The Art Gallery of NSW
Sydney Modern Development

Extended Working Hours Construction Noise and Vibration Management Plan

Richard Crookes Constructions

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1 INTRODUCTION

Pulse White Noise Acoustics (PWNA) has been engaged to undertake an acoustic assessment of the proposed extended working hours for the internal fitout construction activities and limited Stage 2 entry plaza, upper land bridge and on Art Gallery Road to be undertaken as part of the Art Gallery of NSW, Sydney Modern development.

The assessment has been undertaken in conjunction with the requirements of the EPA's Interim Construction Noise Guideline, the City of Sydney Council's *Construction Noise/Noise within the Central Business District, City of Sydney Code of Practice 1992,* the Coffey *Geotechnical Excavation Monitoring Plan (Ref: SYDGE210394-BB)* and the Arup *Environmental Impact Statement – Acoustic Report* (Ref: Rev H 28 February 2018*)* which is included as part of the SSD 6471 approvals.

The following assessment focusses on the potential noise and vibration impacts during the proposed extended working hours including the following:

1. 6pm-12am Mon-Fri (6 additional hours per weekday);
2. 3.30pm-12am Sat (8.5 additional hours per Saturday); and
3. Sunday 7am-12am (17 additional hours per Sunday).

This report includes the assessment of potential noise and vibration impacts on the surrounding receivers to the site and includes required acoustic mitigations and management controls to ensure noise and vibration complies with the relevant criteria and can therefore be undertaken during the proposed extended working hours periods, including works to be undertaken within the completed building as part of the internal fitout and finishes and limited external works adjacent to Art Gallery Road of the project.

A glossary of acoustic terminology used throughout this report is included in Appendix A.

2 DEVELOPMENT DESCRIPTION

The NSW Art Gallery, Sydney Modern development includes the demolition of existing buildings on the site, excavation of basement in ground works such that the future Sydney Modern project can be constructed.

The site is located within the Art Gallery of NSW site and is located to the north of the existing gallery, partly extending over the Eastern Distributor land bridge and includes a disused Navy fuel bunker located to the north east of this land bridge.

The new expansion, known as the Sydney Modern project, comprises a new entry plaza, new exhibition spaces, shop, food and beverage facilities, visitor amenities, art research and education spaces, new roof terraces and landscaping and associated site works and infrastructure, including loading and service areas, services infrastructure and an ancillary seawater heat exchange system.

All demolition and majority of excavation and construction work on the site have been completed (works including excavation as part of the landscaping areas remain) as well as construction of the building structure and external façade elements, excluding external stone cladding.

The surrounding receivers to the site include a number of residential, infrastructure and recreational receivers including the following:

1. Receiver 1 - 10 Lincoln Crescent, Woolloomooloo (Wharf Terraces) – Residential receiver to the east of the site.
2. Receiver 2 - 9-31 Lincoln Crescent, Woolloomooloo (Wharf Terraces) – Residential receiver to the east of the site.
3. Receiver 3 - 6 Lincoln Crescent, Woolloomooloo – Electrical infrastructure building
4. Receiver 4 - Botanic Gardens – Passive recreational area to the north of the site.
5. Receiver 5 - The Domain – Active recreational area to the west of the site.
6. Receiver 6 - The Eastern Distributor – Traffic Roadway located to the west of the site.
7. Receiver 7 - Existing buildings of the Art Gallery of NSW – to the west of the site.

Compliance at the receivers detailed in the points above represents compliance at all surrounding residential receivers.

The site location, in relation to surrounding buildings, is shown in Figure 1 below.

