental Protection Authority, "NSW Industrial Noise Policy - application notes," Environmental Protection Authority, Sydney, 2013.

[3] Department of Environment and Climate Change NSW, "Interim Construction Noise Guideline," Department of Environment and Climate Change NSW, Sydney, 2009.

[4] Department of Environment and Conservation (NSW), "Assessing Vibration: A technical guideline," Department of Environment and Conservation (NSW), Sydney, 2006.

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[11] Cadence Australia, "Walsh Bay Arts and Cultural Precinct - Environmental, Construction and Site Management Plan," Sydney, 2017.

[12] Standards Australia, "AS 2436-2010 - Guide to noise and vibration control on construction, demolition and maintenance sites," Standards Australia, 2010.

[13] Department for Environment Food and Rural Affairs, "Update of noise database for prediction of noise on construction and open sites," Department for Environment Food and Rural Affairs, 2006.

[14] M. Hayne, J. Taylor, R. Rumble and D. Mee, "Prediction of Noise from Small to Medium Sized Crowds," in *Acoustics 2011*, Gold Coast, 2011.

[15] I. R. Cushing, F. F. Li, T. J. Cox, K. Worral and T. Jackson, "Vocal effort levels in anechoic conditions," *Applied Acoustics,* vol. 72, pp. 695-701, 2011.

[16] H. Rindel, "Acoustical capacity as a means of noise control in eating establisments," in *Joint Baltic-Nordic Acoustics Meeting*, Lyngby, 2012.

Appendix B

Acoustic Glossary

B1 Acoustic Glossary

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, and min$L_{A90,1hour}$ in QLD.

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}

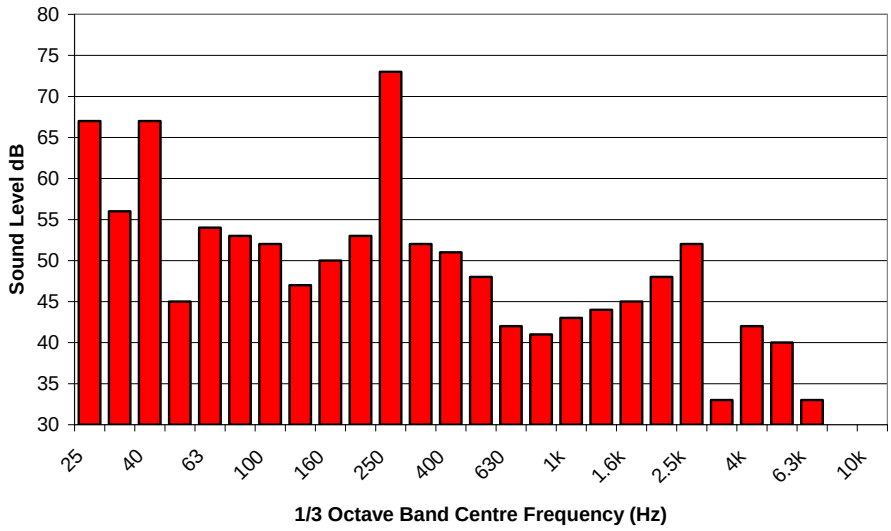
The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

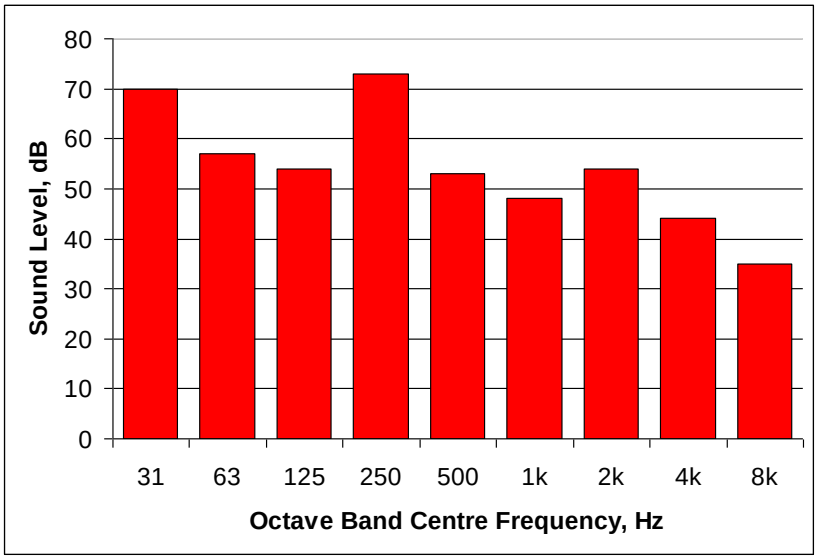
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

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

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".





Peak Particle Velocity (PPV)

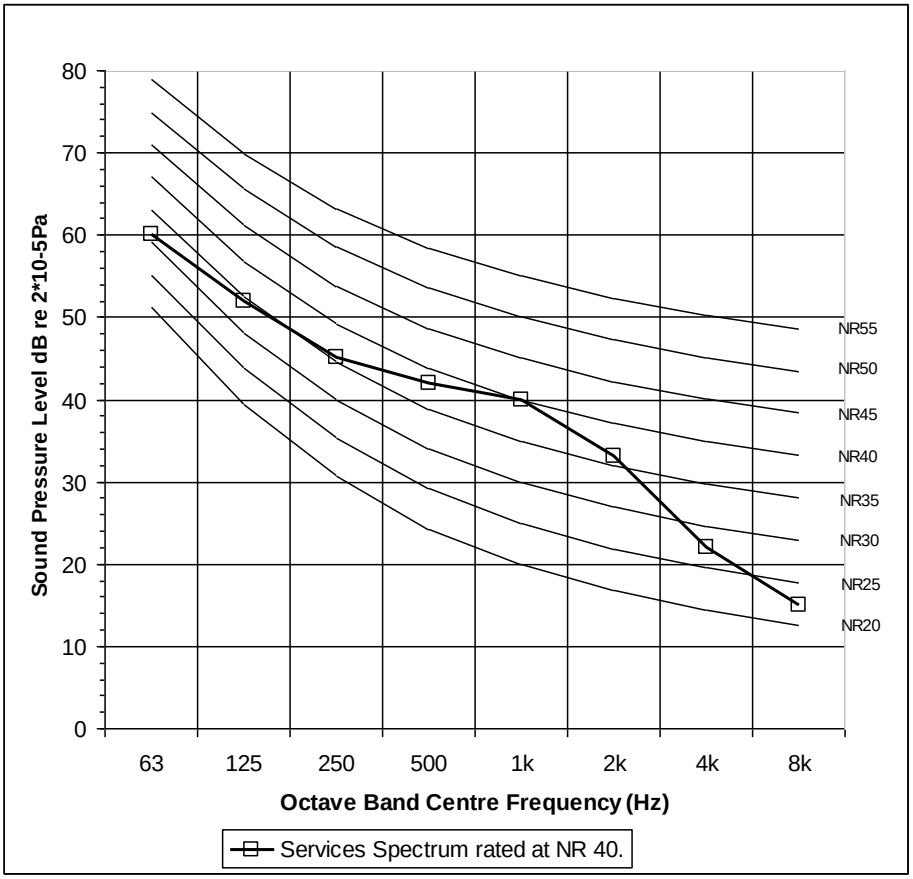
Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement.

PPV is commonly used as a vibration criterion, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Noise Rating (NR) Curves

Noise rating (NR) curves are a set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The NR value of a noise

is obtained by plotting the octave band spectrum on the set of standard curves. The highest value curve which is reached by the spectrum is the NR value. Shown below is a plant noise spectrum that is equivalent to NR 40.



Sound Level Difference (D)

Sound level difference is used to quantify the sound insulation between two spaces, and is equal to the difference in sound level between the two rooms at a particular frequency (e.g. if the sound level in the source room is 100 dB and the sound level in the adjacent room is 75 dB, the sound level difference is 25 dB). The weighted sound level difference, D_w, (as defined in AS/NZS ISO 717.1) is commonly used to provide a single-number descriptor to describe the overall performance of a partition across a wider frequency range.

The terms used to describe the airborne sound insulation rating of a building element when tested on-site are the weighted normalised level difference ($D_{n,w}$), which corrects the measured sound level difference to a reference absorption area in the receiving room, or the weighted standardized level difference ($D_{nT,w}$), which corrects the measurements to a reference reverberation time in the receiving room. These single numbers are determined by comparing the spectral sound insulation test results (as defined in ISO 140-4) with reference values, as outlined in AS/NZS ISO 717.1.

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.

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/s²) or else using a decibel scale.

Appendix C

Measurement Methodology and Results

C1 Noise Monitoring Methodology and Results

C1.1 Noise monitoring equipment

Unattended and attended monitoring was carried out using the following equipment:

Monitoring	Measurement location	Equipment/model	Serial No.	SLM Type
Unattended long-term	Meas. 1	RTA04 (CESVA SC310)	T229740	Class 1
	Meas. 2	Ngara (ARL)	878 0D1	Class 1
	Meas. 4	Ngara (ARL)	878 061	Class 1
	Meas. 5	Ngara (ARL)	878 07F	Class 1
	Meas. 6	Ngara (ARL)	878 107	Class 1
	Meas. 7	RTA04 (CESVA SC310)	T229742	Class 1

Notes: All meters comply with AS IEC 61672.1 2004 “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 Class 4231 calibrator. No significant drift in calibration was observed.

C1.2 Long-term measurement methodology

C1.2.1 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 Appendix B of the NSW Industrial Noise Policy (INP).

Data was provided by the Bureau of Meteorology (BOM) collection station at Sydney Observatory Hill. 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*'.

Unattended monitoring: Meas 1 (Free Field)

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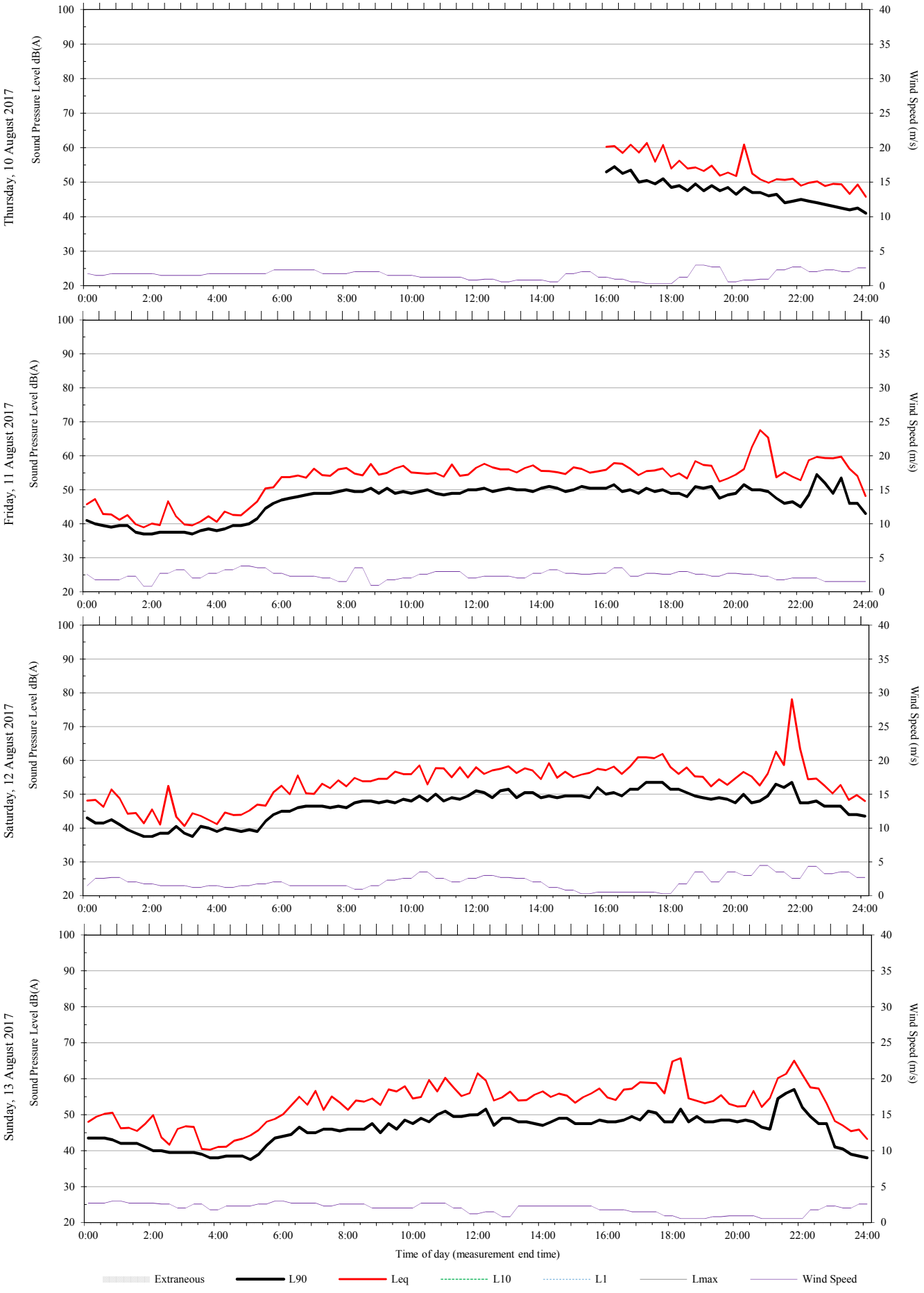

