University of Sydney

Chau Chak Wing Museum

Acoustic SEARs Report

AAC/SEARs/01

Issue 2 | 31 March 2017

Job number 248177

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia
www.arup.com

ARUP

Document Verification

ARUP

Job title		Chau Chak Wing Museum			**Job number** 248177
Document title		Acoustic SEARs Report			**File reference**
Document ref		AAC/SEARs/01			
Revision	**Date**	**Filename**	Acoustic SEARs Report v0 2017-02-22.docx		
Draft 1	22 Feb 2017	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Harvey Yang	Glenn Wheatley	Glenn Wheatley
		Signature			
Draft 2	27 Mar 2017	**Filename**	AC02 (v2) Acoustic SEARs Report 2017-03-27.docx		
		Description	Updated draft		
			Prepared by	Checked by	Approved by
		Name	Harvey Yang	Glenn Wheatley	Glenn Wheatley
		Signature			
Issue 2	31 Mar 2017	**Filename**	AC02 (v2,1) Acoustic SEARs Report 2017-03-30.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Harvey Yang	Glenn Wheatley	Glenn Wheatley
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document Verification with Document	✓

Summary

Objectives

This report has been produced in response to the Secretary's Environmental Assessment Requirements (SEARs) Application Number SSD 7894 on behalf of The University of Sydney in support of the State Significant Development (SSD) Application.

This report assesses noise and vibration emissions for the construction and operational phases of the Project, specifically addressing SEARs 4 and 7.

Methods and results

The proposed construction and operations have been reviewed and assessed to identify where mitigation and management measures may be required to address impacts to development surrounding the site.

The assessment has utilised a combination of unattended and short-term attended monitoring to quantify the existing acoustic environment on site and at the nearest potentially affected receiver locations. The results have been used to establish project specific criteria in accordance with EPA noise policy.

Predictions have been carried out for the construction and operational phases, to assess potential impacts from the Project at surrounding development.

Construction activities are predicted to only marginally exceed the *Noise Affected* management level, but below the *Highly Affected* level. Given the distance to the site to surrounding buildings, vibration is not expected to be significant for the works. Notwithstanding, noise and vibration management measures are outlined.

Operational aspects, such as general daily use of the café space, and intermittent evening/night time functions are both predicted to be able to comply with the established project criteria. Functions will require some management with regard to music noise levels and the use of outdoor areas by patrons. It is expected that external areas of the site may be used for functions up to midnight, while internal areas could reasonably be used after midnight with the building façade closed, and no external areas being used.

Operational noise from building services equipment will be able to satisfy the project noise goals, however requires further acoustic design during the detailed design phase.

Conclusions

The acoustic assessment has been carried out in accordance with the requirements of SEARs 4 and 7, and finds that the development is able to satisfy the NSW EPA requirements for both the construction and operation stages.

Contents

Appendices

1 Objectives of assessment

Arup has been engaged by the University of Sydney to carry out a noise and vibration assessment for the purpose of addressing the Secretary's Environmental Assessment Requirements (SEARs) Application Number SSD 7894.

This report specifically addresses the following SEARs as they relate to construction and operational noise and vibration:

(4) Environmental Amenity

Detail amenity impacts including solar access, acoustic impacts, visual privacy, view loss, overshadowing, lighting impacts and wind impacts. A high level of environmental amenity for the surrounding locality must be demonstrated.

(7) Noise and Vibration

Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding sensitive receivers.

Relevant Policies and Guidelines:

- *NSW Industrial Noise Policy (EPA)*
- *Interim Construction Noise Guideline (DECC)*
- *Assessing Vibration: A Technical Guideline 2006*

In addition to the above, road traffic noise ingress has considered SEPP (Infrastructure) 2007.

2 Site and project descriptions

2.1 The site and surrounds

The development site is located to the northeast of the University's grounds adjacent to the Parramatta Rd entrance, within the area currently used as the Fisher Tennis Courts site.

Parramatta Rd runs in an approximate east to west alignment and borders the site to the north. University Place that runs in a north south direction is located to the west, beyond which is the University's main Quadrangle Building. University Avenue borders the site to the south, with Victoria Park located beyond the University grounds to the east.

The main portion of the site consists of three tennis courts, to the north of which is a small weatherboard tennis pavilion building. An area of lawn is located to the east of the site.

The northern boundary between the University campus and Parramatta Rd features a retaining wall above which is a linear garden bed containing significant trees. Ground conditions of the area consist of a sloped garden bed.

The development site is bound on all sides by trees of varying significance.

Figure 1: Aerial View of Site

2.2 The project

The proposal comprises the construction of the new Chau Chak Wing Museum in the north eastern sector of the Camperdown campus. The proposed museum will comprise a new five level building (maximum of three storeys above ground) with central void and will include:

- Entry foyer and museum shop
- Gallery space
- CERC (Collections Education Research & Conservation Facility) space
- Collection storage and workshop areas
- Staff offices, facilities and boardroom
- Study rooms and schools education area
- A 130 seat Auditorium
- Café and terrace facilities
- Loading dock
- Plant rooms

The proposed works also include associated earthworks, tree removal, landscape works and augmentation to existing infrastructure and services.

3 Site analysis

3.1 Assessment locations

The nearest potentially affected receiver locations to the subject site are residential receivers on the opposite side of Parramatta Road, as identified in Table 4. Locations within the University have not been deemed sensitive receptors based on the proposed use of the building and its proximity to other buildings on site. Furthermore, these locations are not deemed relevant to the SEARs assessment requirements.

Table 1: Assessment location(s)

ID	Location	Description
A1	13 Arundel Street	Residential location, being in closest to the proposed terrace at the eastern end of the building. Predicted noise levels will be representative for neighbouring residential premises.

3.2 Existing noise environment

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.