Figure 1 Site Map and Surrounding Receivers

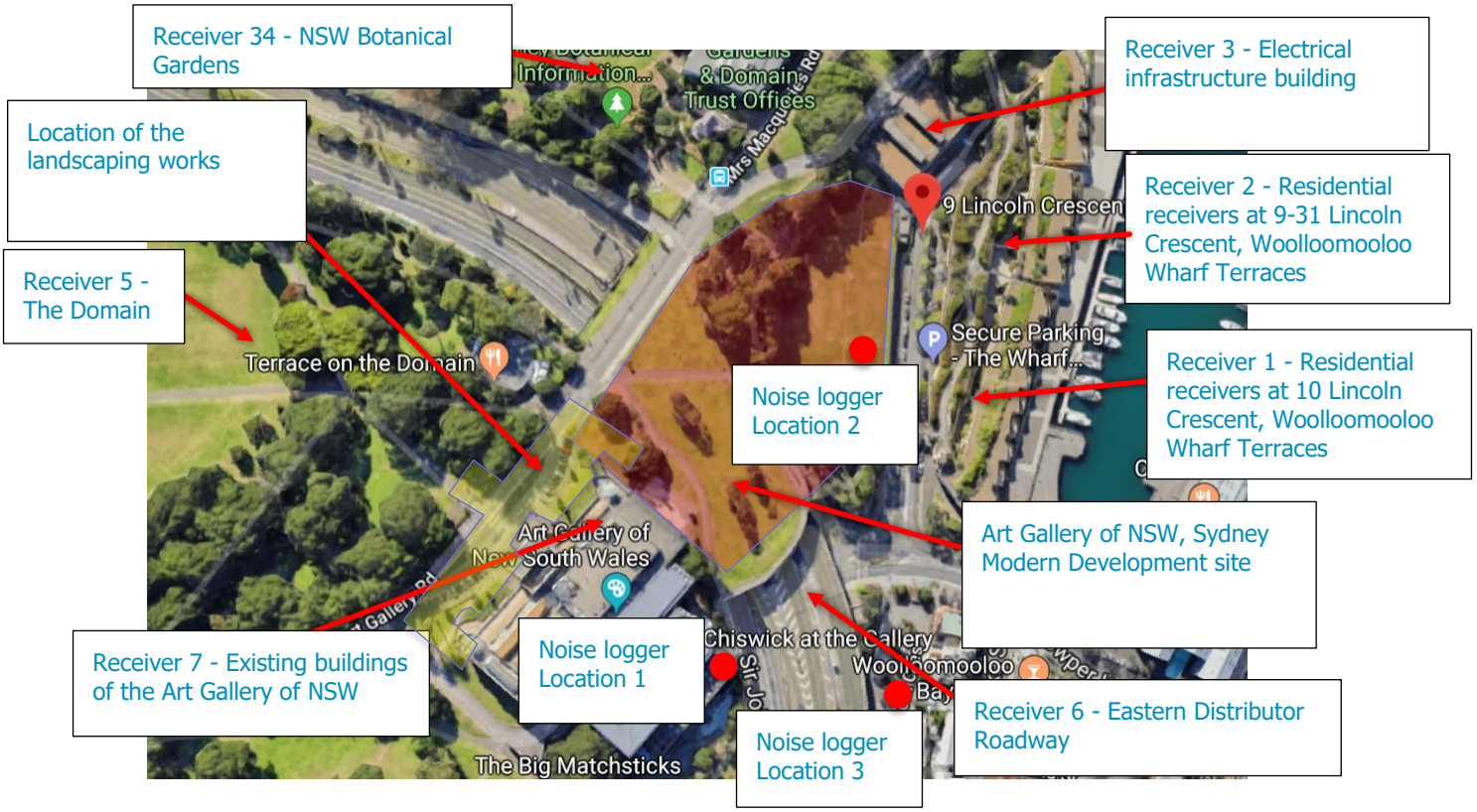
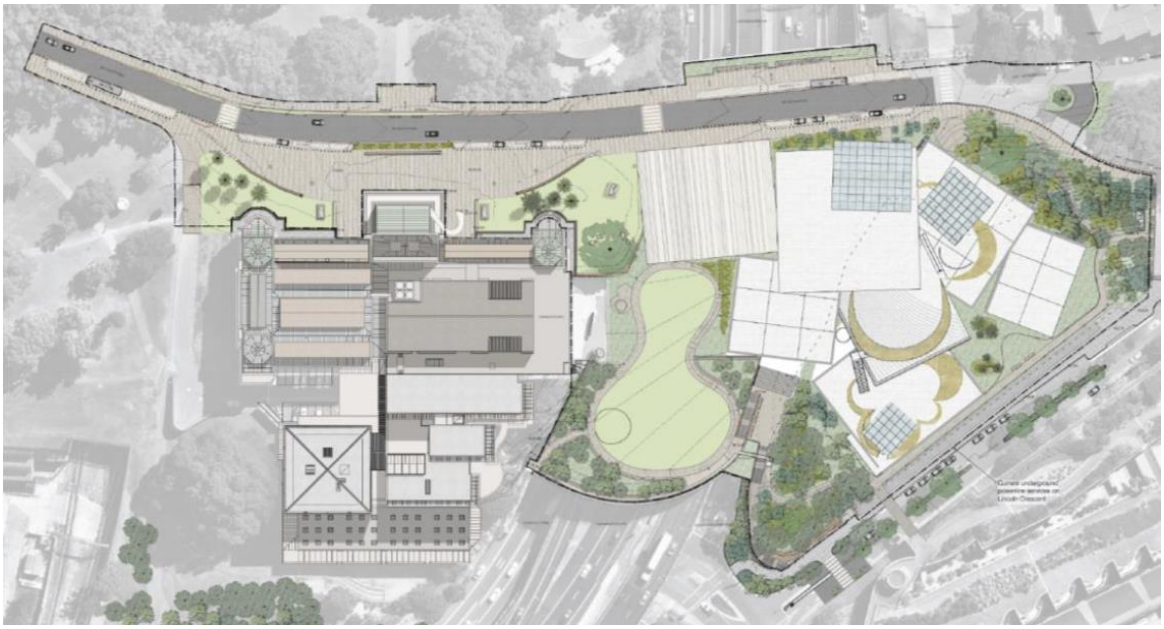