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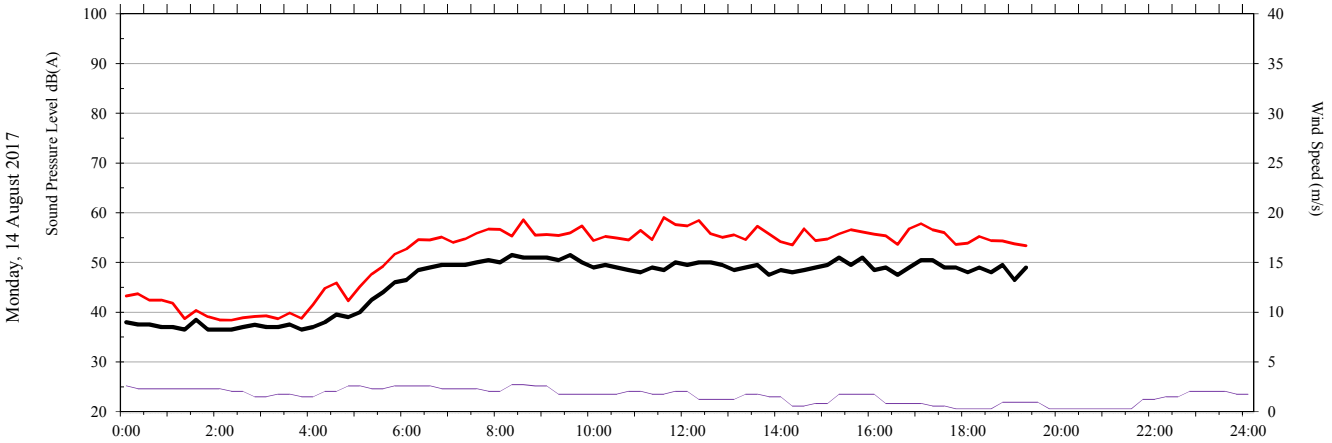
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Sound Pressure Level dB(A)
Wind Speed (m/s)
100
90
80
70
60
50
40
30
20
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00

Unattended monitoring: Meas 1 (Free Field)

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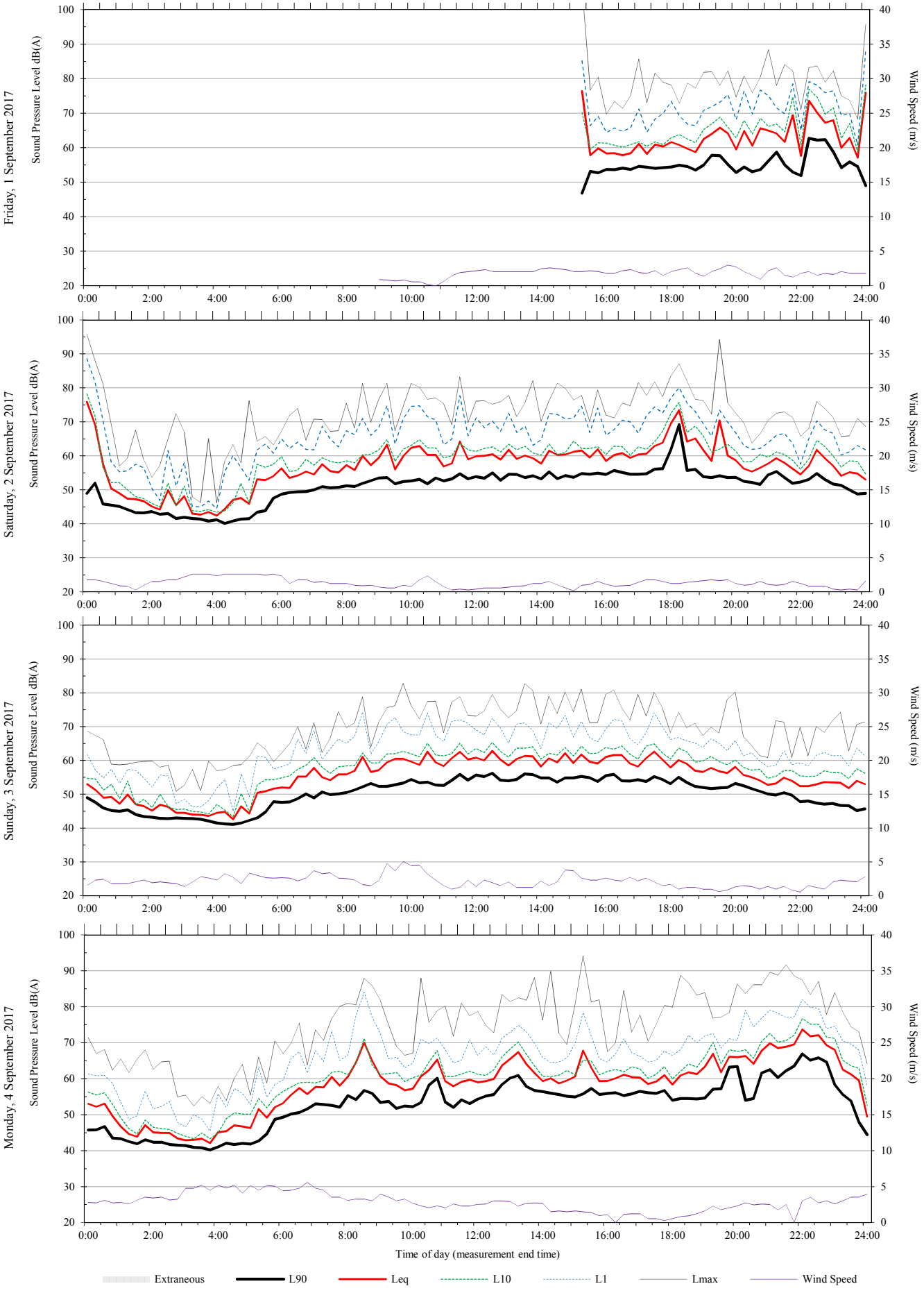

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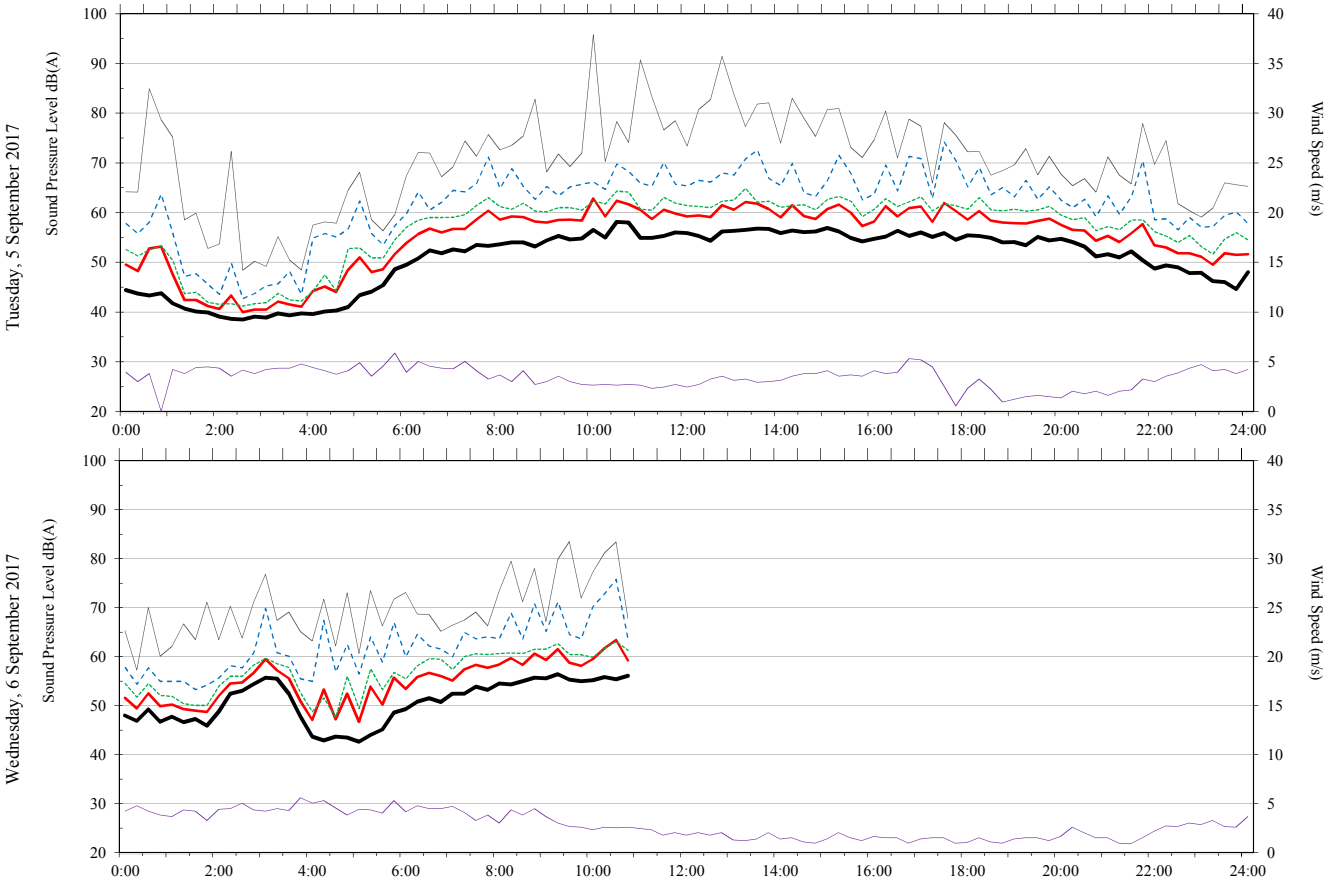