Appendix B of the NSW EPA Industrial Noise Policy (INP) outlines two methods for determining the background noise level of an area, being 'B1 – Long-term background noise method' and 'B2 – Short-term background noise method'. This assessment has used long-term monitoring.

Short-term attended noise measurements have also been carried out on site for the assessment of noise ingress to the proposed building.

3.2.1 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 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 long-term and short-term measurement locations are described in Table 2 shown in Figure 2.

Table 2: Noise measurement locations

ID	Location	Description
L1	13 Arundel Street	Residential location. Logger located at the front boundary of the property, 1.2 m above the ground in the free field.
S1	Development site - south	Free-field measurements carried out 1.2 m above the local ground level at various locations around the perimeter of the development site. Utilised for noise ingress assessment, not for background noise assessment of residential receivers.
S2	Development site - southwest	
S3	Development site – northwest	
S4	Development site - north	
S5	Development site – northeast	
S6	Development site – southeast	

Figure 2: Project site location and measurements locations

3.2.2 Long-term noise measurement results

Long-term noise monitoring was carried out from Wednesday, 22 February 2017 to 09 March 2017. The long-term noise monitoring methodology and graphed results are detailed in Appendix B.

Table 3 presents the overall single Rating Background Levels (RBL) and representative ambient Leq noise levels for each assessment period, determined in accordance with the INP.

Table 3: Long-term noise monitoring results, dB(A)

Location	Time period	Rating background noise levels, dBL_{A90}	Ambient dBL_{Aeq} noise levels
13 Arundel St.	Day	55	63
	Evening	54	62
	Shoulder (22:00-00:00)	50	59
	Night	45	59

Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays

Evening: 18:00-22:00 Monday to Sunday & Public Holidays

Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

The shoulder period has been established for 22:00-00:00. The shoulder period rating background level is taken to be the mid-point between the rating background levels between the two assessment periods that are on either side of the shoulder period.

As required by the INP, the external ambient noise levels presented are free-field noise levels. [i.e.. no façade reflection]

3.2.3 Attended noise measurement

Attended noise measurements have been conducted at the subject site during the traffic peak time (1600-1800) of Parramatta Road on 5 October 2016. Broadband and octave band L_{Aeq}, L_{A10} and L_{A90} measurements were made. The locations of the attended noise measurements are shown in Figure 2.

The measured noise levels are summarised in Table 4 below.

Table 4: Attended measurement summary

Location^	dB L_{Aeq}, 15mins	dB L_{A90}, 15mins	Notes
S1	54	50	Traffic noise from Parramatta Road is dominate source. Light traffic form the University Ave. Some crowd noise from university.
S2	54	50	Traffic noise from Parramatta Road is dominate source. Some crowd noise from university.
S3	59	54	Traffic noise from Parramatta Road is dominate source. Parramatta Road is sunken from the level of measurement location.
S4	69	61	Measured at the boundary of the Parramatta Road.
S5	62	57	Traffic noise from Parramatta Road is dominate source. Angle of view to the Parramatta Road is wider at the location. Parramatta Road is sunken from the level of measurement location.
S6	58	54	Traffic noise from Parramatta Road is dominate source.

Notes:

^ Refer to Figure 2 for location)

Measurements were undertaken using B&K 2270 Type 1 sound level meter. Equipment calibration was checked with a B&K Type 4231 calibrator before and after measurements and did not exhibit any significant drift.

4 Construction noise and vibration

4.1 Regulatory context

4.1.1 Construction noise

The NSW *Interim Construction Noise Guideline* 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 provides two methods for assessing construction noise, varying typically on the basis of the project duration, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement of background noise levels for determination of management levels and prediction of construction noise levels. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification. The project is expected to warrant a quantitative assessment.

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 5 and other sensitive receivers in Table 6 below.

Table 5: 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 + 10 dB	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 75 dB(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 + 5 dB	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 5 dB(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.

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 6: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$ [1]
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

1 - Noise management levels apply when receiver areas are in use only.

For work within standard construction hours, if after implementing all 'feasible and reasonable' noise levels the site still exceeds the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community. While there is no 'highly-noise affected level' outlined in the ICNG for out-of-hours work, this report adopts the terminology where the construction noise level is 5 dB above the noise affected level.

4.1.1.1 Project construction noise targets

Measured noise data obtained at the logger location has been used to derive appropriate noise management levels for the nearest receivers to Project, being residential premises on the opposite side of Parramatta Road on Arundel Street. These are summarised in Table 7.

Table 7: Construction noise management levels for standard hours

Assessment location	**RBL**	**Noise Management level $dBL_{Aeq(15\ min)}$[1]**	
		Noise Affected	**Highly Noise Affected**
A1 – Arundel Street	55	65	75

4.1.2 Vibration criteria

Potential vibration disturbance to human occupants of buildings is made in accordance with the NSW DEC '*Assessing Vibration; a technical guideline*' (DEC, 2006). The criteria outlined in the guideline is based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent', as described in Table 8, with light rail projects typically being defined as intermittent.

Table 8: Types of vibration – Definition

Type of vibration	**Definition**	**Examples**
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.

Type of vibration	Definition	Examples
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Table 9 reproduces the 'Preferred' and 'Maximum' values for continuous and impulsive vibration from Table 2.2 of the Guideline.

Table 9: Preferred and maximum vibration acceleration levels for human comfort, m/s^2

Location	Assessment period1	Preferred values		Maximum values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

1 - Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2 - Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Alternative criteria is outside the scope of the policy and other guidance documents should be referred to.

Table 10 reproduces the 'Preferred' and 'Maximum' values for intermittent vibration from Table 2.4 of the Guideline.

Table 10: Acceptable vibration dose values (VDV) for intermittent vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	**Maximum value**	**Preferred value**	**Maximum value**
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1- Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

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

4.2 Proposed works

4.2.1 Proposed construction plan

This section summarises the proposed construction plan. Please also refer to *Chau Chak Wing Museum Preliminary Construction & Traffic* report for details.