Figure 2 Proposed Sydney Modern Development

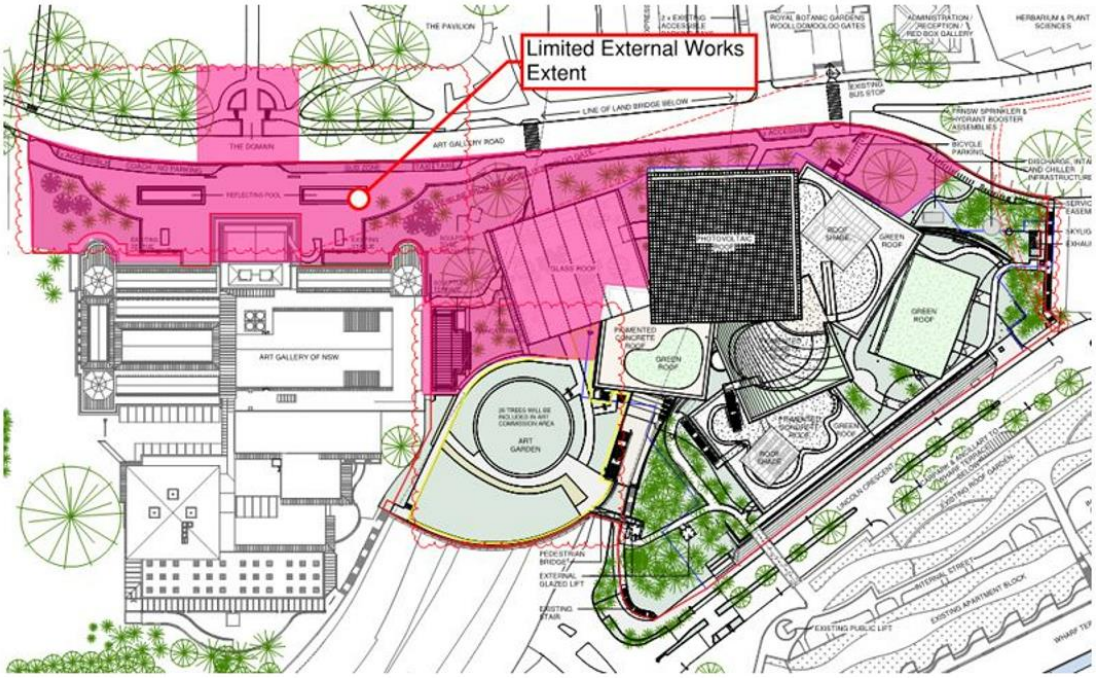


2.1 Proposed Additional Working Hours

The proposed works to be undertaken during the proposed extended working hours are summarised below:

1. Construction stage –
    a. Building Structure and external façade – Not proposed to be included as additional working hours
    b. Internal building fitout and finishes – Proposed to be undertaken during the proposed extended working hours period.
    c. Limited external works on the external areas of Stage 2, entry plaza and land bridge of the project adjacent to Art Gallery Road. These works will not required to use of power equipment or tools including percussive or cutting tools. Details of the proposed are for external works to be undertaken are included in the Figure below.

Figure 3 Proposed External Works Area



The proposed additional working hours for the project include the following:

1. 6pm-12am Mon-Fri (6 additional hours per weekday);
2. 3.30pm-12am Sat (8.5 additional hours per Saturday); and
3. Sunday 7am-12am (17 additional hours per Sunday).

3 PROJECT REQUIREMENTS

The project requirements regarding construction noise and vibration include the following *Conditions of Consent* which are included in the SSD 6471 approvals.

	Noise and Vibration Management
C7	The development must be constructed with the aim of achieving the construction noise management levels detailed in the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009). All feasible and reasonable noise mitigation measures must be implemented and any activities that could exceed the construction noise management levels must be identified and managed in accordance with the Construction Environmental Management Plan.
C8	Heavy vehicles and oversized vehicles must not queue or idle on Art Gallery Road, Mrs Macquaries Road or Lincoln Crescent outside of construction zones awaiting access to the Subject Site.
C9	The Applicant must schedule intra-day 'respite periods' for construction activities predicted to result in noise levels in excess of the "highly noise affected" levels, including the addition of 5 dB to the predicted levels for those activities identified in the Interim Construction Noise Guideline as being particularly annoying to noise sensitive receivers.
C10	Vibration caused by construction at any residence or structure outside the subject site must be limited to: a) for structural damage vibration to buildings (excluding heritage buildings), British Standard BS 7385 Part 2-1993 Evaluation and Measurement for Vibration in Buildings; b) for structural damage vibration to heritage buildings, German Standard DIN 4150 Part 3 Structural Vibration in Buildings Effects on Structure; and c) for human exposure to vibration, the evaluation criteria presented in British Standard BS 6472-Guide to Evaluate Human Exposure to Vibration in Buildings (1Hz to 80 Hz) for low probability of adverse comment.

	Construction Noise and Vibration Management Plan
B63	Prior to the issue of the relevant Crown Building Works Certificate, a Construction Noise and Vibration Management Plan (CNVMP) prepared by a suitably qualified person shall be submitted to the Certifying Authority. The CNVMP must be prepared in consultation with, and address the relevant requirements of, Council and the EPA. The CNVMP shall address (but not be limited to): a) be prepared in accordance with the EPA's Interim Construction Noise Guideline b) identify nearby sensitive receivers and land uses; c) identify the noise management levels for the project; d) identify the construction methodology and equipment to be used and the key sources of noise and vibration; e) details of all reasonable and feasible management and mitigation measures to be implemented to minimise construction noise and vibration; f) be consistent with and incorporate all relevant recommendations and noise and vibration mitigation measures outlined in the Acoustic Report (dated 28 February 2018) in Appendix P of the RTS; g) ensure all potentially impacted sensitive receivers are informed by letterbox drops prior to the commencement of construction of the nature of works to be carried out, the expected noise levels and duration, as well as contact details for a construction community liaison officer; and h) include a suitable proactive construction noise and vibration monitoring program which aims to ensure the construction noise and vibration criteria in this consent are not exceeded. Prior to the commencement of works, a copy of the CNVMP must be submitted to Council and the Planning Secretary.

The currently approved working hours for the project include those within the SSD approval and included below:

Construction Hours

C2 Construction, including the delivery of materials to and from the site, may only be carried out between the following hours:

a) between 7.00 am and 6.00 pm, Mondays to Fridays inclusive;

b) between 8.00 am and 3.30 pm, Saturdays.

C3 No construction work may be carried out on Sundays or public holidays

C4 Activities may be undertaken outside of these hours if required:

a) by the Police or a public authority for the delivery of vehicles, plant or materials; or

b) in an emergency to avoid the loss of life, damage to property or to prevent environmental harm.

C5 Notification of such activities must be given to affected residents before undertaking the activities or as soon as is practical afterwards.

C6 Rock breaking, rock hammering, sheet piling, pile driving and similar activities may only be carried out between the following hours:

a) 9.00 am to 12.00 pm, Monday to Friday;

b) 2.00 pm to 5.00 pm, Monday to Friday; and

c) 9.00 am to 12.00 pm, Saturday.

The assessment of the proposed extended hours works for the internal areas of the project has been undertaken in accordance with the following, as required by the project *Conditions of Consent* detailed above:

1. Environmental Protection Authorities (EPA) *Interim Construction Noise Guideline*.

2. The City of Sydney Council's *Construction Noise/Noise within the Central Business District, City of Sydney Code of Practice 1992* including works to be undertaken during category 2, 3 and 4 periods.