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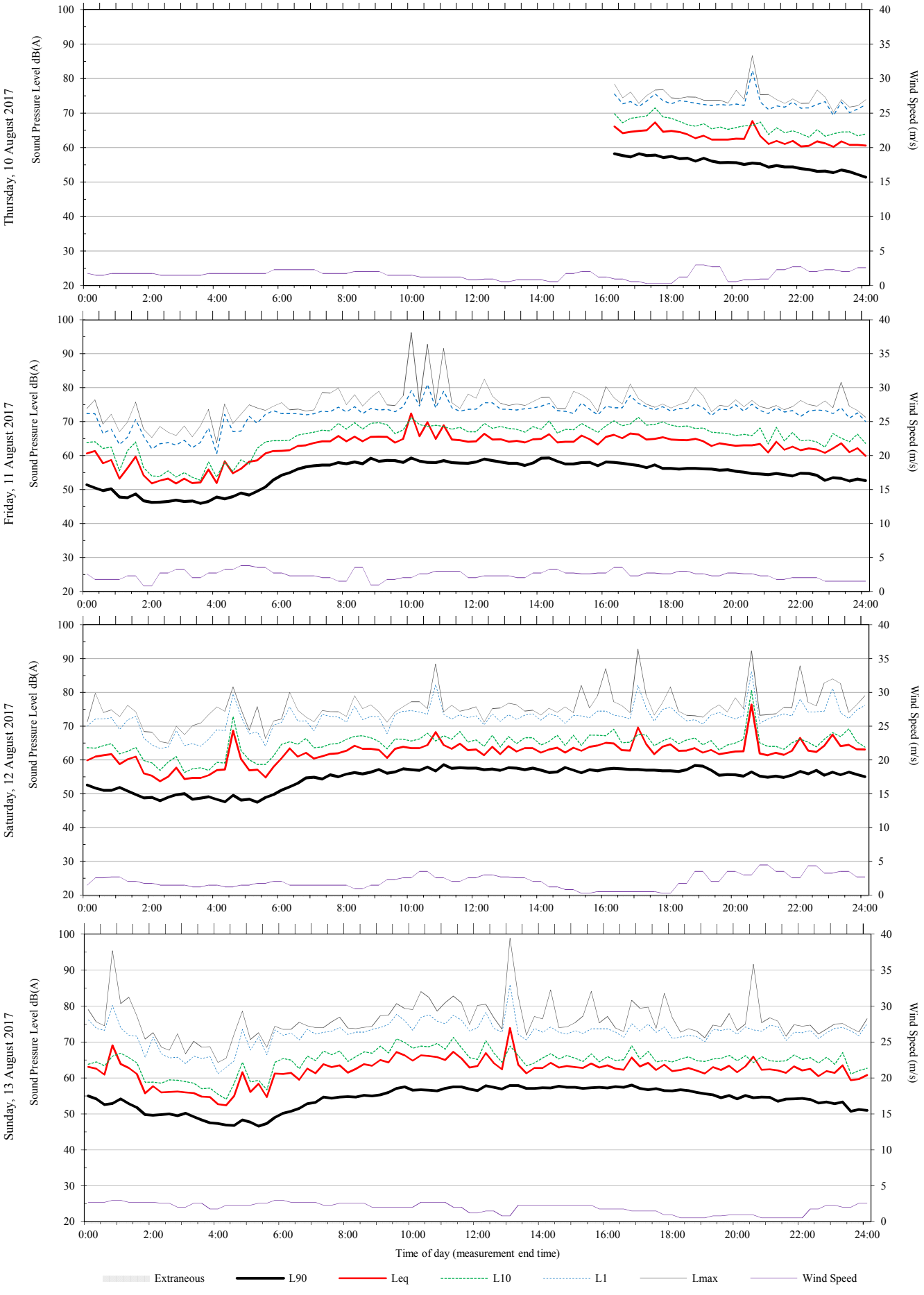

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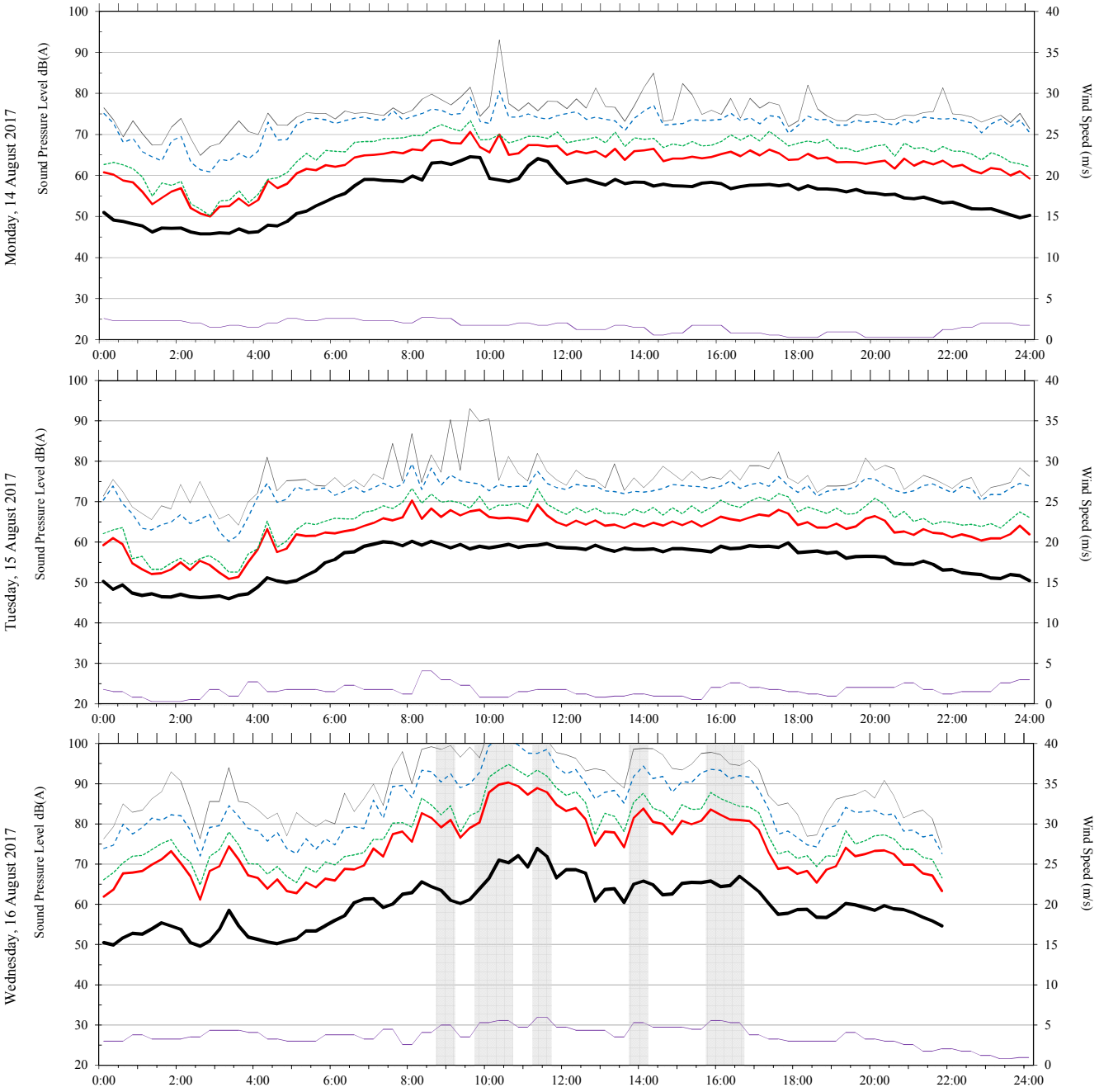
Monday, 14 August 2017
Tuesday, 15 August 2017
Wednesday, 16 August 2017
Sound Pressure Level dB(A)
Wind Speed (m/s)
100
90
80
70
60
50
40
30
20
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
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24:00

Unattended monitoring: Meas 4 (Free Field)

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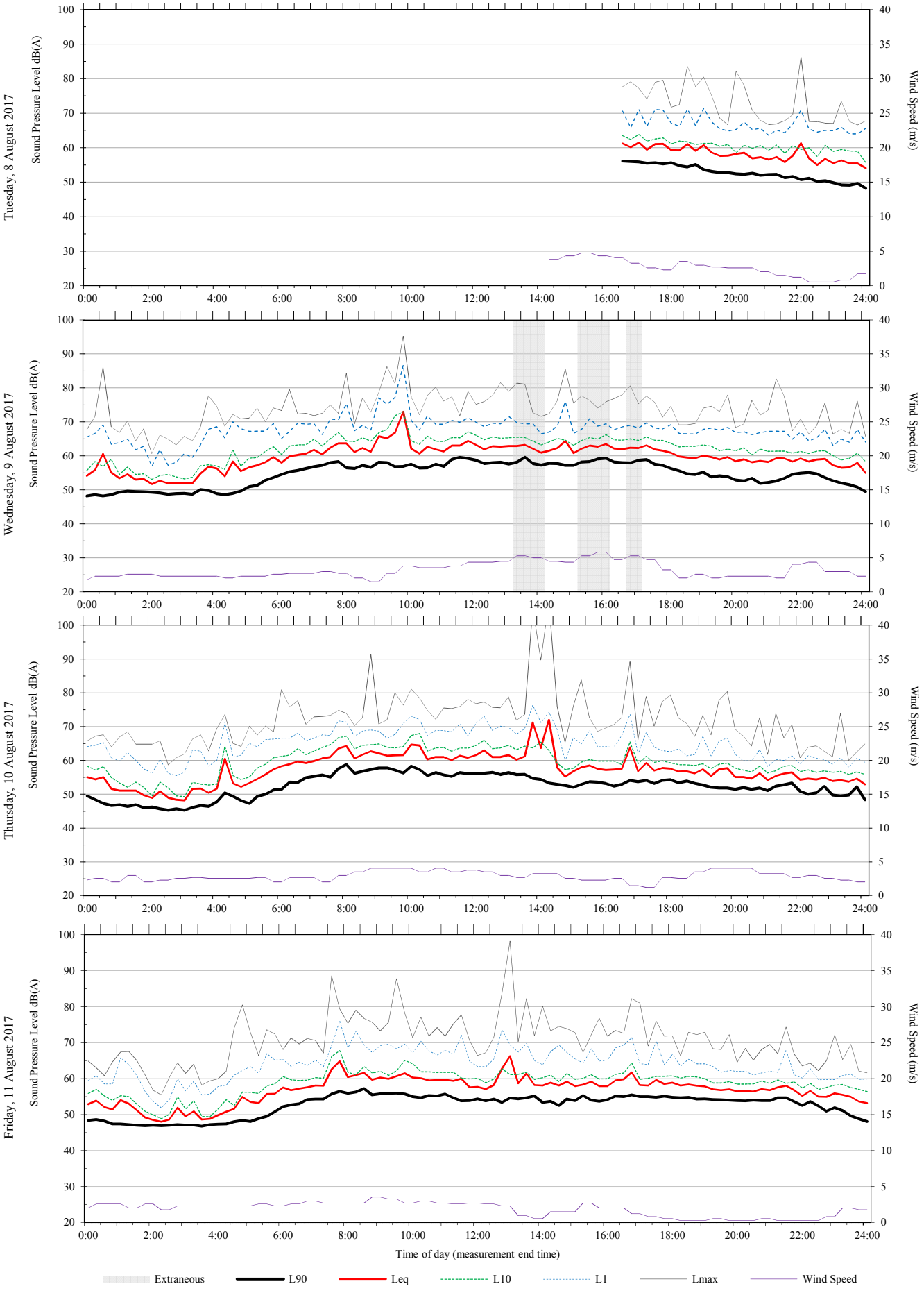