4.2.1.1 Programme

The following key milestones are identified for the construction of the Chau Chak Wing Museum:

- Commencement of Construction Works -1 May 2017;
- Base Building Completion - 31 July 2018; and
- Fitout of Exhibition Space Completed, and Museum Opening - 6 December 2018.

The concrete structure and the building envelope trades will represent the peak construction vehicle movements with an average of 20 to 30 per day. During each of the 12 major concrete pours there will be up to 45 deliveries.

The construction phase will involve bulk excavation of the two lower levels, the building foundations, four levels of concrete structure from the basement level, steel portal frame roof, glass façade, building fit-out complete with services and external works to the public realm around the ground floor areas.

4.2.1.2 Hours of construction

Development approval is still to be sought, however it is anticipated that working hours will be:

- Monday to Friday: 7:00am to 6:00pm;
- Saturday: 7:30am to 5:00pm; and

- No work on Sundays or NSW Public Holidays.

4.2.2 Construction staging and equipment

The proposed construction staging and equipment are presented in Table 11 and shown in Figure 3.

Note the construction staging shown in Table 11 is selected for the purpose of acoustic assessment. Please refer to *Chau Chak Wing Museum Preliminary Construction & Traffic* report for full detailed staging schedule.

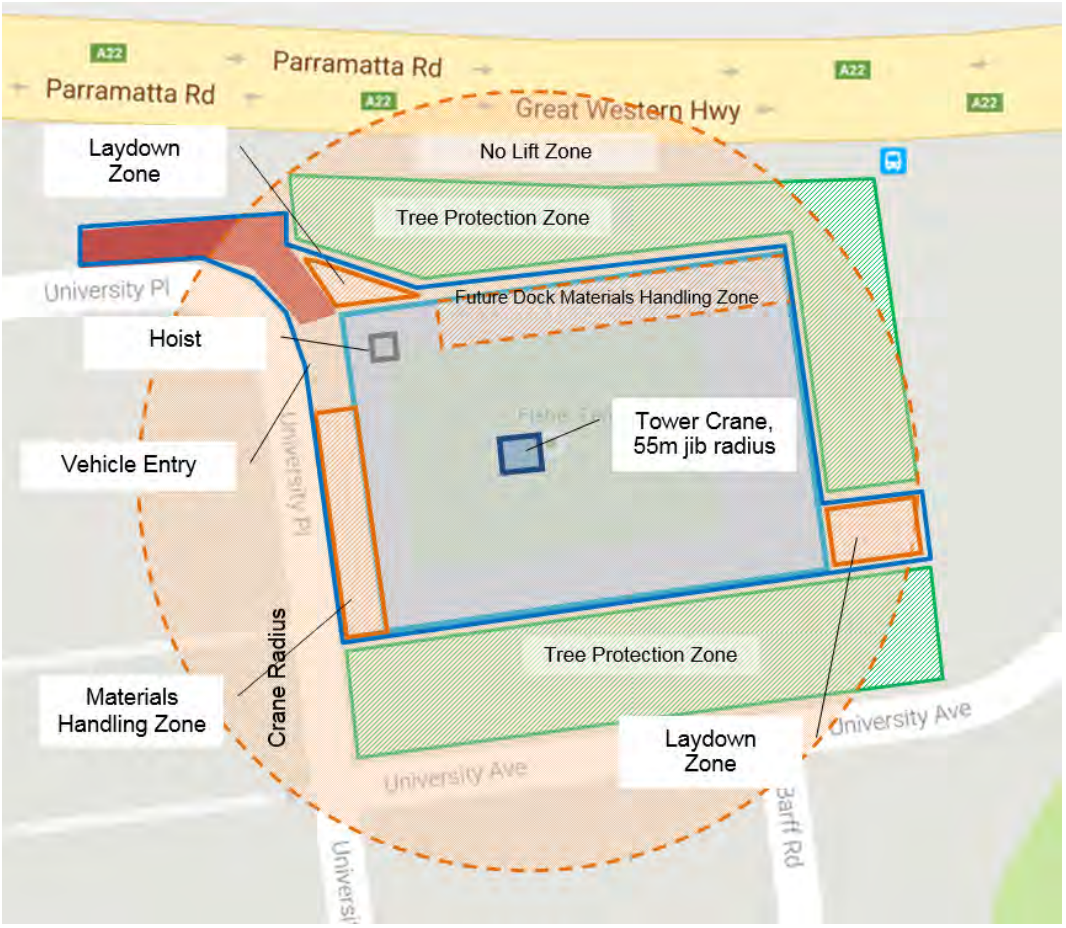


Figure 3: Proposed equipment plan

Table 11: Proposed construction stages and equipment

Construction stage	Proposed equipment	Indicative No.	Sound Power Level, dB $L_{Aeq,15minute}$
Earthworks/Inground Works	Bored Piling rig	1	110
	Excavators	2	103
	Trucks	2	111
	TOTAL	5	114
Structure/Façade	Tower crane	1	110

Construction stage	Proposed equipment	Indicative No.	Sound Power Level, dB $L_{Aeq,15minute}$
	Trucks	2	111
	Concrete static pump	1	109
	TOTAL	4	115

4.3 Assessment

Noise predictions for the primary construction phases is summarised in Table 12.

Table 12: Construction noise assessment

Assessment location	Construction stage	Predicted noise level, dB $L_{Aeq,15min}$	Noise management levels, dB $L_{Aeq,15min}$	
			Noise affected	Highly noise affected
A1	Earthworks/ Inground Works	68	65	75
	Structure/Façade	69	65	75

The construction noise levels are predicted to exceed the *Noise affected* criteria by only 3 – 4 dB(A) and comply with the *Highly noise affected* criteria. Notwithstanding, consideration should be given to all feasible and reasonable noise mitigation measures, as discussed below.