The relevant requirements are detailed in the following sections.

3.1 EPA – Interim Construction Noise Guideline

Noise criteria for construction activities are discussed in the EPA's *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works;
- Focus on applying all "feasible" and "reasonable" work practices to minimise construction noise impacts;
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours;
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage; and
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for receivers have been reproduced from the guideline and are listed in the table below.

Table 1 Noise Management Levels from Construction – Quantitative Assessment

Receiver Type	Time of Day	Noise Management Level LAeq(15minute)[1,2]	How to Apply
Residential	Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 3.30 pm 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 LAeq(15minute) 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.
		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: 1. 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. 2. 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 above the noise affected level, the proponent should negotiate with the community.
Office, retail outlets	When is use.	Highly noise affected 70 dB(A)	• The external noise levels should be assessed at the most-affected occupied point of the premises

Note 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.*

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Noise Policy for Industry (EPA 2017).*

The EPA's Interim Construction Noise Guideline defines normal day time hours as the following:

2.2 Recommended standard hours

The recommended standard hours for construction work are shown in Table 1; however, they are not mandatory. There are some situations, as described below, where construction work may need to be undertaken outside of these hours. The likely noise impacts and the ability to undertake works during the recommended standard hours should be considered when scheduling work.

Table 1: Recommended standard hours for construction work

Work type	Recommended standard hours of work*
Normal construction	Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays
Blasting	Monday to Friday 9 am to 5 pm Saturday 9 am to 1 pm No blasting on Sundays or public holidays

* The relevant authority (consent, determining or regulatory) may impose more or less stringent construction hours.

3.2 City of Sydney Council – Construction Noise

The City of Sydney Council *City of Sydney Construction Hours /Noise Code of Practice 1992* includes suitable Categories for Working Hours and Noise Criteria for the construction site. The recommended hours and noise levels for the control of construction noise are detailed below.

CATEGORIES OF WORKING HOURS, AND NOISE CRITERIA

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

NOTE: 00.00 or 24.00 means 12.00 midnight.

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

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

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

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

4 EXISTING ACOUSTIC ENVIRONMENT

The site of the Sydney Modern Project includes the expansion of the Art Gallery of NSW including the area of land to the north of the existing building partly extending over the Eastern Distributor land bridge and includes a disused Navy fuel bunker located to the north east of this land bridge.

Noise levels at the site are predominantly a result of traffic movements of surrounding roadways including the Eastern Distributor which carries high volumes of traffic including heavy vehicles.

As part of the previously conducted *Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx)* which was included as part of the SSD 6471 approvals a noise survey of the surrounding area has been conducted including an assessment of existing background noise levels. The noise levels detailed within this report have been used as the basis of this report as they are included as part of the approval of project acoustic criteria.

4.1 Existing Background Noise Levels at the site

As part of the SSD 6471 approvals a background noise survey of the site and surrounding areas has been conducted and is detailed in the Arup *Environmental Impact Statement – Acoustic Report* (Ref: Rev H 28 February 2018*).*

The noise levels detailed within this report have been used as the basis of this management plan.

Section 3.2 Measurement of existing noise levels of the Arup *Environmental Impact Statement – Acoustic Report* (Ref: Rev H 28 February 2018*)* includes details of the noise survey undertaken at the site in 2016, prior to works commencing on the site. The obtained noise levels undertaken within the Environmental Impact Statement – Acoustic Report include noise levels which are suitable for the assessment of the current noise levels at the site. As the main source of noise impacting the site is a result of traffic noise levels from the Eastern Distributor and the number of vehicles using the roadway has not changed significantly since 2016 the resulting noise levels on and surrounding Sydney Modern Development will not have changes significantly.

As part of the Arup *Environmental Impact Statement – Acoustic Report* (Ref: Rev H 28 February 2018*)* both long term unattended noise logging as well as short term attended noise level measurements were conducted around the site. A summary of the acoustic survey is detailed in the tables below.

The results of the unattended noise monitoring are detailed in the table below. The location of the noise logger on the site was such that the obtained noise levels are representative of the background noise levels ($L_{90\,(t)}$) at the site as well as the existing ambient noise levels (Leq (t)), and are therefore suitable for the noise impact assessment. The values in Table 2 have been used as the basis of this assessment.

Table 2 Summary of SSD Approved Noise Levels at the Site

Measurement Location	Time of Measurement	$L_{Aeq,\ 15min}$ dB(A)	$L_{A90,\ 15min}$ dB(A)	Comments
Location 1 – South East of the existing Art Gallery of NSW building facing Eastern Distributor	Day	65	59	Noise level at the site was dominated by vehicle movements on surrounding roadways including the Eastern Distributor and other surrounding roadways
	Evening	63	58	
	Night	60	47	
Location 2 – West of Lincoln Crescent on the proposed Sydney Modern Development site	Day	60	49	
	Evening	62	49	
	Night	54	44	
Location 3 – To the west of the residence at 731 Bourke Street @ 5.2m above ground level	Day	60	54	
	Evening	58	53	
	Night	55	42	

Noise levels based on levels detailed within the Arup *Environmental Impact Statement – Acoustic Report* (Ref: Rev H 28 February 2018*)* and included as part of the SSD 6471 approvals.

Measurement locations based on the *Environmental Impact Statement – Acoustic Report* and are detailed within Figure 1 of this report. Additional noise monitoring undertaken at the site during the construction phase of the project has confirmed the noise levels detailed above are suitable for the assessment of additional construction working hours.