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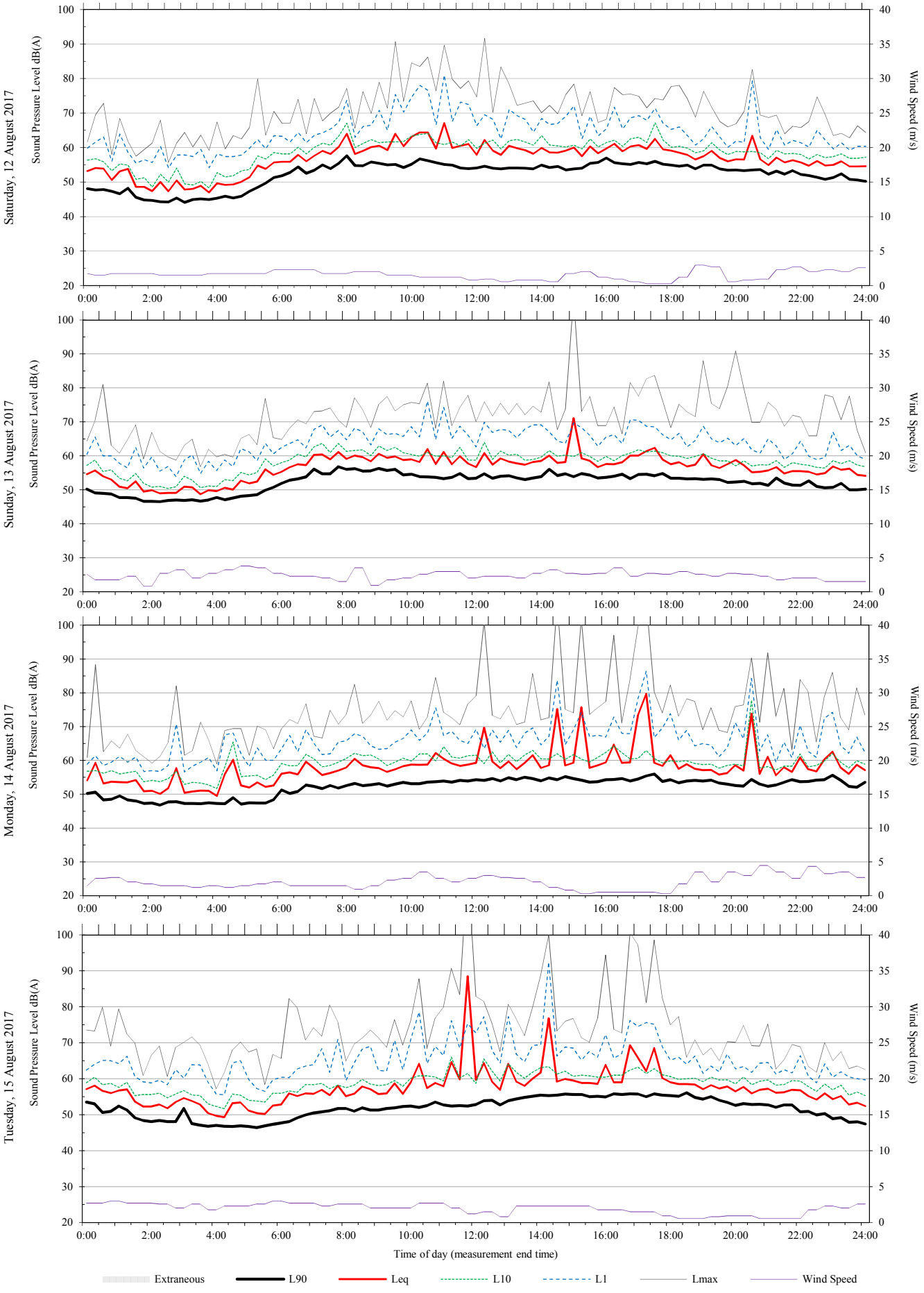

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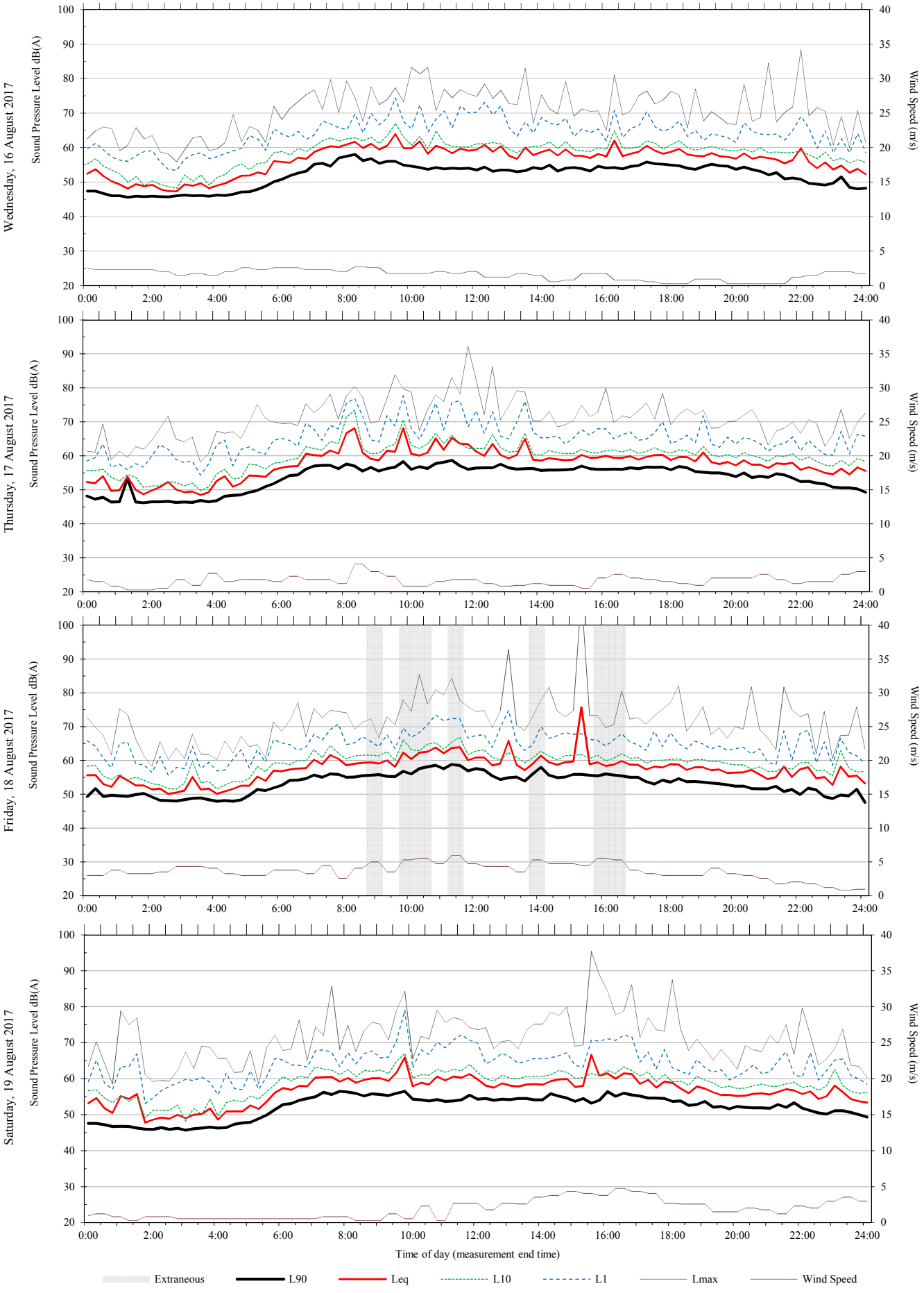

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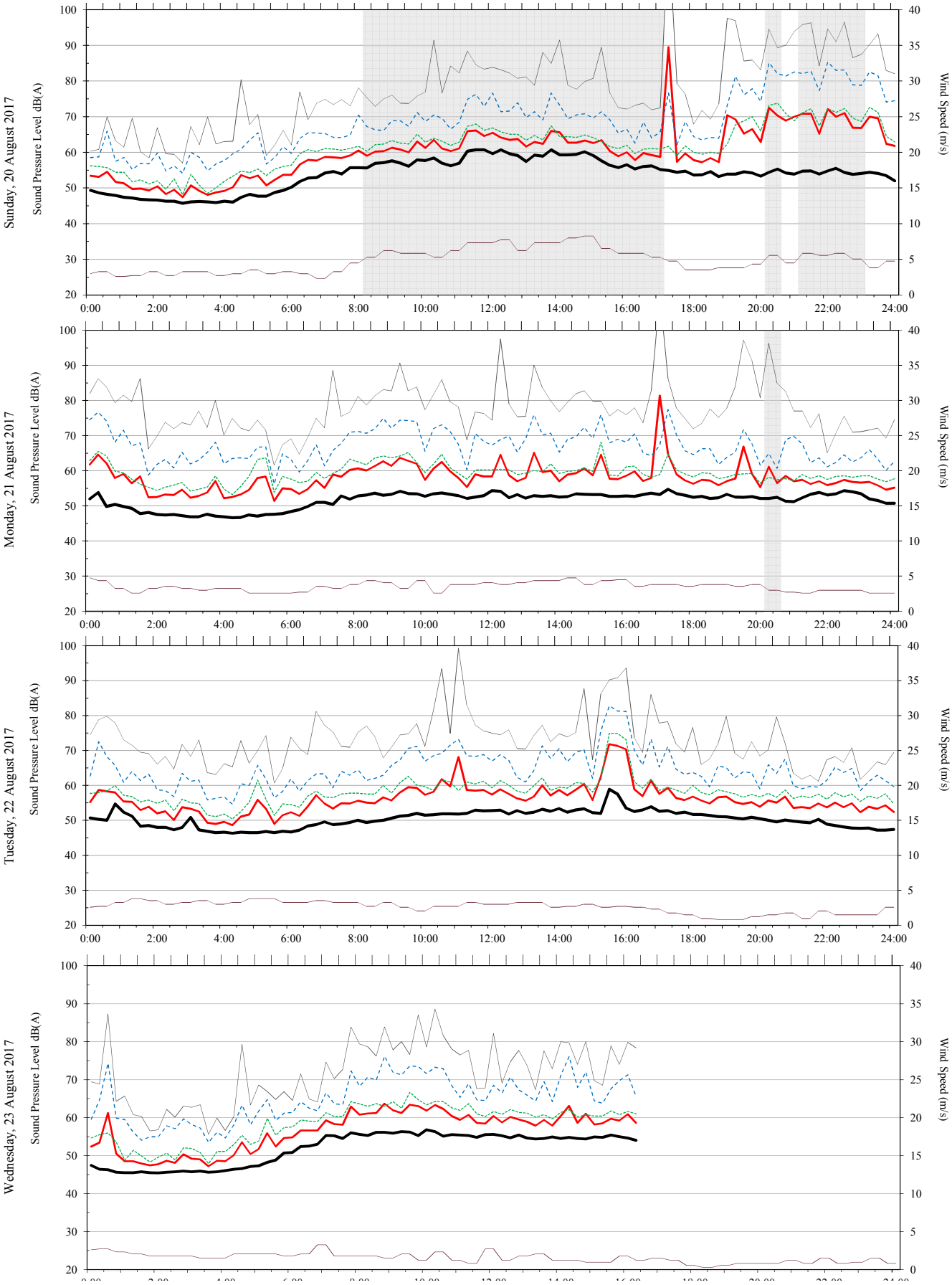

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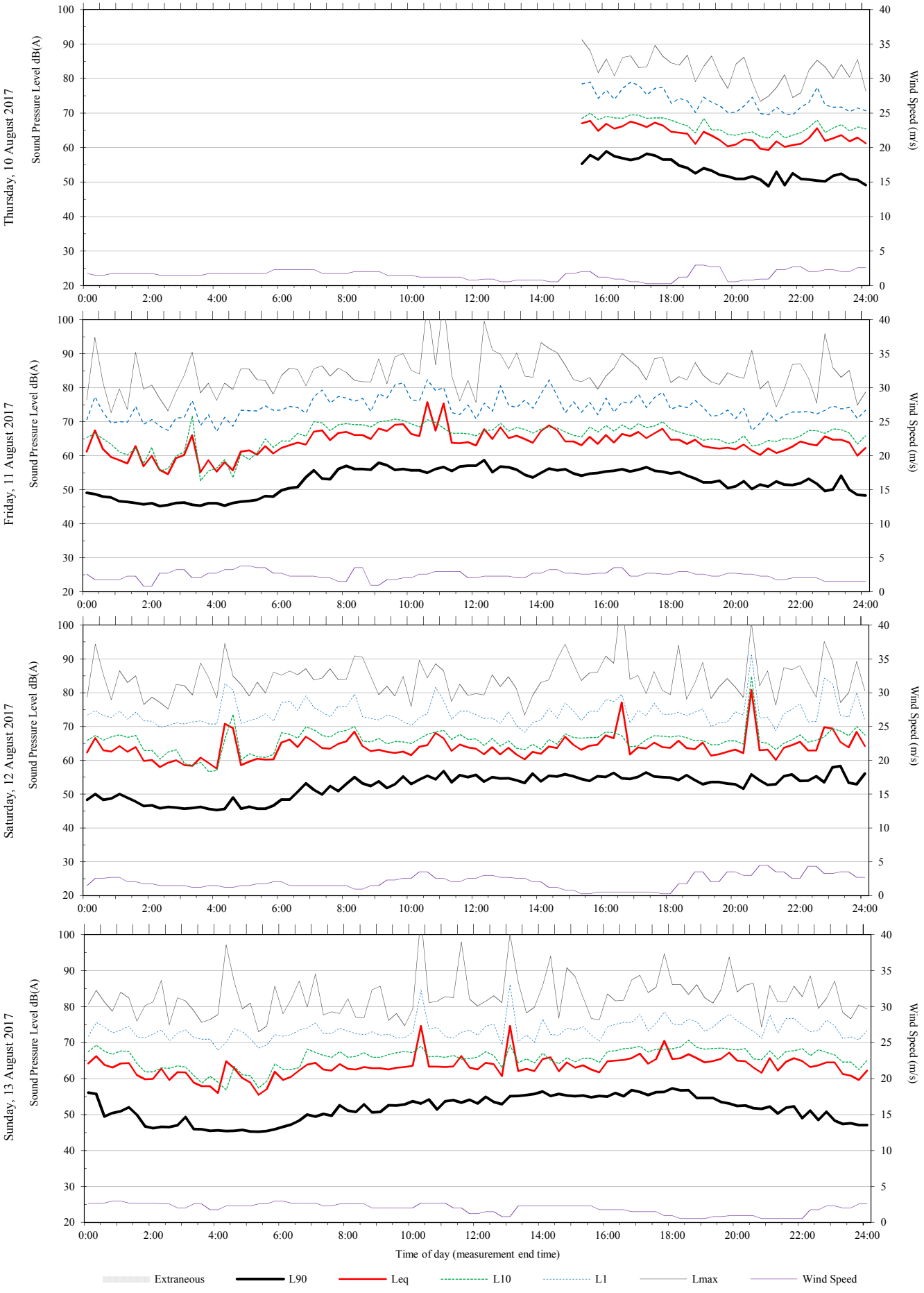