4.4 Recommendations

Noise mitigation measures for each major construction activity are discussed in the following sections. These mitigation measures are considered to represent all 'feasible and reasonable' mitigation measures suitable for implementation during construction of the project.

4.4.1 General

In general, practices to reduce construction noise impacts will be required, and may include;

- Adherence to the standard approved working hours for construction projects where possible as outlined in Section 4.2.1.2.
- Manage noise from construction work that might be undertaken outside the recommended standard hours following Section 2.3 of the Interim Construction Noise Guidelines (DECC, 2009)
- The location of stationary plant (air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using natural screening by topography wherever possible to reduce noise impacts
- Using site sheds and other temporary structures or screens to limit noise exposure where possible

- Installing operational noise barriers as early as possible to provide ongoing screening from construction activities, where possible
- The appropriate choice of low-noise construction equipment and/or methods
- Modifications to construction equipment or the construction methodology or programme. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity, or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.

The above represents the best practical means of control. While the contractor will be able to achieve moderate reductions in noise and vibration, some impact is expected. A Construction Noise and Vibration Management Plan could be adopted for construction stages incorporating a programme of noise monitoring at sensitive receivers, a community information programme and a complaints hotline.

4.4.2 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use.

4.4.3 Piling

To reduce the effect on residents of piling noise, nearby residents should be consulted regarding the intended activities associated with the piling process.

Mitigation measures to reduce the impact of percussive piling activities include:

- Using a resilient pad (dolly) between pile and hammer head
- Enclosing the hammer head in a temporary acoustic shroud.

Alternatively, rotary bored or vibro-piling may be used where consistent with the type of pile used and restrictions on soil disturbance.

Piling, in particular, should not be undertaken outside of the standard working hours.

4.4.4 Noise level reductions from mitigation

Indicative noise reduction for different noise mitigation measures relevant to construction activities for the project have been obtained from the guidance of AS2436 and BS5228.1, as summarised below in Table 13.

Table 13: Indicative noise reduction provided by noise mitigation measures

Construction equipment	Noise mitigation measure	Indicative noise reduction, dB(A)	Source
Jackhammer	Muffler and screen	20	Table C2 AS2436:2010
Compressor Cement mixers Hand-held tools	Screening	5	Table C3 AS2436:2010
Excavators/loaders Trucks Mobile cranes Asphalt paver Bulldozers Road graders Rollers/compactors	Residential-grade silencer	10	Table C2 AS2436:2010 Table B1 BS5228.1:2009
Excavator with hammer attachment	Residential-grade silencer Screening of hammer attachment	15	Table C2 AS2436:2010
Piling impact	Resilient pad (dolly) between pile and hammerhead	10	Table C2 AS2436:2010 Table B1 BS5228.1:2009

4.4.5 Vibration

Reference has been take from TfNSW guidelines with regard to recommended minimum working distances for vibration intensive plant. These are based on international standards and guidance and reproduced in Table 14 below for reference.

Table 14: 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)
Pile Boring	≤ 800 mm	2 m (nominal)	N/A

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

There are no sensitive receivers located within these ‘safe working distances’.

5 Operational noise

5.1 Regulatory context

Operational noise emission from the Project has been assessed in accordance with the NSW *Industrial Noise Policy* (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.

5.1.1 Intrusive noise criteria

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

- $L_{Aeq,15minute}$ ≤ 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.

5.1.2 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, industrial receivers and other sensitive receivers.

Table 15: 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[1]**	**Recommended $L_{Aeq(Period)}$ noise level**	
			Acceptable	**Recommended maximum**
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
	Urban/Industrial Interface - for existing situations only	Day	65	70
		Evening	55	60
		Night	50	55

Type of receiver	Indicative Noise Amenity Area	Time of day[1]	Recommended $L_{Aeq(Period)}$ noise level	
			Acceptable	Recommended maximum
School classrooms - internal	All	Noisiest 1 hour period when in use	35	40
Hospital ward - internal - external	All	Noisiest 1 hour period	 35 50	 40 55
Place of worship - internal	All	When in use	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

1 – Daytime, 7.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night-time 10.00pm to 7.00am

On Sundays and Public Holidays, Daytime 8.00am - 6.00pm; Evening 6.00pm - 10.00pm; Night-time 10.00pm - 8.00 am.

5.1.3 Project specific INP criteria

Based on the background and ambient noise monitoring, Table 16 summarises the derived project noise criteria based on the INP.

Table 16: INP noise criteria modifying factor corrections for duration

Receiver	Time period	Existing noise levels[1]			Project goals		
		RBL	Industry[2] dBL_{Aeq}	Traffic[3] dBL_{Aeq}	Intrusive	Base Amenity	Modified Amenity
A1	Day	55	N/A [4]	63	60	60	53
	Evening	54	N/A [4]	63	59	50	53
	10pm to midnight	49	N/A [4]	60	54	45	50
	Night	45	N/A [4]	60	50	45	50

Notes:

1 – Free-field noise levels

2 – Does not include noise from the subject site

3 – For assessment against Section 2.2.3 of INP

4 – No other industrial noise sources identified

5.1.4 Sleep disturbance

While not specifically outlined in the NSW INP, as the proposal includes possible use of outdoor terrace areas after 10:00 pm for use by patrons, potential for sleep disturbance has been assessed.

5.2 Assessment

The following outlines the primary operational noise sources associated with the development:

- Patron noise from terrace café
- Patron and background music during functions
- Building services equipment

At this stage of the project, details of the building services plant selections are not known and therefore only a qualitative assessment can be carried out. Noise the terrace café and functions have been assessed below, and considered separately. Cumulative assessment is not relevant as during function the café would not be operational or occupied by function attendees.

5.2.1 Café

There is an outdoor terrace area at café on Lower Ground Level as highlighted in red in Figure 4 below. The dimensions of the space are also marked on the figure. The patron noise from café is not expected to be excessive.