5 EXTENDED WORKING HOURS NOISE CRITERIA

Based on the requirements of the EPA *Interim Construction Noise Guideline* and the City of Sydney Council *City of Sydney Construction Hours /Noise Code of Practice 1992*, suitable construction noise criteria levels for the proposed extended working hours (including 24 hours periods) are detailed in the table below.

Table 3 Site Construction Noise Management Levels – Wharf Terraces (Lincoln Crescent) Residential Receivers

Noise Source	Standard	Time Period	Receiver Type	Construction Noise Management Level	Resulting Noise Level Criteria
Internal Works Construction Noise	EPA	Outside of recommended standard hours	Residential (hotel) Receivers	Background Noise + 5 dB(A)	Evening – 54 dB(A) $L_{Aeq\ (15min)}$ Night – 49 dB(A) $L_{Aeq\ (15min)}$
	City of Sydney Council	Category 2	All Receiver Types	Background Noise + 3 dB(A)	52 dB(A) $L_{A\ av\ max\ (15min)}$[1]
		Category 3		Background Noise + 3 dB(A)	52 dB(A) $L_{A\ av\ max\ (15min)}$[1]
		Category 4		Background Noise + 0 dB(A)	44 dB(A) $L_{A\ av\ max\ (15min)}$[1]

Note 1: Construction noise management levels based on the Interim Construction Noise Guideline and the City of Sydney Council - City of Sydney Construction Hours /Noise, Code of Practice 1992.

Note 2: The $L_{A\ av\ max\ (15min)}$ has been defined as an $L_{A10\ (15min)}$ for the purpose of this assessment.

Table 4 Site Construction Noise Management Levels – Residential Receivers at 731 Bourke Street

Noise Source	Standard	Time Period	Receiver Type	Construction Noise Management Level	Resulting Noise Level Criteria
Internal Works Construction Noise	EPA	Outside of recommended standard hours	Residential (hotel) Receivers	Background Noise + 5 dB(A)	Evening – 58 dB(A) $L_{Aeq\ (15min)}$ Night – 47 dB(A) $L_{Aeq\ (15min)}$
	City of Sydney Council	Category 2	All Receiver Types	Background Noise + 3 dB(A)	56 dB(A) $L_{A\ av\ max\ (15min)}$[1]
		Category 3		Background Noise + 3 dB(A)	57 dB(A) $L_{A\ av\ max\ (15min)}$[1]
		Category 4		Background Noise + 0 dB(A)	42 dB(A) $L_{A\ av\ max\ (15min)}$[1]

Note 1: Construction noise management levels based on the Interim Construction Noise Guideline and the City of Sydney Council - City of Sydney Construction Hours /Noise, Code of Practice 1992.

Note 2: The $L_{A\ av\ max\ (15min)}$ has been defined as an $L_{A10\ (15min)}$ for the purpose of this assessment.

6 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

This section of the report details the assessment of noise associated with the proposed extended hours for the internal works within the Sydney Modern development.

The assessment has been undertaken to assess the potential noise and vibration impacts from the proposed internal works to be undertaken within the partially enclosed building's façade (as completed), noting that the entry point of Lincoln Crescent can remain open, including fitout and finishes works.

6.1 Construction Vibration Assessment

This section of the report details the assessment of construction vibration impacts on surrounding receivers.

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed.
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects.
- Effects on building structures – where vibration can compromise the integrity of the building or structure itself.

6.1.1 Vibration Criteria – Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled "*Assessing Vibration – A Technical Guideline*" (AVTG. This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration – from uninterrupted sources (refer to Table 5).
- Impulsive vibration – up to three instances of sudden impact e.g., dropping heavy items, per monitoring period (refer to Table 6).
- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 7).

Table 5 Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
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
		0.04	0.029	0.080	0.058
Workshops	Day or night-time	0.04	0.029	0.080	0.058

Table 6 Impulsive vibration acceleration criteria (m/s2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
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

Table 7 Intermittent vibration impacts criteria ($m/s^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
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

6.1.2 Vibration Criteria – Building Contents and Structure

The vibration effects on the building itself are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration" (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 "Effects of Vibration on Structure" (DIN 1999).

6.1.2.1 Standard BS 7385 Part 2 – 1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 8 and illustrated in Figure 4 below.

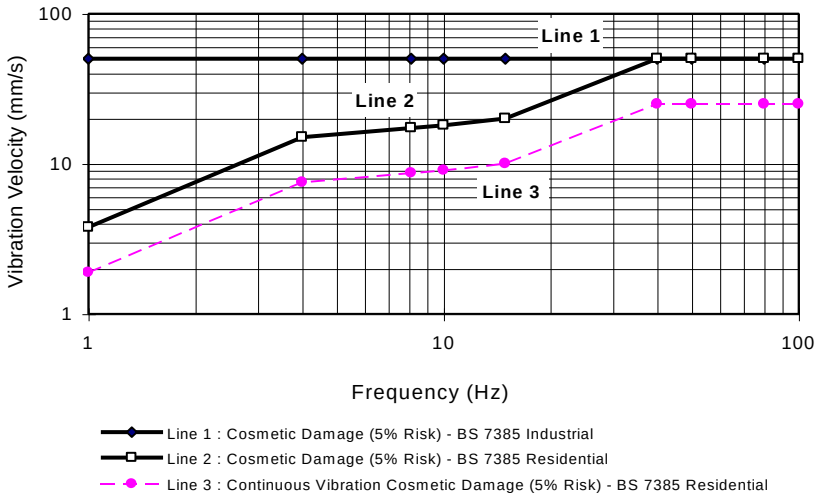
Table 8 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in figure below	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385 Part 2 – 1993 states that the values in Table 8 relate to transient vibration which does not cause resonant responses in buildings.

Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 8 may need to be reduced by up to 50% (refer to Line 3 in the figure below).

Figure 4 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the recommended values corresponding to Line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 8, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless a calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 8 should not be reduced for fatigue considerations.