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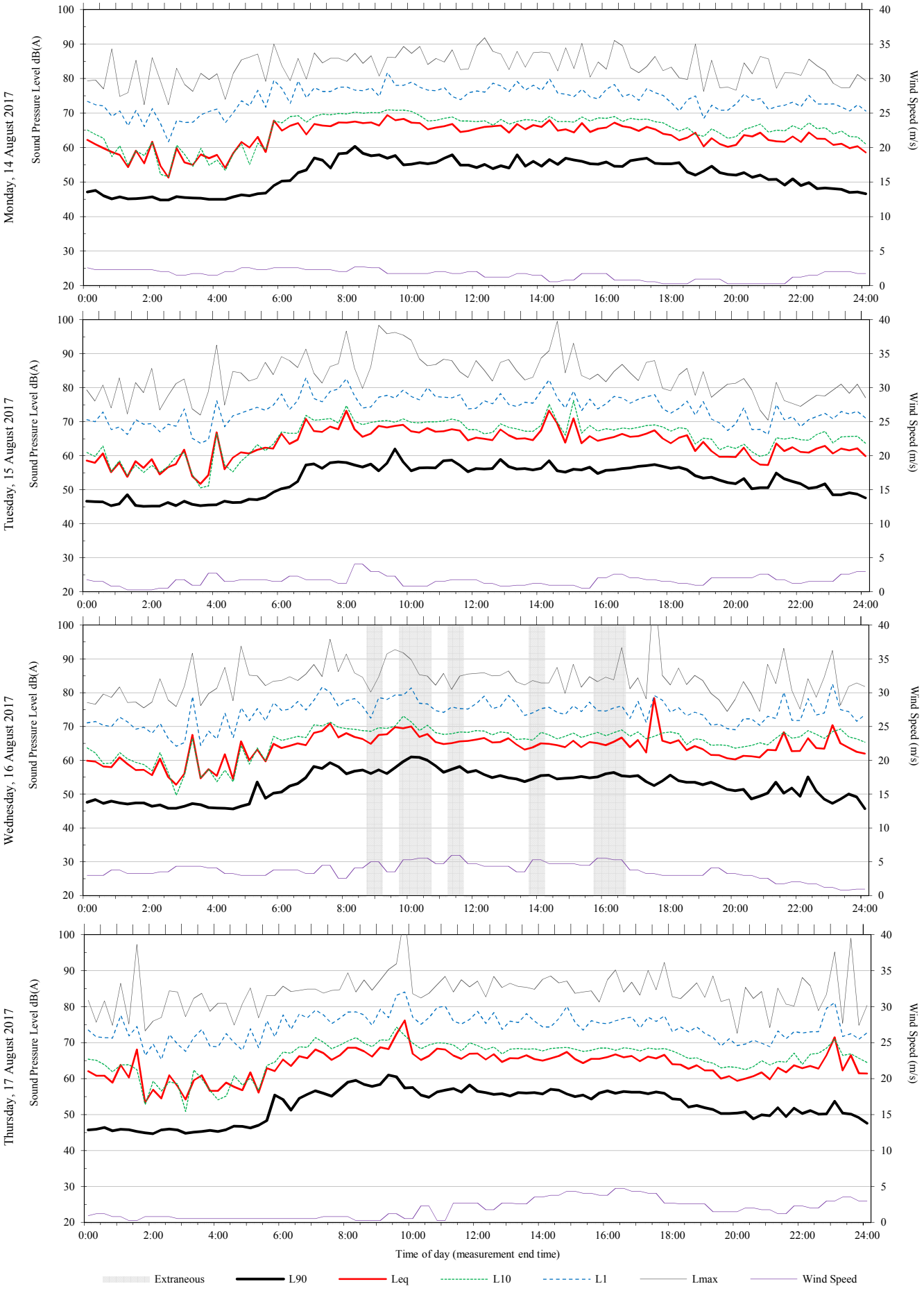

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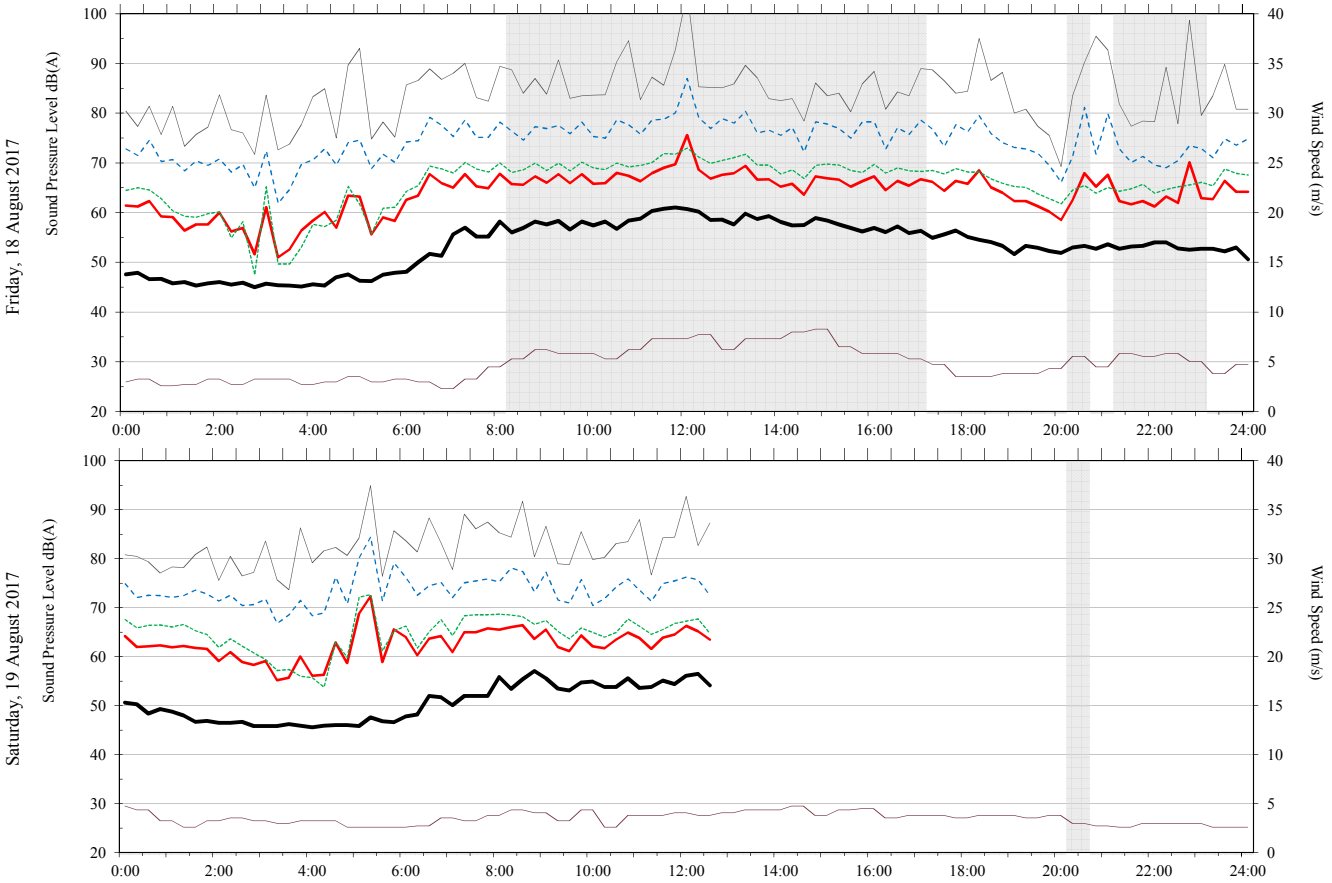

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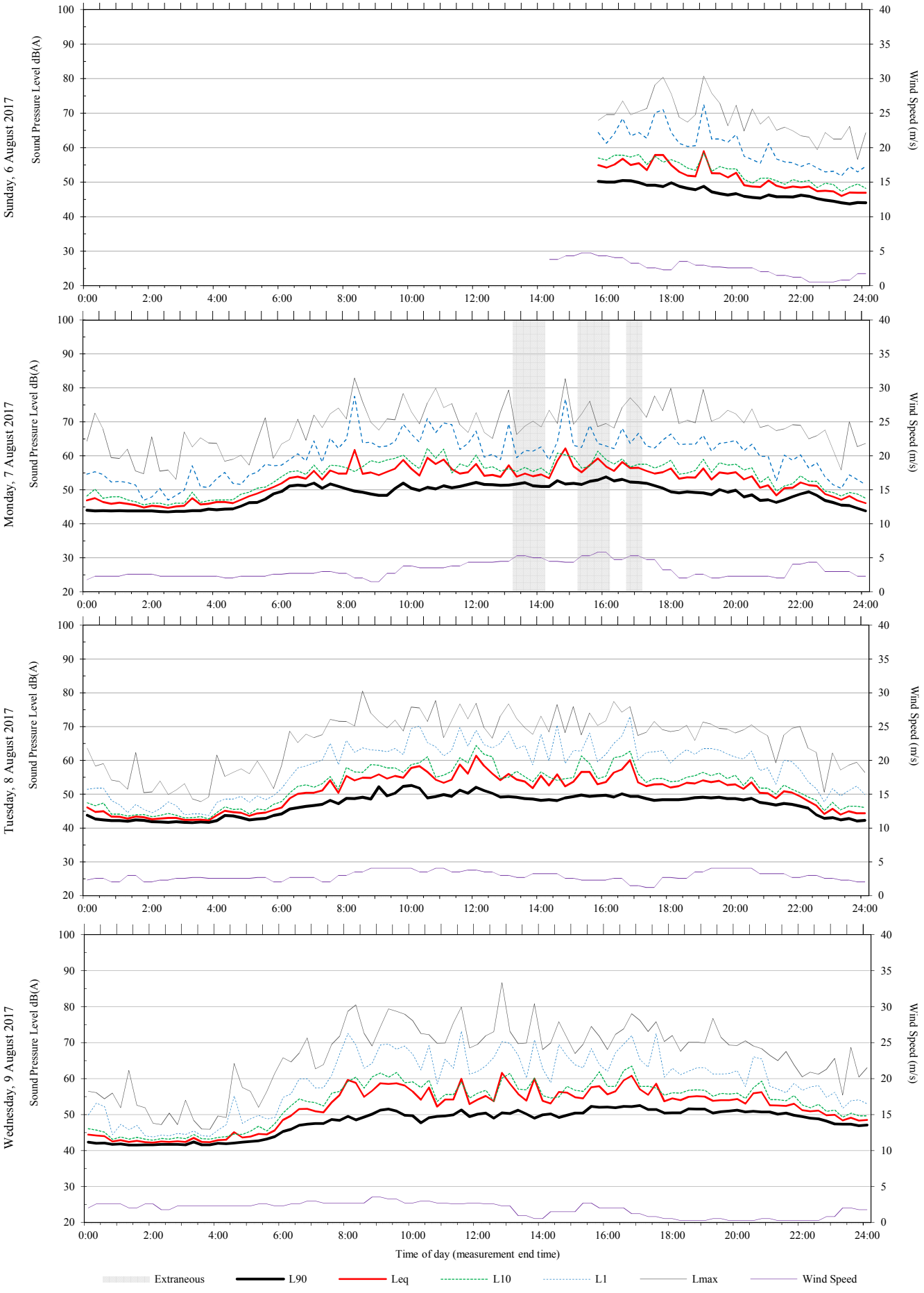