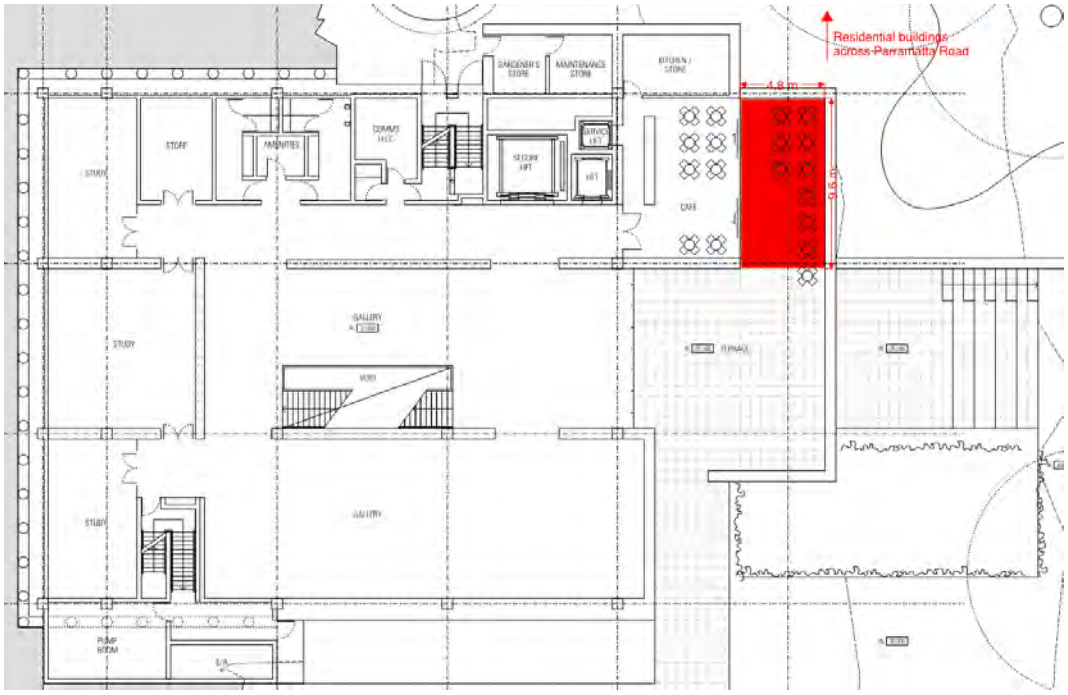


Figure 4: Location and dimensions of the Cafe Terrace – Lower Ground

For the purpose of this assessment, the following assumptions for the normal operation of the café have been made:

- 40 people occupying the space;
- Normal conversational noise;
- No or minimal background music anticipated;
- Operational hours 8:00 am to 9:00 pm.

Noise from crowds can be estimated using empirical methods described in a paper by Hayne and others[1].

Table 17: Café noise assessment

Assessment location	**Noise source**	**Predicted noise level, $dBL_{Aeq,15min}$**	**Project goals, $dBL_{Aeq, period}$**		
			Day	**Evening**	**Night**
A1 – Arundel St	Café patrons	45	53	53	45

The noise level from café operation is predicted to readily satisfy the project requirements for the proposed operating hours up to 10:00 pm, being 8 dB lower than project specific criteria. The use is also predicted to comply with the night time criteria.

5.2.2 Functions

Culturally focussed functions and events are anticipated in the operation of the Chau Chak Wing Museum. Table 9 presents the operational assumptions of events and functions for the noise impact assessment. These assumptions are based on the design intent of the Chau Chak Wing Museum.

Table 18: Assumptions of Events and Functions

Item	**Assumptions**
Type of use/functions	Typically Art or Artefact exhibition openings, book launches, corporate functions, Senate Xmas party or Senate NYE party. Noisy events, such as rock concerts or discos, are NOT anticipated.
Hours of operations	Events will typical end at 10:00 pm – 11:00 pm; Outdoor space will be closed at 10:00 pm
Patron capacity	Typically 100 – 150 across the building, including maximum 75 people in the outdoor area.
Music	Typically light music such as background music, a string quartet or choir/soloist performance

[1] Prediction of Noise from Small to Medium Sized Crowds. M.J. Hayne (1), J.C. Taylor (1), R.H. Rumble (1) and D.J. Mee (2), (1) Ron Rumble Renzo Tonin, 96 Petrie Terrace, Petrie Terrace QLD Australia 4000, (2) School of Mechanical and Mining Engineering, The University of Queensland, Brisbane, Australia 4072

For the purpose of this assessment, the patrons at the outdoor space are considered to be the major potential noise source to the nearest residential receivers on the Arundel Street.

Table 19: Function noise assessment

Assessment location	Noise source	Predicted noise level, $dBL_{Aeq,15min}$	Project goals, $dBL_{Aeq, period}$		
			Day	Evening	22:00-00:00
A1 – Arundel St	Patrons and background music[1]	52	53	53	50

The noise level from functions in the outdoor is predicted to comply with the project goals during the day and evening periods. There is a 2 dB minor shortfall in meeting the shoulder period (10:00 pm to midnight) modified amenity goal, however this is considered a conservative application of the criteria. With reference to the intrusiveness goal, the operations are predicted to comply.

5.2.3 Building services noise

At this stage of the project, details of the building services plant selections are not known and therefore only a qualitative assessment can be carried out. Typical acoustic mitigation measures are given in Section 5.3.3.

5.3 Recommendations

5.3.1 Café

Café is expected to meet the project goals during its operation in day and evening period.

5.3.2 Functions

The following recommendations are made with regard to functions:

- All outdoor areas should close at 10:00 pm
- Any in-house sound system should incorporate a noise limiter

5.3.3 Building services assessment

Plant noise is to be limited to the criteria listed in Section 5.1.3. At this stage in the project, details of the plant selections are not known.