6.1.2.2 Standard DIN 4150 Part 3 – 1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 9. The criteria are frequency dependent and specific to particular categories of structures.

Table 9 Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.				

6.1.3 Summary of Construction Vibration Criteria

The existing buildings which neighbour the project site are detailed below:

1. North – Electrical infrastructure building.
2. East – residential buildings including Wharf Terraces.
3. West – Existing Art Gallery of NSW.
4. Heritage storage tanks on the site.
5. The Eastern Distributor road infrastructure.

Based on the details of the vibration criteria detailed in the sections above and the Coffey *Geotechnical Excavation Monitoring Plan* the recommended construction vibration impact criteria to protect the neighbouring receivers to the site includes the following:

1. Electrical infrastructure building - 7mm/s or specific criteria provided by the Ausgrid.
2. Residential Receivers (Wharf residence) – 5mm/s.
3. Eastern Distributor road infrastructure - 10mm/s.
4. Existing Art Gallery Buildings – 2.5mm/s.
5. Heritage storage tanks – 5mm/s

Based on the proposed works to be undertaken during the proposed extended hours periods, including internal fitout and finishes works, and limited external works compliance with vibration criteria at all surrounding locations will be achieved without additional mitigations or controls.

All vibration resulting from the proposed works included in the extended hours periods will comply with the projects criteria as detailed in item C10 of the Conditions of Consent.

6.2 Construction Activities Noise Assessment

This section of the report details the assessment of extended hours noise impacts from construction undertaken within the building. The assessment of internal construction appliances including works during the proposed additional working hours, in accordance with the requirements of the Environmental Protection Authorities (EPA) Interim Construction Noise Guideline and the City of Sydney Council during periods when the building's façade partially completed and will be used for acoustic mitigation based on the competition of the buildings construction.

6.2.1 Proposed Appliances

The proposed appliances which will be used as part of the internal construction works are detailed in the table below.

Table 10 Proposed Appliances to be Undertaken During Extended Hours Period

Tasks	Equipment	Sound Power Levels per task dB(A) L_{10}	Aggregate Sound Power Level per Task dB(A) L_{10}
Internal Construction Works including Fitout and Finishes within the partially completed building	Hand held power tools[1]	109	114
	Materials Movements	105	
	Saw cutter	109	
	Hammering and power fixing	109	
	Fixing and fitting activities	95	
Stage 2, External Works (including works included in this report)	Landscaping and manual spoil movement	90	97
	Paver Installation	95	
	Other general works (not including power tools or equipment)	90	

Note: Noise levels of proposed equipment to be used on the site are based on the Australian Standard AS2436-2010 and noise level measurements previously undertaken of similar equipment on construction sites.

Note 1: Equipment includes the specific equipment included in the Richard Crookes Constructions – SSD 6741 – Out of hours Work Management Plan – Internal Fitout Report.

6.2.2 Noise Impact Assessment

A quantitative assessment of the construction noise levels resulting from the proposed extended hours period for internal construction activities has been undertaken. The assessment includes a number of assumptions, including the following:

1. All internal fitout and finishes works are to be undertaken within the building with the external building façade closed, including the currently completed building structure. The current building construction includes and entry point off Lincoln Crescent which is not currently completed and can remain open. Works within the entry area directly within the entry off Lincoln Crescent should not be undertaken during the proposed extended hours period.
2. The required external works include landscaping, manual spoil movement and other general external works which do not required the use of power tools or equipment (such as those used for cutting or grinding). The use of Hand tools, mixers bits on drills, rollers, brushes, screeders, light towers and like are proposed to be used. Location of the external works to be undertaken as part of the Stage 2 entry and upper land bridge area as detailed in Figure 3 above.
3. All materials delivery and removal from the site will be undertaken within the project's approved normal working hours period.

4. Construction activities will be undertaken within a number of locations simultaneously, including a possible 3 floors at any one time including up to 100 workers within the partially completed internally area and 50 on the external areas.

The assessment has been based on the expected noise levels to be generated within and externally to the Sydney Modern building during the proposed extended hours periods including:

1. 6pm-12am Mon-Fri (6 additional hours per weekday);
2. 3.30pm-12am Sat (8.5 additional hours per Saturday); and
3. Sunday 7am-12am (17 additional hours per Sunday).

Calculation of the resulting construction noise levels at the surrounding receivers within proximity to the site (see Section 2) is detailed in the table below.

The assessment of noise impact during the proposed extended working hours periods includes the residential receivers and are included the following tables.

Table 11 Quantitative Assessment of Construction Noise during Extended Hours Periods Internally within the Building (15-minute period)

Receiver Location	Source Noise	Time Period	Noise Source	Aggregate Sound Power Level dB(A) L_{10}	Correction for Number of areas with Activities in use	Building Corrections	Distance correction	Barrier/ Directivity Correction	Calculated Construction Noise Levels dB(A) L_{10}	Extended Hours Noise Criteria dB(A) L_{10}	Compliant
Receiver 1 (R1) – Wharf Terraces	Internal Construction including Fitout and Finishes including use within partially completed areas of the building	Category 2 periods – 7pm to 11pm	Activities and equipment detailed in Section 6.2.1	114	+ 4 dB	-28 dB (façade as completed) - 11 dB (Volume)	-36 dB (25m)	non	Up to 43 dB(A)	52 dB(A)	Yes
		Category 3 periods – Sundays	Activities and equipment detailed in Section 6.2.1	114	+ 4 dB	-28 dB (façade as completed) - 11 dB (Volume)	-36 dB (25m)		Up to 43 dB(A)	52 dB(A)	Yes
		Category 4 periods – 11pm to 7am	Activities and equipment detailed in Section 6.2.1	114	+ 4 dB	-28 dB (façade as completed) - 11 dB (Volume)	-36 dB (25m)		Up to 43 dB(A)	44 dB(A)	Yes
Receiver 2 (R2) – Residential Receivers at 731 Bourke Street	Internal Construction including Fitout and Finishes including use within partially completed areas of the building	Category 2 periods – 7pm to 11pm	Activities and equipment detailed in Section 6.2.1	114	+ 4 dB	-28 dB (façade as completed) - 11 dB (Volume)	-49 dB (125m)	-5 dB Including barrier from neighboring structures	Up to 25 dB(A)	56 dB(A)	Yes
		Category 3 periods – Sundays	Activities and equipment detailed in Section 6.2.1	114	+ 4 dB	-28 dB (façade as completed) - 11 dB (Volume)	-49 dB (125m)		Up to 25 dB(A)	57 dB(A)	Yes
		Category 4 periods – 11pm to 7am	Activities and equipment detailed in Section 6.2.1	114	+ 4 dB	-28 dB (façade as completed) - 11 dB (Volume)	-49 dB (125m)		Up to 25 dB(A)	42 dB(A)	Yes