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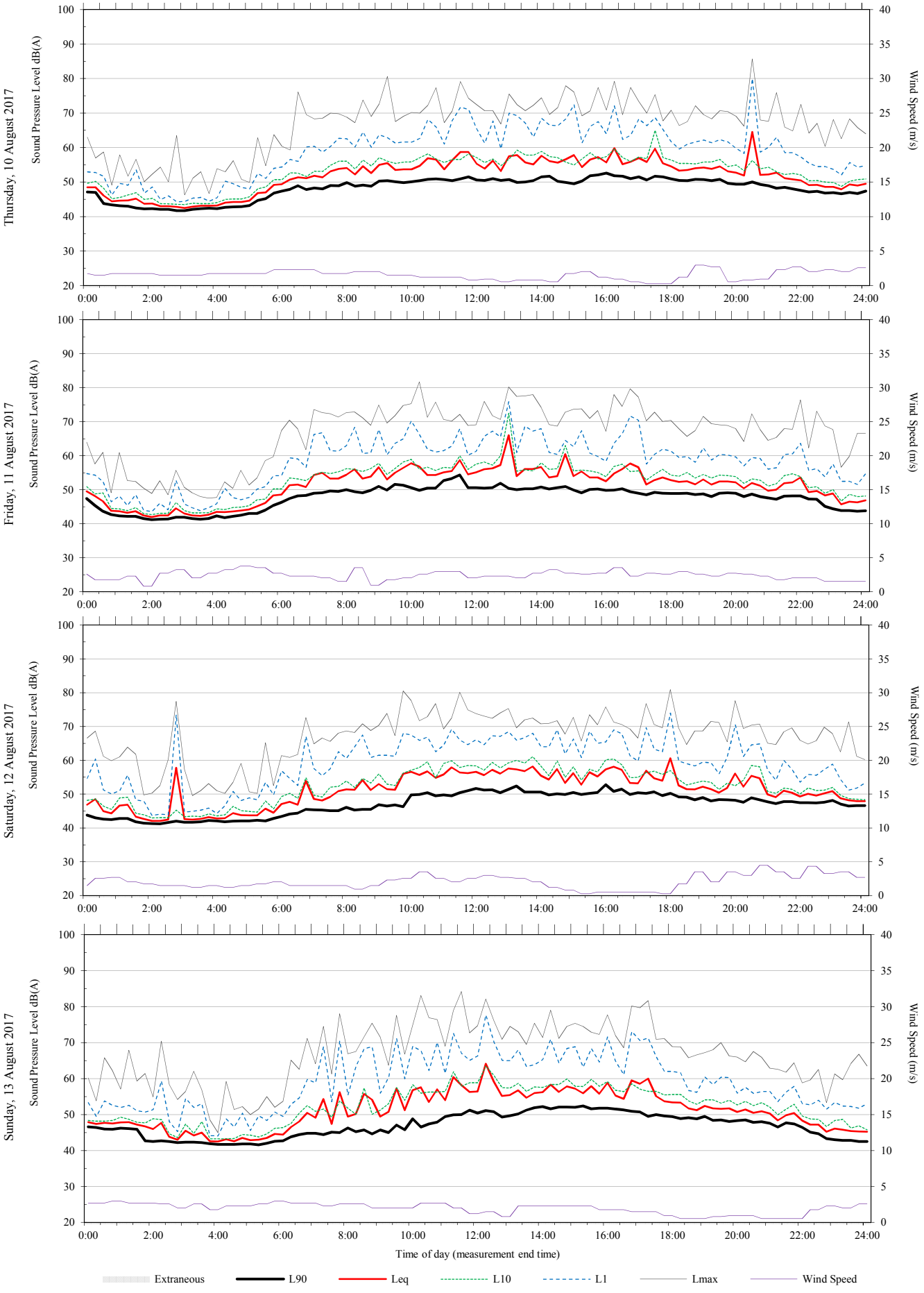

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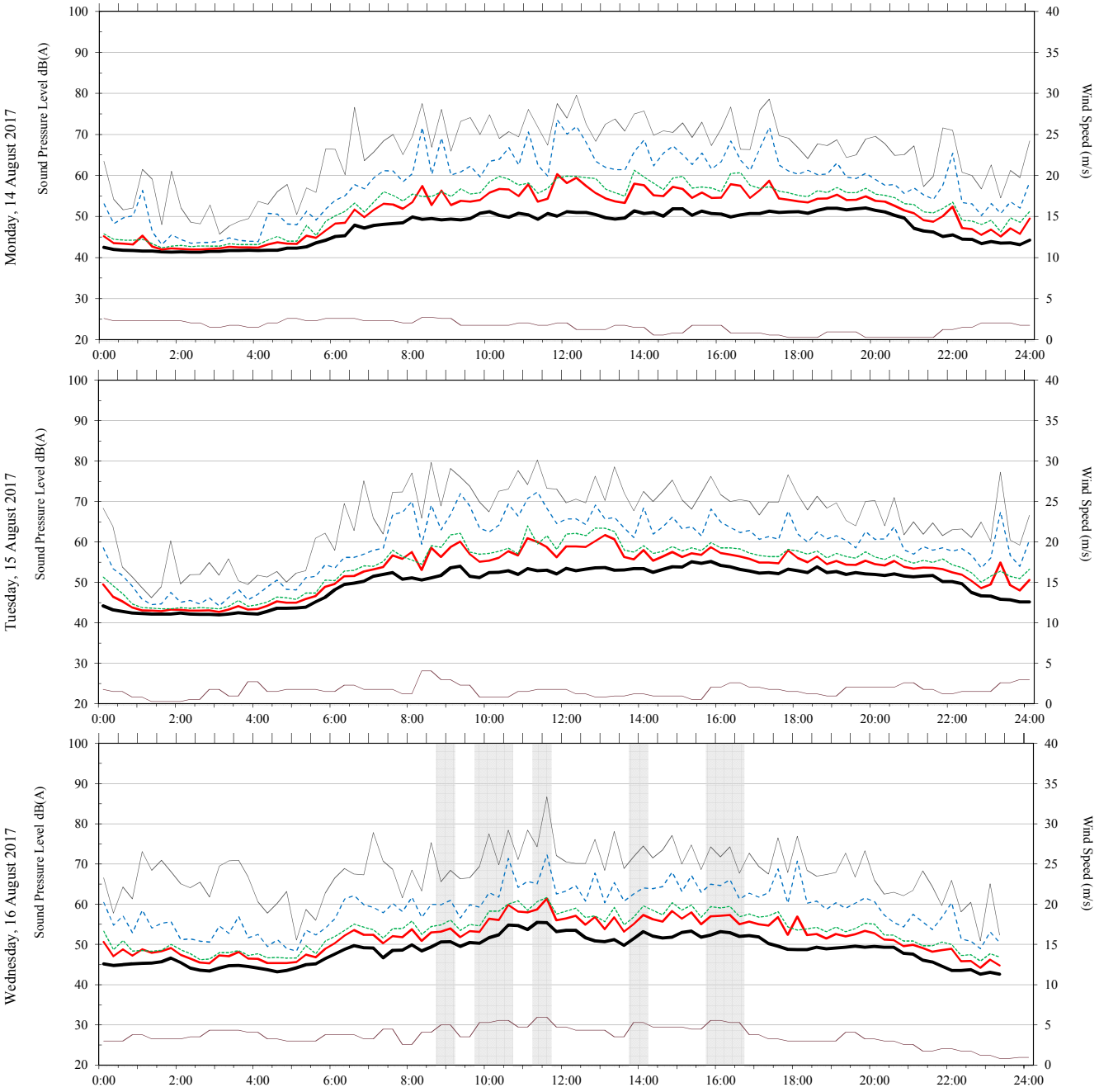

Unattended monitoring: Meas 7 (Free Field)

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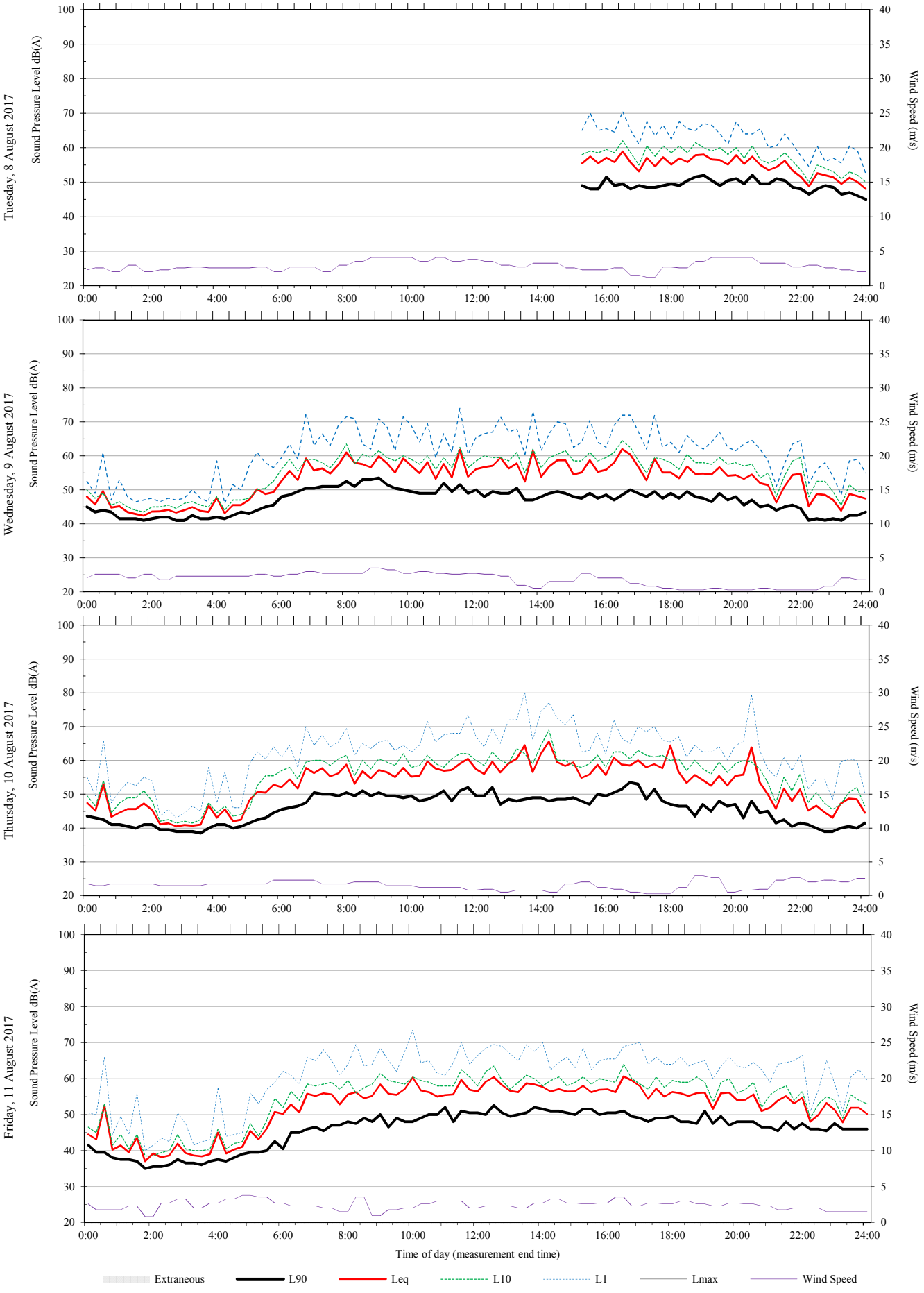