During the detailed design process, appropriate noise and vibration control treatments will be specified to ensure that the noise limits are maintained. The following treatments are allowed and 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
- Cooling air and flue gas attenuators on the generator set
- 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.

6 Noise ingress

6.1 Regulatory context

The NSW State Environmental Planning Policy (Infrastructure) 2007 (known as 'ISEPP') came into force in NSW on 1 January 2008 to facilitate the effective delivery of infrastructure across the State. As the Chau Chak Wing Museum is a part of an education establishment (University of Sydney) which is adjacent to Parramatta Road; thus the following clauses are relevant to the acoustic assessment:

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

(1) This clause applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RTA) and that the consent authority considers is likely to be adversely affected by road noise or vibration:

a) a building for residential use,

b) a place of public worship,

c) a hospital,

d) an educational establishment or child care centre.

(2) Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.

(3) If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

a) in any bedroom in the building - 35 dB(A) at any time between 10 pm and 7am,

b) anywhere else in the building (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.

In this clause, "freeway", "tollway" and "transitway" have the same meanings as they have in the Roads Act 1993.

6.2 Recommendations

The Chau Chak Wing Museum will be designed according to Australian Standard 2107-2016 and noise criteria specified in Table 3.1 of *Development Near Rail*

Corridors and Busy Roads – Interim Guideline by Department of Planning, NSW Government.

Appropriate acoustic treatments to façade system/elements will be provided to comply the noise criteria and will be further developed during the detailed design of the project.

Based on the attended measurements carried out during the peak traffic period, Table 20 presents indicative façade sound insulation performance requirements and indicative glass configurations for the Chau Chak Wing Museum. This information is for guidance only and not for construction.

Table 20: Indicative façade sound insulation requirements

Direction	**Indicative façade sound insulation target and glass configurations**
North	R_w 37 (e.g. 6mm/12mm gap/10mm)
North (Boardroom with VC/Reference Room)	R_w 41 (e.g. 6mm/12mm gap/10mm Lam)
East	R_w 33 (e.g. 6mm/12mm gap/6.38mm Lam)
South	R_w 33 (e.g. 6mm/12mm gap/6.38mm Lam)
West	R_w 32 (e.g. 6mm/12mm gap/6mm Lam)

7 Conclusion

This report has addressed the SEARs Key Issue Nos 4 and 7 regarding the impact of the noise and vibration from development during its construction and operation.

Reference has been made to relevant NSW EPA procedures and assessment requirements for the construction and operational noise assessments. On the basis current design, construction methods, and operations of the site, and the information currently available for the development, we see no impediment to approval.

8 References

- Prediction of Noise from Small to Medium Sized Crowds. M.J. Hayne (1), J.C. Taylor (1), R.H. Rumble (1) and D.J. Mee (2), (1) Ron Rumble Renzo Tonin, 96 Petrie Terrace, Petrie Terrace QLD Australia 4000, (2) School of Mechanical and Mining Engineering, The University of Queensland, Brisbane, Australia 4072
- Chau Chak Wing Museum Preliminary Construction & Traffic . CB, 18.11.2016

Appendix A

Glossary of acoustic terminology

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear, which allows hearing over a large range of sound pressure levels. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

dB(A)

dB(A) is a single number to describe a sound pressure level and includes a frequency weighting to reflect the subjective loudness level.

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

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. Some typical dB(A) levels are shown below.

Sound Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chainsaw at 1 m
100	Inside nightclub
90	Large trucks at 5 m
80	Beside 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	Human threshold of hearing

dBL_1

The dBL_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the dBL_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 $dBL_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

dBL_{10}

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

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

dBL_{90}

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

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

dBL_{eq}

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

dBL_{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. When the dB(A) weighting is applied, the level is denoted $dBL_{Aeq.}$ Often the measurement duration is quoted, thus $dBL_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

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" and sounds with a higher frequency are perceived as "high pitched".

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. 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. Either metric units (such as mm, mm/s and mm/s2) or using a decibel scale are used to describe vibration.

Appendix B

Unattended noise monitoring

B1 Noise monitoring equipment

Unattended monitoring was carried out using the following equipment:

Measurement location	Equipment/model	Serial No.	SLM Type
L1	ARL Ngara	8780d1	Type 1

Notes:

All meters comply with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and designated either Type 1 as per table, and are suitable for field use.

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

B2 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 provided by the Bureau of Meteorology (BOM), for the nearest representative weather station to noise monitoring location(s). Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B3 Logger graphs

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

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

ARUP

13 Arundel Street (Free Field)

Southern boundary fronting Arundel Street, 1.2 m above the ground

Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

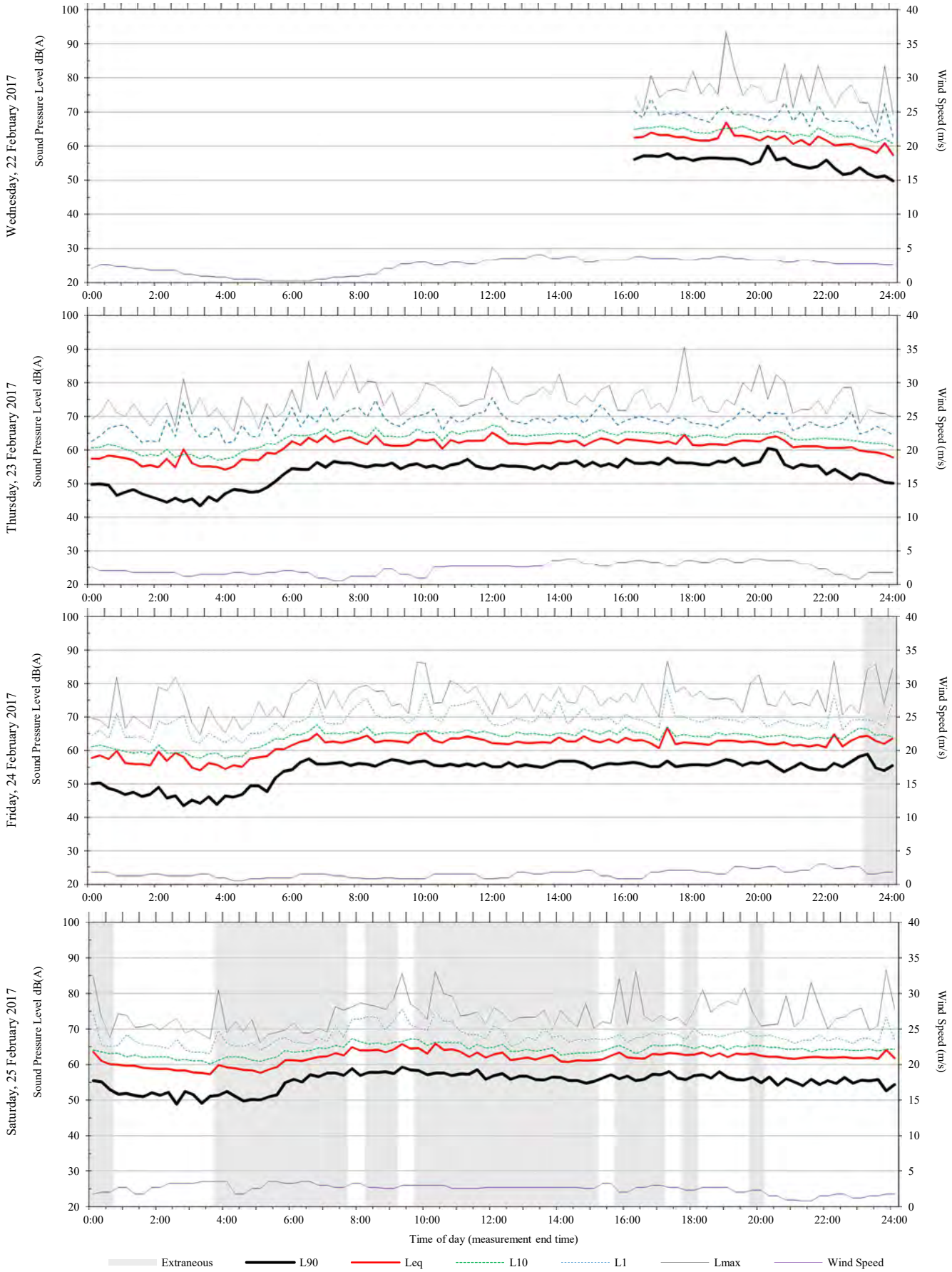
	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-22-February-2017		54	45		63	59
Thursday-23-February-2017	55	55	45	63	62	59
Friday-24-February-2017	55	54		63	62	
Saturday-25-February-2017		54			62	
Sunday-26-February-2017	54	54		62	62	
Monday-27-February-2017	56	54		64	62	
Tuesday-28-February-2017		53			62	
Wednesday-01-March-2017		54			63	
Thursday-02-March-2017						
Friday-03-March-2017						
Saturday-04-March-2017		54	49		62	60
Sunday-05-March-2017		54	45		62	59
Monday-06-March-2017		54	47		62	59
Tuesday-07-March-2017		54	44		62	59
Wednesday-08-March-2017	56	55	45	63	63	60
Thursday-09-March-2017						
Representative Weekday[5]	**55**	**54**	**45**	**63**	**62**	**59**
Representative Weekend[5]	**54**	**54**	**47**	**62**	**62**	**60**
Representative Week[5]	**55**	**54**	**45**	**63**	**62**	**59**

Notes:

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

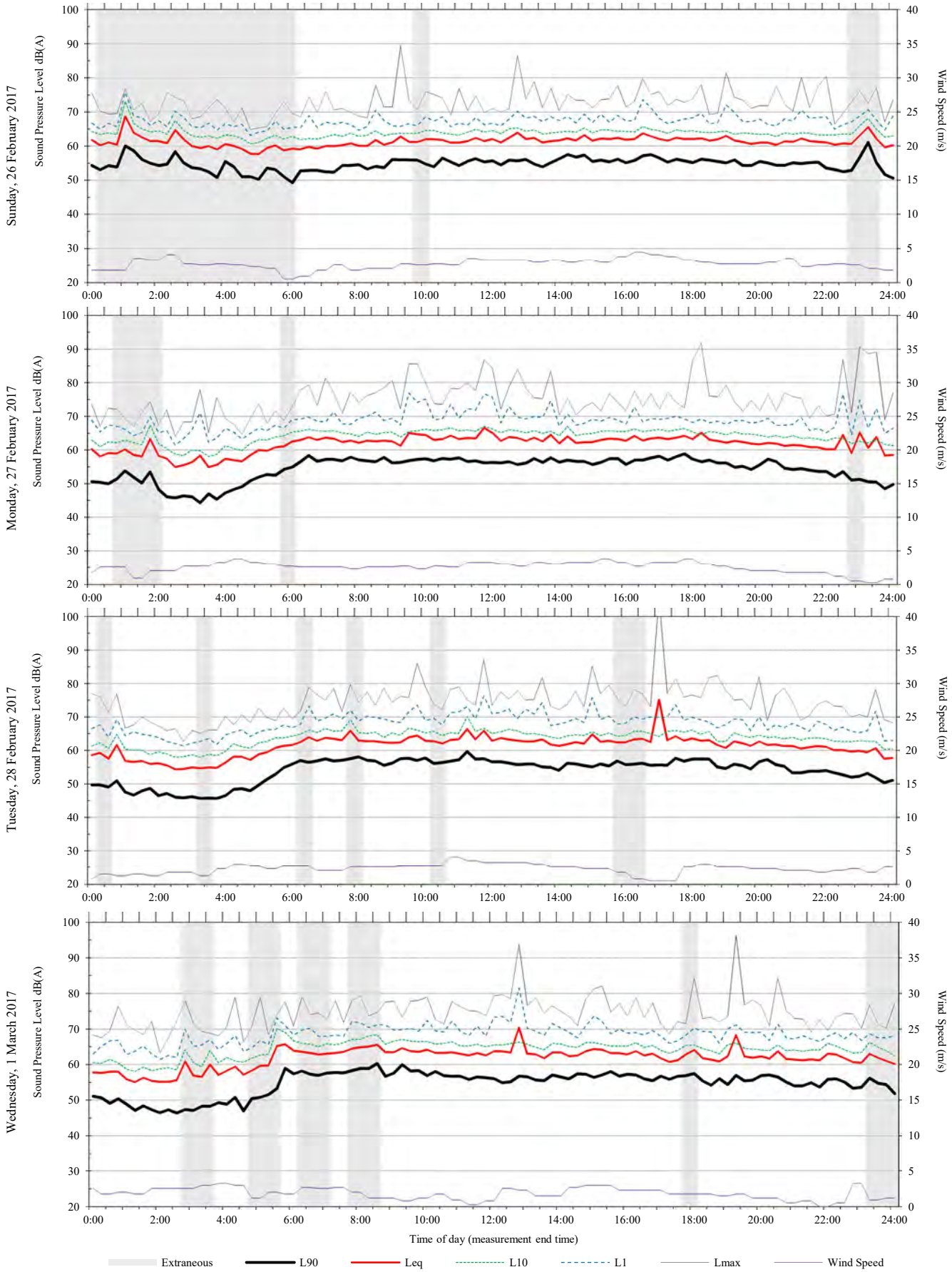
Unattended monitoring: 13 Arundel Street (Free Field)

ARUP



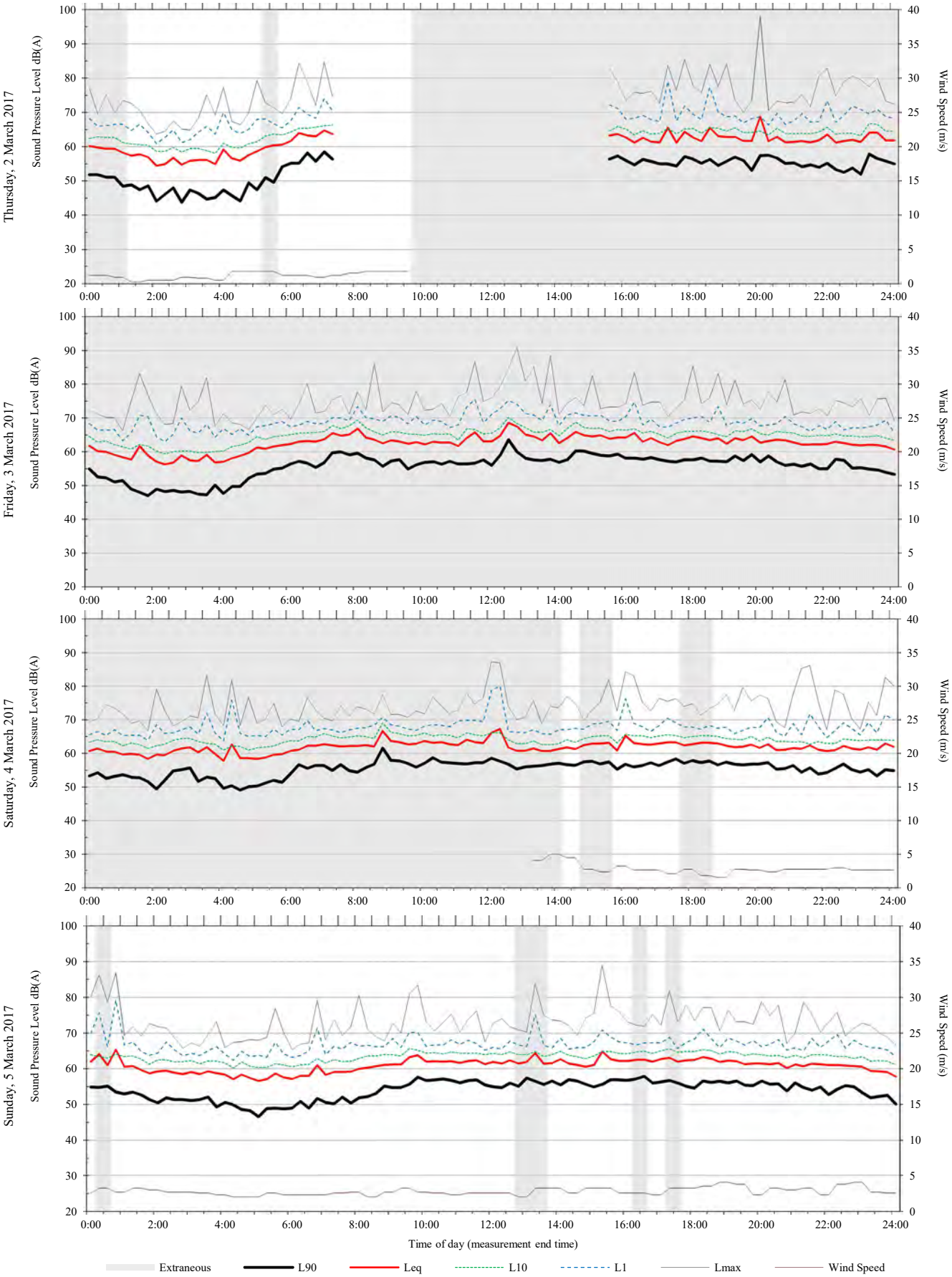
Unattended monitoring: 13 Arundel Street (Free Field)

ARUP



Unattended monitoring: 13 Arundel Street (Free Field)

ARUP



Unattended monitoring: 13 Arundel Street (Free Field)

ARUP