Table 12 Quantitative Assessment of Construction Noise during Extended Hours Periods, External Works (15-minute period)

Receiver Location	Source Noise	Time Period	Noise Source	Aggregate Sound Power Level dB(A) L_{10}	Correction for Number of areas with Activities in use	Building Corrections	Distance correction	Barrier/ Directivity Correction	Calculated Construction Noise Levels dB(A) L_{10}	Extended Hours Noise Criteria dB(A) L_{10}	Compliant
Receiver 1 (R1) – Wharf Terraces	Stage 2 limited external works	Category 2 periods – 7pm to 11pm	Activities and equipment detailed in Section 6.2.1	97	+ 4 dB	Non	-51 dB (140m)	-8 for line of sight barriers from building structures	Up to 42 dB(A)	52 dB(A)	Yes
		Category 3 periods – Sundays	Activities and equipment detailed in Section 6.2.1	97	+ 4 dB	Non	-51 dB (140m)		Up to 42 dB(A)	52 dB(A)	Yes
		Category 4 periods – 11pm to 7am	Activities and equipment detailed in Section 6.2.1	97	+ 4 dB	Non	-51 dB (140m)		Up to 42 dB(A)	44 dB(A)	Yes
Receiver 2 (R2) – Residential Receivers at 731 Bourke Street	Stage 2 limited external works	Category 2 periods – 7pm to 11pm	Activities and equipment detailed in Section 6.2.1	97	+ 4 dB	Non	-52 dB (160m)	-8 for line of sight barriers from building structures	Up to 41 dB(A)	56 dB(A)	Yes
		Category 3 periods – Sundays	Activities and equipment detailed in Section 6.2.1	97	+ 4 dB	Non	-52 dB (160m)		Up to 41 dB(A)	57 dB(A)	Yes
		Category 4 periods – 11pm to 7am	Activities and equipment detailed in Section 6.2.1	97	+ 4 dB	Non	-52 dB (160m)		Up to 41 dB(A)	42 dB(A)	Yes

Based on the above quantitative assessment of construction noise associated with the proposed extended hours period (Table 11 and Table 12), the resulting noise levels at the identified nearest receivers will be acoustically acceptable based on the proposed extended working hours for internal fitout and finishes as well as the external works proposed for the Stage 2 entry plaza, upper land bridge area and Art Gallery Road.

In addition to the calculated noise levels above, the following statements regarding construction noise during the proposed extended hours period are made:

1. Calculated noise levels represent the levels at the external façade of the neighbouring buildings. The resulting internal noise levels will be further mitigated within the surrounding in the event the façades are closed. As the Wharf Terraces located to the east of the site does not include windows or openings into residential dwelling which directly face the site there will be an additional reduction of noise to the levels detailed in the table above.
2. Calculated noise levels include the potential maximum levels resulting from construction activities. As construction includes period with varying noise levels, the periods when maximum noise is not being generated will result in lower noise levels impacting surrounding receivers than those detailed in the calculations above.
3. Other receiver locations within the vicinity of the site do not include residential dwellings and will not be negatively affected from noise resulting from the proposed internal works to be undertaken during the proposed extended hours period.
4. Tool box meetings informing works to enter and exit the site will be undertaken. Workers entering and exiting site during the extended working period are to be instructed not to park on Lincoln Crescent.

Subject to the implementation of the recommended management measures included in this report, the resulting noise impact from the proposed extended hours period within the Sydney Modern development will be acoustically acceptable.

6.2.3 Construction Noise Management – Qualitative Assessment

Based on the assessment conducted of the expected construction noise levels generated from the proposed extended hours construction period, the project noise levels are expected to comply with the relevant EPA and City of Sydney Council requirements for construction works undertaken outside of normal working hours.

The following management controls are required to be included as part of the extended hours working scheme to ensure noise levels comply with the relevant criteria:

1. All plant and equipment are to be maintained such that they are in good working order.
2. A register of complaints is to be recorded in the event of complaints being received, including location, time of complaint, nature of the complaint and actions resulting from the complaint.
3. A contact number is to be available during the period of works are being conducted such that complaints can be registered, investigated and mitigation undertaken.
4. If required, a noise level measurement of the offending plant item generating complaints is to be conducted and noise mitigations undertaken to reduce noise levels to within noise emission criteria. Alternatively, the equipment/activity is not to be undertaken during the extended hours period
5. The delivery and removal of material to and from the site is to be undertaken during the approved normal working hours of the project.
6. Workers are to be instructed not to park on Lincoln Cresset when they require access to the site during the proposed extended hours period and enter from Art Gallery Road.