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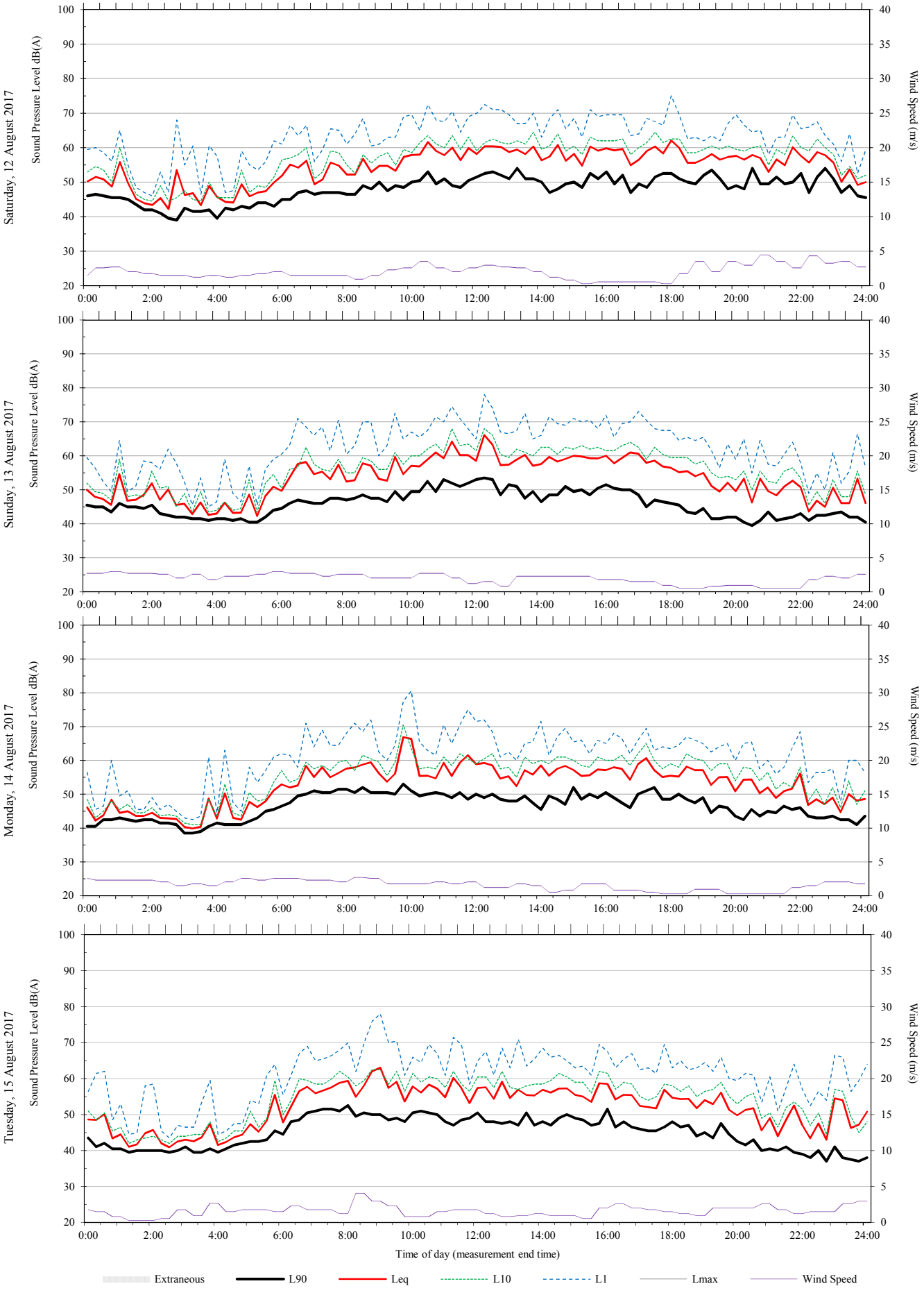

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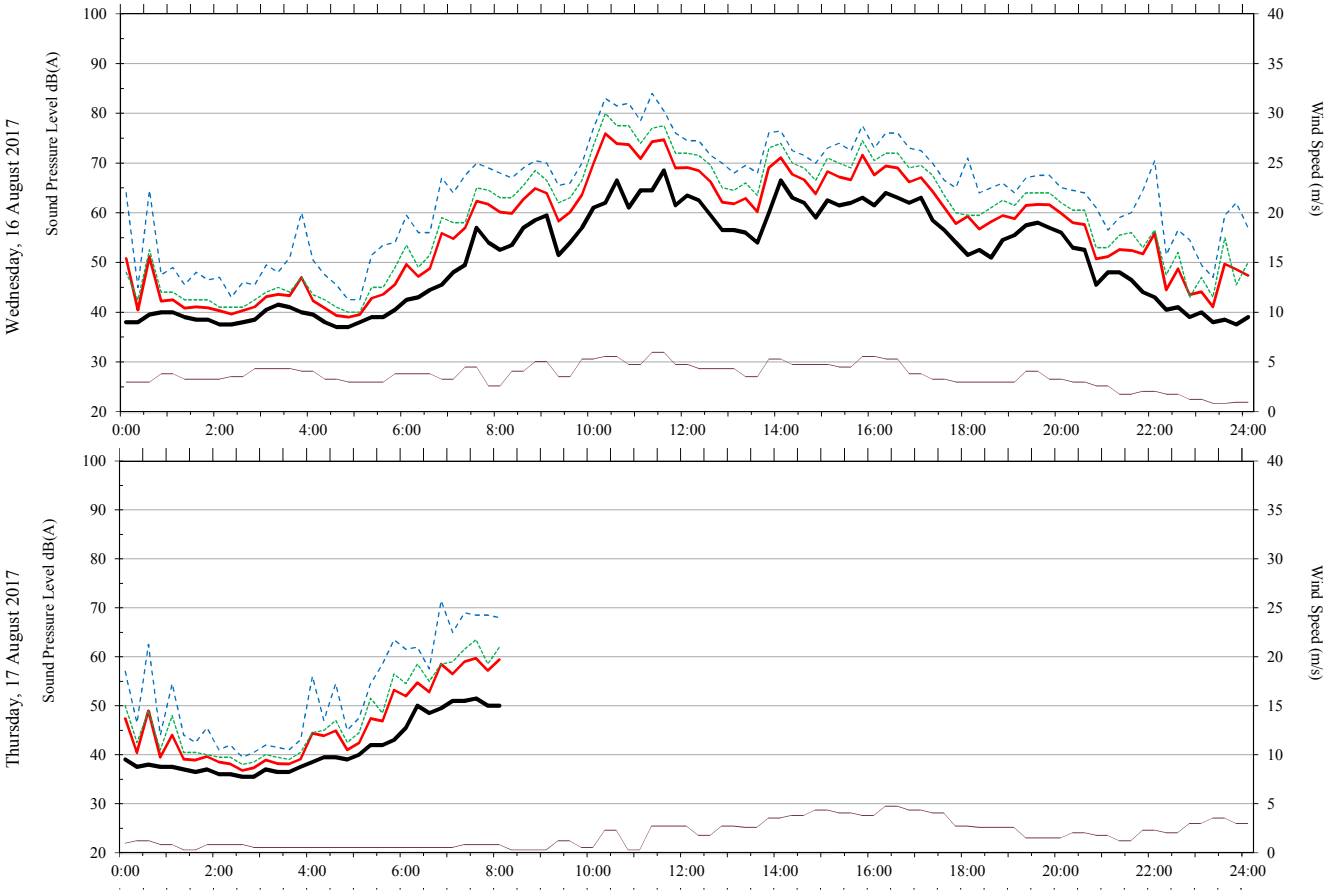


Appendix D

Mechanical Services Drawing List

D1 Mechanical Services Drawing List

No.	Drawing name	Revision
M-0001	Mechanical Services Legend A	A
M-1000	WBAP Air Schematic 42796	A
M-1001	WBAP Air Schematic 42859 South	A
M-1002	WBAP Air Schematic 42859 North	A
M-1003	WBAP Air Schematic Shore Sheds	A
M-1200	WBAP Pipework Schematic - Primary Side	A
M-1201	WBAP 42796 Pipework Schematic - Secondary Side	A
M-1202	WBAP 42859 + Shore Sheds Pipework Schematic - Secondary Side	A
M-2000	Mechanical Services AC and Ventilation - Pier 42796 North- Below Ground Layout	A
M-2001	Mechanical Services AC and Ventilation - Pier 42796 North - Ground Layout	A
M-2002	Mechanical Services AC and Ventilation - Pier 42796 South - Ground Layout	A
M-2003	Mechanical Services AC and Ventilation - Wharf 42859 North - Ground Layout	A
M-2004	Mechanical Services AC and Ventilation - Wharf 42859 South - Ground Layout	A
M-2005	Mechanical Services AC and Ventilation - Shore Sheds - Ground Layout	A
M-2006	Mechanical Services AC and Ventilation - Pier 42796 North - Mezzanine Layout	A
M-2007	Mechanical Services AC and Ventilation - Pier 42796 South - Mezzanine Layout	A
M-2008	Mechanical Services AC and Ventilation - Wharf 42859 North - Mezzanine Layout	A
M-2009	Mechanical Services AC and Ventilation - Wharf 42859 South - Mezzanine Layout	A
M-2010	Mechanical Services AC and Ventilation - Shore Sheds - Mezzanine Layout	A
M-2011	Mechanical Services AC and Ventilation - Pier 42796 North - Level 1 Layout	A
M-2012	Mechanical Services AC and Ventilation - Pier 42796 South - Level 1 Layout	A
M-2015	Mechanical Services AC and Ventilation - Pier 42796 North - Level 2 Layout	A
M-2016	Mechanical Services AC and Ventilation - Pier 42796 South - Level 2 Layout	A
M-2019	Mechanical Services AC and Ventilation - Pier 42796 North - Roof Layout	A

No.	Drawing name	Revision
M-2020	Mechanical Services AC and Ventilation - Pier 42796 South - Roof Layout	A
M-2021	Mechanical Services AC and Ventilation - Pier 42796 South - Roof Layout	A
M-2100	Mechanical Services Piped Systems - Pier 42796 South - Below Ground Layout	A
M-2101	Mechanical Services Piped Systems - Pier 42796 North - Ground Layout	A
M-2102	Mechanical Services Piped Systems - Pier 42796 South - Ground Layout	A
M-2103	Mechanical Services Piped Systems - Wharf 42859 North - Ground Layout	A
M-2104	Mechanical Services Piped Systems - Wharf 42859 South - Ground Layout	A
M-2105	Mechanical Services Piped Systems - Shore Sheds - Ground Layout	A
M-2106	Mechanical Services Piped Systems - Pier 42796 North - Mezzanine Layout	A
M-2107	Mechanical Services Piped Systems - Pier 42796 South - Mezzanine Layout	A
M-2108	Mechanical Services Piped Systems - Wharf 42859 North - Mezzanine Layout	A
M-2109	Mechanical Services Piped Systems - Wharf 42859 South - Mezzanine Layout	A
M-2110	Mechanical Services Piped Systems - Shore Sheds - Mezzanine Layout	A
M-2111	Mechanical Services Piped Systems - Pier 42796 North - Level 1 Layout	A
M-2112	Mechanical Services Piped Systems - Pier 42796 South - Level 1 Layout	A
M-2115	Mechanical Services Piped Systems - Pier 42796 North - Level 2 Layout	A
M-2116	Mechanical Services Piped Systems - Pier 42796 South - Level 2 Layout	A
M-2118	Mechanical Services Piped Systems - Pier 42796 South - Roof Layout	A
M-2119	Mechanical Services Piped Systems - Pier 42796 North - Roof Layout	A

Appendix E

Venue Patron Numbers

E1 Venue Patron Numbers

The modelled outdoor patron numbers are presented in Table 38, Table 39 and Table 40 are based on patron numbers provided by the client.

The proportion of outdoor to indoor occupants was assumed to be equal to the proportion of outdoor floor area to indoor floor area.

Table 38: Outdoor patron numbers - Normal scenario

Venue	Day 7am - 6pm	Evening 6pm - 10pm	Night 10pm - 12am
Bangarra Outdoors	20	16	4
SDC Outdoors	6	21	0
ATYP Outdoor	5	7	1
Pier 2/3 Function Outdoor	35	35	17
Com 2 Outdoor	13	3	0
Com 3 Outdoor	22	22	1
Com 4 Outdoor	19	19	1

Table 39: Outdoor patron numbers - Peak scenario & Logistics Activities / Patrons Leaving scenario

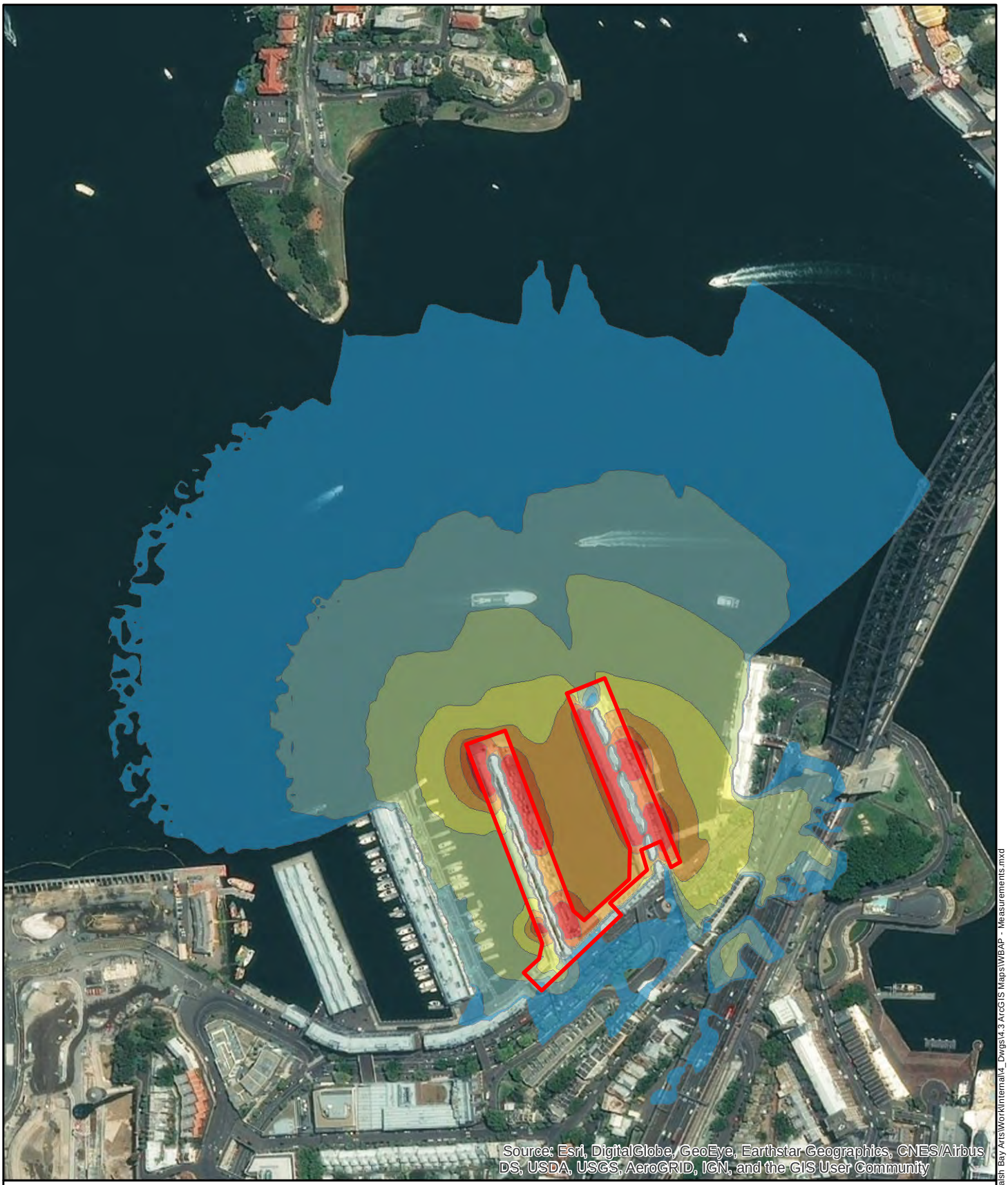
Venue	Day 7am - 6pm	Evening 6pm - 10pm	Night 10pm - 12am
Bangarra Outdoors	40	33	8
SDC Outdoors	12	41	0
ATYP Outdoor	9	14	1
Pier 2/3 Function Outdoor	70	70	35
Com 2 Outdoor	27	6	0
Com 3 Outdoor	44	44	1
Com 4 Outdoor	38	38	1

Table 40: Outdoor patron numbers - Event scenario

Venue	Day 10am - 10pm	Night 10pm - 12am
Precinct apron – north of Pier 2/3, Pier 4/5 and shoresheds, west of Pier 2/3, east of Pier 4/5	1700	425

Appendix F

Noise Contour Maps



Legend

WBACP

Sound pressure level, L_{Aeq}, dB(A)

50 55 60 65 70 75 80

Client
Infrastructure New South Wales

Job Title
Walsh Bay Arts and Cultural Precinct

Map Title
Noise Contours - Demolition works 3m/s source to receiver winds

Meters
0 100 200

Issue	Date	By	Chkd	Appd
D1	8/09/2017	MS	NB	NB

ARUP
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Tel +61 3 9668 5500 Fax +61 3 9663 1546
www.arup.com

Scale at A4	Map Status
1:5,000	Draft for review

Coordinate System
GDA 1994 MGA Zone 56

Job No	Map No
248995	1

\\global.arup.com\australasia\SYD\Projects\248000\248995-00 Walsh Bay Arts\Work\Internal\4_Dwgs\4.3 ArcGIS Maps\WBAP - Measurements.mxd

Legend

WBACP

Sound pressure level, L_{Aeq}, dB(A)

40 45 50 55 60 65 70

Client
Infrastructure New South Wales

Job Title
Walsh Bay Arts and Cultural Precinct

Map Title
Noise Contours - Everyday Operation 3m/s source to receiver winds

Meters
0 100 200

Issue	Date	By	Chkd	Appd
D1	8/09/2017	MS	NB	NB

ARUP
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Tel +61 3 9668 5500 Fax +61 3 9663 1546
www.arup.com

Scale at A4	Map Status
1:5,000	Draft for review

Coordinate System
GDA 1994 MGA Zone 56

Job No	Map No
248995	2

\\global.arup.com\australasia\SYD Projects\248000\248995-00 Walsh Bay Arts\Work\Internal\4_Dwgs\4.3 ArcGIS Maps\WBAP - Measurements.mxd

Legend

WBACP

Sound pressure level, L_{Aeq}, dB(A)

40 45 50 55 60 65 70

Client
Infrastructure New South Wales

Job Title
Walsh Bay Arts and Cultural Precinct

Map Title
Noise Contours - Peak Operation 3m/s source to receiver winds

Meters
0 100 200

Issue	Date	By	Chkd	Appd
D1	8/09/2017	MS	NB	NB

ARUP
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Tel +61 3 9668 5500 Fax +61 3 9663 1546
www.arup.com

Scale at A4	Map Status
1:5,000	Draft for review

Coordinate System
GDA 1994 MGA Zone 56

Job No	Map No
248995	3

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Legend

WBACP

Sound pressure level, L_{Aeq}, dB(A)

40 45 50 55 60 65 70

Client
Infrastructure New South Wales

Job Title
Walsh Bay Arts and Cultural Precinct

Map Title
Noise Contours - Logist. / patrons leav. 3m/s source to receiver winds

Meters
0 100 200

Issue	Date	By	Chkd	Appd
D1	14/09/2017	MS	NB	NB

ARUP
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Tel +61 3 9668 5500 Fax +61 3 9663 1546
www.arup.com

Scale at A4	Map Status
1:5,000	Draft for review

Coordinate System
GDA 1994 MGA Zone 56

Job No	Map No
248995	4

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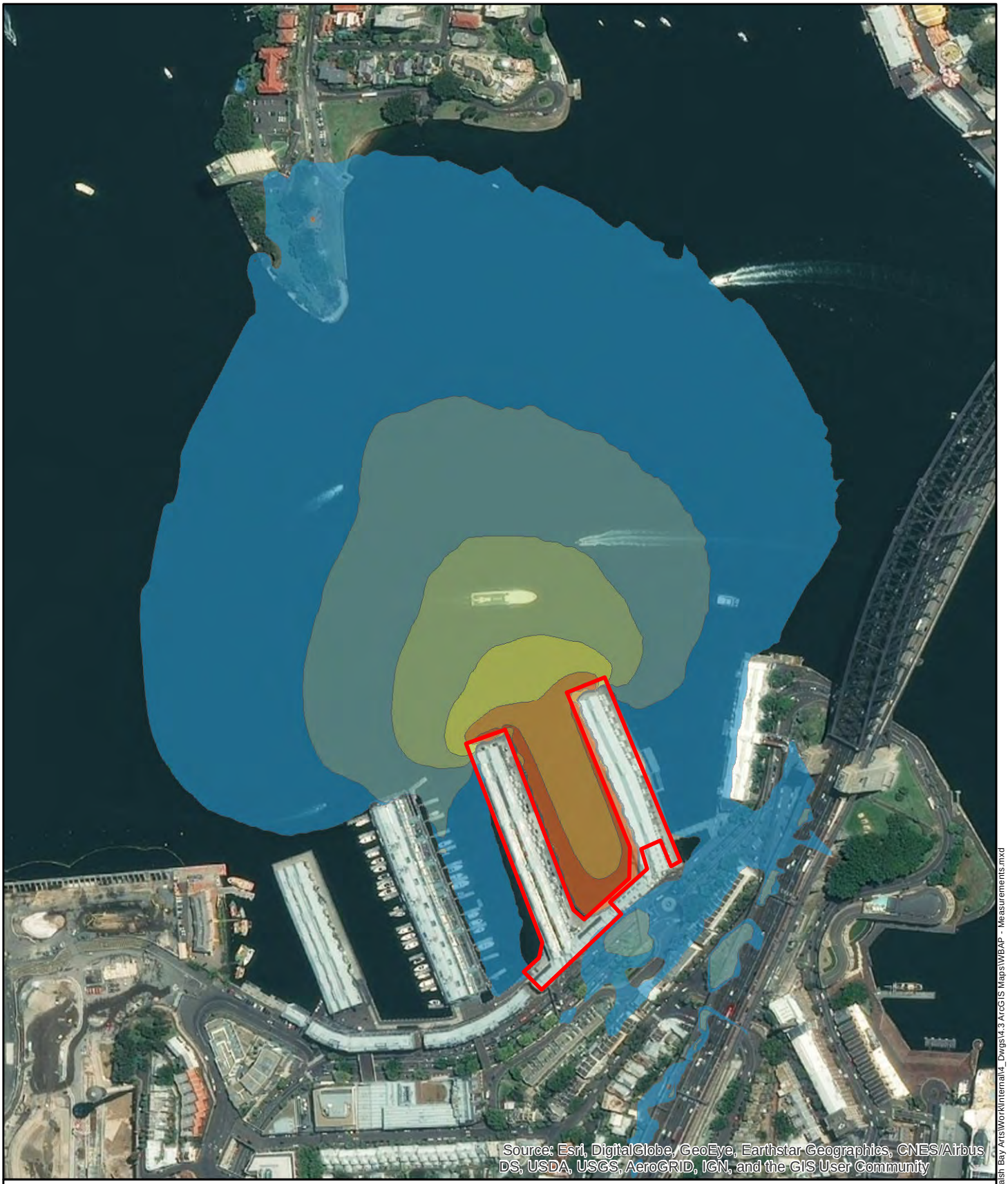

Legend

WBACP

Sound pressure level, L_{Aeq}, dB(A)

40 45 50 55 60 65 70

Client
Infrastructure New South Wales

Job Title
Walsh Bay Arts and Cultural Precinct

Map Title
Noise Contours - Events
3m/s source to receiver winds

Meters
0 100 200

Issue	Date	By	Chkd	Appd
D1	28/09/2017	MS	NB	NB

ARUP
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Tel +61 3 9668 5500 Fax +61 3 9663 1546
www.arup.com

Scale at A4	Map Status
1:5,000	Draft for review

Coordinate System
GDA 1994 MGA Zone 56

Job No	Map No
248995	4

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