Providing the recommended mitigation and management measures detailed above are included as part of the extended hours works to be undertaken in the site, the resulting noise impacts to the surrounding receivers will comply with the relevant EPA and City of Sydney Council requirements.

7 COMMUNITY ENGAGEMENT

Prior to the commencement of the proposed construction during extended hours period the building contractor is required to engage in community interaction. The community interaction and notification should be undertaken in accordance with the existing project requirements and include the following:

1. Notification of the proposed works to be undertaken on the site and the periods when works will be conducted, including information regarding the programme of works such as demolition and excavation.

2. A register of complaints, to be kept on site including record of time and nature of the complaint as well as the outcomes and comments regarding investigations resulting from the complaint.

3. Details of a contact numbers in the event of a complaint should be included on the perimeter of the site.

7.1 Community Notification

Community notification of the proposed construction period and periodic updates regarding scheduled works is required to be conducted. The community notification is to be undertaken using electronic notification using emails to relevant stakeholders. The notification should be provided in line with the project communication strategy and include the following:

1. Expected works to be undertaken in the upcoming period, typically monthly,

2. Proposed period when works are to be conducted during the proposed extended hours period,

3. Contact information of relevant construction personnel regarding complaints, including the construction community liaison officer.

4. Notifications to be provided electronic format. Notification to receivers identified in this report are required to be undertaken prior to works commencing during the extended hours.

5. Newsletter updates and community information will be available during the out-of-hours period consistent with the approved Community Consultation Strategy.

8 CONSTRUCTION NOISE MANAGEMENT

Based on the assessment conducted of the proposed extended hours construction, noise levels generated from the internal works are acoustically acceptable and comply with the relevant EPA and City of Sydney Council requirements. Providing suitable management controls are included as part of the works.

The required management controls include the following:

1. All material deliveries are to be conducted during the normal working hours.

2. The contractor site contact is required to be included on a site notification board displayed externally to the site.

3. All plant and equipment are to be maintained such that they are in good working order.

4. A register of complaints is to be recorded in the event of complaints being received, including location, time of complaint, nature of the complaint and actions resulting from the complaint.

5. A contact number is to be available during the period of works are being conducted such that complaints can be registered, investigated and mitigation undertaken.

6. If required, a noise level measurement of the offending plant item generating complaints is to be conducted and noise mitigations undertaken to reduce noise levels to within noise emission criteria. Alternatively, the equipment/activity is not to be undertaken during the extended hours period.

7. The delivery and removal of material to and from the site is to be undertaken during the approved normal working hours of the project.

8. Workers are to be instructed not to park on Lincoln Cresset when they require access to the site during the proposed extended hours period and enter from Art Gallery Road. Details of the proposed worker parking are included in the TTPA *Sydney Modern Expansion Project – Out of Hours Works Management Plan* with reference 142/1019 and dated 31 March 2021.

   Detailed within the *Sydney Modern Expansion Project – Out of Hours Works Management Plan* (point 4) the parking of works accessing the site for the extended hours periods are to use Mrs Macquarie Road, Art Gallery Road and the Domain Car Park. Parking on Lincoln Crescent is not to be undertaken.

9 NOISE AND VIBRATION MONITORING

As part of the management of noise and vibration during the proposed extended hours period the following noise and vibration measurements are recommended to be undertaken:

1. Noise –

    a. Permanent unattended continuous noise monitoring is to be undertaken during the period when the proposed extended hours of work is to be undertaken. Monitoring is to include a location which is representative for the noise impact to the Wharf Terraces (including the monitoring currently being undertaken as part of the main works).

        i. Noise monitoring is to include monitors which can be remotely accessed and downloaded in response to complaints.

        ii. The results of monitoring are to be included in a monthly report.

    b. Attended noise level measurements or noise monitoring (including the use of the currently installed noise loggers within the vicinity of the site) of typical internal and external works to be undertaken at the site. Construction noise monitoring or measurements of the site and surrounding impacts on neighbours should be undertaken during the following as a minimum:

        i. Commencement of internal and external works during the proposed extended hours period.

        ii. In response to any ongoing complaints received from neighbours.

        iii. Ongoing monthly report as currently undertaken as part of the main works of the project.

2. Vibration monitoring – Based on the proposed activities to be conducted on the location of the site (with physical separation to neighbouring buildings), vibration monitoring is not required for the works to be conducted during the extended hours period.

10 CONCLUSION

This report details the construction noise and vibration assessment of the extended hours construction period proposed to be used as part of the Art Gallery of NSW Sydney Modern Project.

The Assessment includes the assessment of potential noise impacts from the use of construction appliances internally (within the partially completed façade) as part of the proposed fiout and finishes of the project during the hours including

1. 6pm-12am Mon-Fri (6 additional hours per weekday);
2. 3.30pm-12am Sat (8.5 additional hours per Saturday); and
3. Sunday 7am-12am (17 additional hours per Sunday).

An assessment of noise and vibration impacts from the construction processes to be undertaken during the proposed extended working hours period both internally and external to the buildings as well as recommendations, including noise mitigations and community engagement, have been presented in this report.

The construction activities which have the potential to generate noise levels above extended construction hours criteria have been identified. The required noise management and mitigation which are required to be implemented during the use of these appliances are presented in this report.

Based on the assessment of noise and vibration during the proposed extended hours period the internal and limited external construction works will be acoustically acceptable and comply with the relevant EPA and City of Sydney Council requirements.

For any additional information please do not hesitate to contact the person below.

Regards

Ben White
Director

White Noise Acoustics

11 APPENDIX A: ACOUSTIC GLOSSARY

The following is a brief description of the acoustic terminology used in this report:

Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
LMax	The maximum sound pressure level measured over a given period.
LMin	The minimum sound pressure level measured over a given period.
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
dB (A)	'A' Weighted overall sound pressure level
Sound Pressure Level, LP dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, Lw dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt