Wanda

Wanda Sydney

Construction Noise and Vibration Management Plan

0001

Rev 2 | 28 October 2016

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 247747

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1 Introduction

Arup has been commissioned by Wanda to prepare a construction noise impact assessment for the Wanda Sydney development. The construction site is located within in the City of Sydney Central Business District.

This report assesses noise impacts associated with the Demolition, Basement Excavation and Construction of the Tower A and Tower B.

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

1.1 References

This document makes reference to the following documents:

- City of Sydney, Code of Practice (1992) Construction Hours/noise within the Central Business District
- NSW EPA (2009) Interim Construction Noise Guideline (ICNG)
- Australian Standard AS 2436 (2010) Guide to noise and vibration control on construction, demolition and maintenance sites
- British Standard BS 5228.1 (2009) Code of practice for noise and vibration control on construction and open sites – Part 1: Noise
- Department for Environment Food and Rural Affairs (United Kingdom) (2006), Update of noise database for prediction of noise on construction and open sites
- British Standard BS 6472 (1992) Evaluation of human exposure to vibration in buildings (1-80Hz)
- British Standard BS 7385.2 (1993) Part 2: Evaluation and measurement of vibration in buildings.
- German Standard DIN 4150 (1999) Part 3: Effects of vibration on structures.

2 Existing Acoustic Environment

2.1 Site Description

The Wanda Sydney site is located at Circular Quay, Sydney, as shown in Figure 1 below. It is bounded by George Street, Alfred Street, Pitt Street and Rugby Place.

The construction works include demolition, basement excavation and construction of Tower A and Tower B.

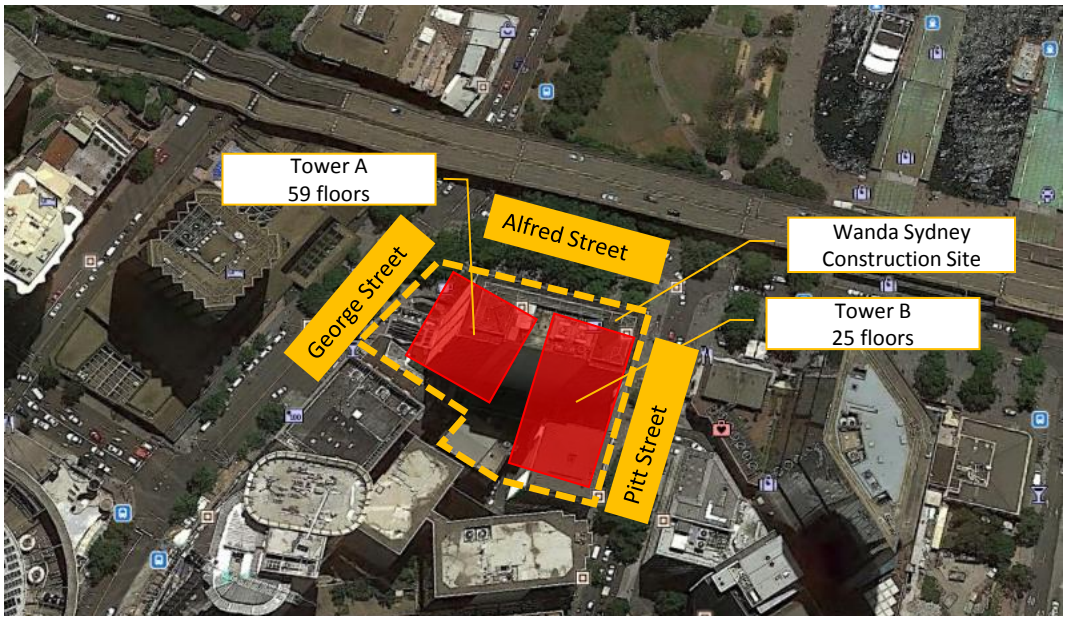

Figure 1: Site location

2.2 Noise Sensitive Receivers

The nearest noise sensitive receivers to the construction site are identified in Figure 2 with a summary of each receiver provided in Table 1.

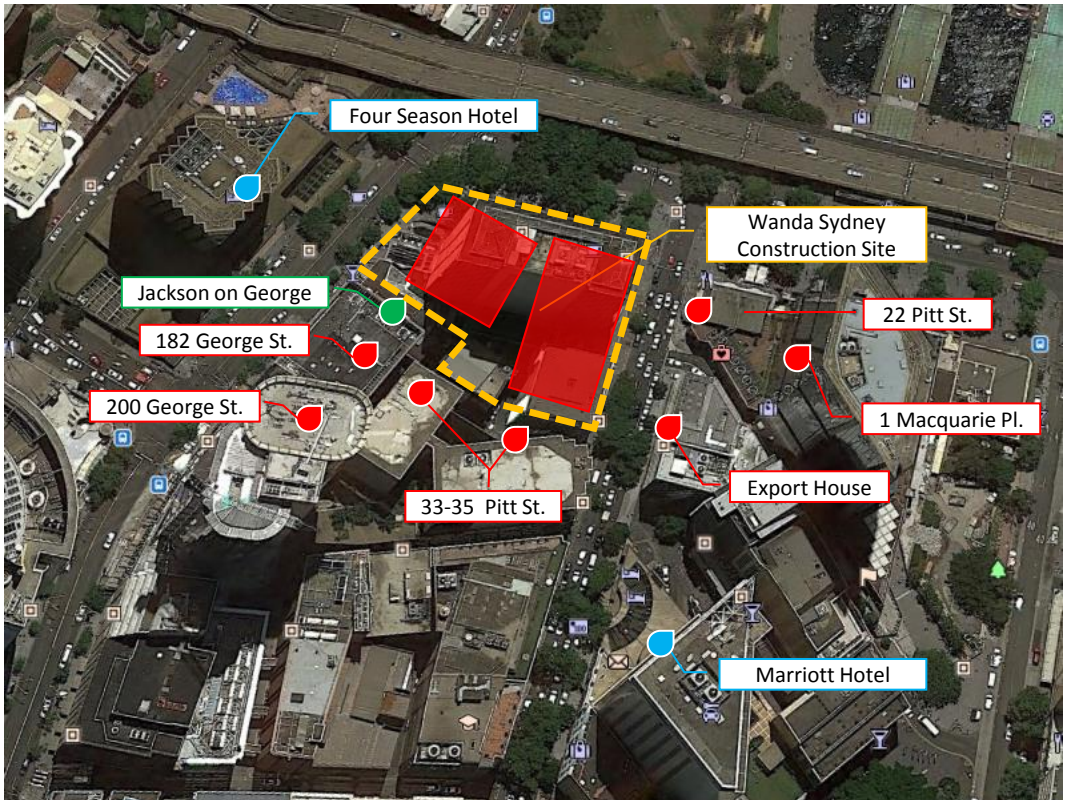

Figure 2: Noise sensitive receivers near the site.

Table 1: Summary of noise sensitive receivers

Noise Sensitive Receiver	Usage	Description
George Street Side		
Four Seasons Hotel	Hotel	~30 stories
Jacksons on George	Entertainment/Pub	3 stories This receiver is expected to be most affected during construction of the low levels (Level 1 – Level 4) of Tower A. * It is understood that a Planning Proposal and DCP Amendment has been submitted for upgrade to Jackson on George and has been on public exhibition.
182 George Street	Office	~18 stories This receiver is expected to be most affected during construction of the mid levels (Level 5 – Level 18) of Tower A.
200 George Street	Office	~35 stories This receiver is expected to be most affected during constructions of the high levels (Level 19 and above) of Tower A.
Pitt Street Side		
1 Macquarie Place	Office	~46 stories
22 Pitt Street	Commercial	3 stories

Noise Sensitive Receiver	Usage	Description
33-35 Pitt Street	Office	~10 stories * It is understood that a Planning Proposal and DCP Amendment has been submitted for upgrade to 33 Pitt Street and has been on public exhibition.
Export House	Office	~5 stories
Marriott Hotel	Hotel	~30 stories

2.3 Environmental Noise Monitoring

Environmental noise monitoring was conducted at the site between 1 June and 19 June, 2016. A combination of long term unattended noise logging and short term attended noise monitoring was used to define the ambient noise environment of the area. Locations used during the survey are depicted in Figure 3.

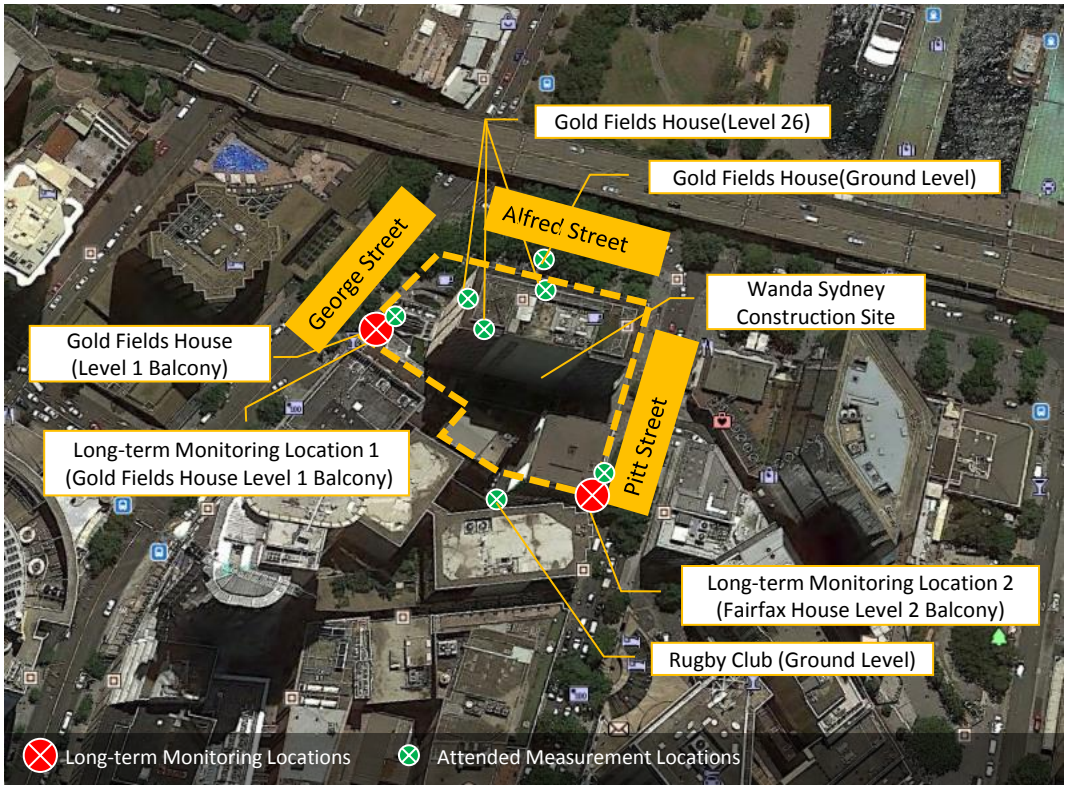

Figure 3: Environmental Noise Monitoring Locations

The following should be noted with regard to the noise monitoring period:

- Severe weather conditions were recorded, particularly on 1, 3, 4, and 5 June.
- Construction of Sydney Light Rail was taking place along George Street during the survey period.
- Paint removal works on the Cahill Expressway were planned but did not occur the noise monitoring, and this has been confirmed by a RMS officer (Mr. Zaw Oakkar).
- Vivid Sydney was running during the night-time periods.

The following measures were implemented to address the list of notes above:

Issue	Measure
All	Audio was recorded to identify the particular noise sources where outlier measurements were noted.
Weather	Weather data was obtained for the entire monitoring period from Bureau of Meteorology weather station at Observatory Hill and data excluded when weather conditions were considered to have impact on the noise logging results
	Noise loggers were redeployed for a second week to supplement limited data obtained during the first week of June
	Additional attended measurements were undertaken to confirm and supplement unattended noise monitoring data
Construction Noise	Measured data was reviewed and construction noise affected data removed from assessment
	Coordination with RMS and Light Rail Construction Team to confirm periods of construction
Vivid	Measured data was reviewed and removed from assessment in accordance with festival start times.

The following sections summarise parameters and results of both unattended and attended noise monitoring.

2.4 Unattended Noise Logging

Long term noise logging was conducted from 1 June 2016 to 15 June 2016. The two noise logging locations, as shown in Figure 3, were chosen to be representative of the ambient noise environment experienced at nearby potentially noise affected receivers. The noise loggers were set to continuously record L_{Aeq}, L_{Amax}, L_{A10} and L_{A90} noise indices with a measurement period of 15 minutes and a fast time response. Calibration of each logger was checked prior and subsequent to the survey with no significant drift being noted.

Measured data has been processed to derive the Rating Background Level (RBL) at each logger location for time periods as defined in the City of Sydney Code of Practice. The measured background noise levels are summarised in Table 2 below. Detailed noise logging data is included in Appendix B for reference.

Table 2: RBL Calculated from unattended noise logging results

Time	Location	Measured Background Noise Levels, Weekday dB $L_{A90,t}$	Measured Background Noise Levels, Saturday, dB $L_{A90,t}$
07.00-08.00	Location 1 (George Street Side)	61	62 [1]
	Location 2 (Pitt Street Side)	61	60
08.00-19.00	Location 1 (George Street Side)	62	62
	Location 2 (Pitt Street Side)	62	60
19.00-22.00	Location 1 (George Street Side)	62	62
	Location 2 (Pitt Street Side)	62	66
22.00-07.00	Location 1 (George Street Side)	59	61
	Location 2 (Pitt Street Side)	56	56

Notes:

[1] Unattended noise logging data measured for this time period was excluded due to adverse weather. It has been derived based on attended measurements and relationship between Location 1 and Location 2.

It should be noted that evening and night-time measured noise levels are potentially not representative of normal conditions due to Vivid festival being in operation. However, this assessment is based on daytime criteria only and this is discussed further in Section 3.2.

2.5 Attended Short Term Noise Measurements

Attended short term noise measurements were conducted on 2 June and 18 June 2016 at various locations (identified in Figure 3) to confirm and supplement the long term noise logging. Where possible, attended measurements were conducted simultaneously with unattended noise logging to enable comparison of results between attended measurements and long term noise logging.

Results of the attended noise surveys are summarised in Table 3.

Table 3: Attended noise monitoring results

Location	**Time**	**Measured Sound Pressure Levels, dB $L_{A90, 15mins}$**
Gold Fields House facing George Street (Location 1)	Typical Weekday 2 June, 2016 10.30-13.15	61
FairFax Building (Location 2)		62
Gold Fields House @ L26 facing West		66
Gold Fields House @ L26 facing South		67
Rugby Club		64
Gold Fields House facing George Street (Location 1)	Saturday 18 June, 2016 12.00	61

It is noted that the noise levels measured on Level 26 of Gold Fields House are approximately 5 dB higher than on Level 1. This is due to the influence of rooftop plant noise from nearby buildings, and traffic noise from Harbour Bridge and Cahill Expressway. This has been taken into consideration when deriving assessment criteria.

3 Assessment Criteria

3.1 Proposed Working Hours

The proposed working hours for construction are summarised as follows:

- Monday to Friday (inclusive) 07.00 to 19.00
- Saturday 07.00 to 17.00

This is the standard Category 1 working hours according to the City of Sydney Code of Practice.

3.2 City of Sydney Noise Criteria

3.2.1 Receiver noise criteria

The following is an excerpt from Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992.

TABLE 1

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

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).

Figure 4: Table 1 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992

Project specific noise criteria are presented in Table 4 and have been developed based on measured noise data summarised in Section 2 and the criteria for Category 1 working hours as defined in Figure 4.

Table 4: Noise Criteria at Noise Sensitive Receivers for Excavation and Construction

Day	**Time Zone**	**Location**	**Noise Criteria at the nearest Nominated Occupancy dB $L_{A\ av\ max,\ 15mins}$ [1]**	
			Low / Mid Levels (Level 18 and below)	**High Levels (Level 19 and above)**
Monday to Friday	07.00 to 08.00	George Street Side	66	71
		Pitt Street Side	66	71
	08.00 to 19.00	George Street Side	67	72
		Pitt Street Side	67	72
Saturday	07.00 to 08.00	George Street Side	67	72
		Pitt Street Side	65	70
	08.00 to 17.00	George Street Side	67	72
		Pitt Street Side	65	70

Note:
[1] According to "para 18.g of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992", L_{A10} is deemed to be equivalent to $L_{A\ av\ max.}$
[2] The noise criteria is developed based on "Background + 5 dB". An extra 5 dB relaxation is to be determined on a site basis according to "Table 1 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992".

Assessment criteria for mid and high levels of receiver buildings are 5 dB higher based on the measured background noise levels being 5 dB higher.

Noise Sensitive Receivers that apply to criteria on the George Street side of the development are The Four Seasons Hotel, Jackson on George, 200 George Street, & 182 George Street.

Noise Sensitive Receivers that apply to criteria on the Pitt Street side of the development are 33-35 Pitt Street, The Marriott Hotel, Export House, 1 Macquarie Place and 22 Pitt Street.

3.2.2 Appliance Noise Limits

Para 49 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992, states that the $L_{A\ av\ max}$ noise level emitted by that Appliance as measured over a one minute period should not greater than the noise level specified in Schedule 1 as measured at a distance of 7 meters from the nearest point of the Appliance. The Schedule 1 has been reproduced in the following Figure 5.

SCHEDULE 1

LISTED APPLIANCES AND ALLOWABLE NOISE LEVELS

GROUP A (see Note 2)	GROUP B 90dBA	GROUP C 85dBA	GROUP D 80dBA	GROUP E 75dBA	GROUP F 70Dba
Pile drivers Hydraulic hammers Machine mounted rock breakers Sand blasters Steam cleaners Mole borers	Earthmoving equipment of engine capacity above 200kW NEP Warning sirens* Reversing alarms+ Trucks	Impulsive tools - air, electric or hydraulic Earthmoving equipment of engine capacity between 100kW and 200kW NEP Explosive power tools Impact wrenches Refuse chutes* Scabblers Chain saws Rock drills	Concrete agitators Concrete pumps Concrete saws Cranes (fixed) Cranes (mobile) Earthmoving equipment up to and including engine capacities of 100kW NEP Concrete vibrators Portable hand tools Vibratory compacters	Air compressors above 170 L/s capacity Construction dumpers over 1m^3 capacity Public address system* Internal combustion or electrically driven equipment (unless grouped elsewhere) over 14kW NEP	Air compressors up to 170 L/s capacity Fluid pumps Internal combustion or electrically driven equipment (unless grouped elsewhere) up to 14kW NEP

* To be measured at the site boundary closest to the affected area.
\+ Reversing alarms must be controlled so that noise levels produced do not exceed the background sound level by more than 10dBA.

Notes

1. Where any appliance is unable to comply with the allowable noise level, para 43 applies.

2. A Certificate of Acoustic Performance (see Form D) shall be provided for each appliance listed in Group A.

3. All noise levels are to be $L_{A\ av\ max}$ (1 minute) measured at 7 m from the point nearest to an Appliance.

4 "NEP" means the Net Engine Power and shall be determined in accordance with Australian Design Rule No.28/00 External Noise of Motor Vehicles, Other Than L-Group Vehicles dated March 1989;

Figure 5: Schedule 1 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992

In addition, para 50 of Construction Hours/noise within the Central Business District, City of Sydney, Code of Practice 1992, states the following:

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

It is noted that this requirement may not be practically achieved at all times, even when equipment complies with the appliance noise limits, as work will at times occur in close proximity to the subject site boundary.

3.3 NSW EPA ICNG

This assessment has also given consideration to the approach and procedures outlined in the NSW EPA Interim Construction Noise Guideline. The Guideline was developed by a number of state and local government along with extensive public consultation and industry stakeholder engagement. The Standards Australia committee was also consulted.

Unlike the City of Sydney policy, the guideline acknowledges the challenges of completely mitigating construction noise impacts and rather than setting limits which must not be exceeded, provides construction management noise levels above which all feasible and reasonable work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 5 and other sensitive receivers in Table 6 below. While the ICNG, sets reduced standard hours, the proposed construction hours set out in Section 3.1 have been adopted for other DPE and EPA approved development occurring in the city area.

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 NOTE: Project standards hours in Section 3.1	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
		• times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 *of the ICNG.*

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.

3.4 Vibration Criteria

3.4.1 Human Comfort

The NSW EPA's Assessing Vibration Guideline (Department of Environment and Conservation NSW, February 2006) provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472.

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

As noted in the Guideline, situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances, such as a construction or excavation projects. Notwithstanding, the recommended vibration limits for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration in Table 7 and Table 8 respectively.

Table 7: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

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

Table 8: Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$)

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

3.4.2 Building damage

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

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

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

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

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

"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if

- cracks form in plastered surfaces of walls;
- existing cracks in the building are enlarged;
- partitions become detached from loadbearing walls or floors.

These effects are deemed ‘minor damage." (DIN4150.3, 1990, p.3)

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

3.4.2.1 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 9 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 (1993, p.5) notes that “*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*”.

Table 9: BS 7385-2 structural damage criteria

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

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

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

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

3.4.2.2 German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure'* (DIN 4150-3) also gives guidelines for short-term and steady state structural vibration and are generally recognised to be conservative. The criteria are presented in Table 10.

Table 10: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

The guidelines state that:

> *"Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding the values in table [17] does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary."*

The most stringent limit recommended in the German Standard is 3 mm/s. This criterion is applicable to particularly sensitive constructions such as heritage structures. While the Tank Stream is a heritage listed structure, in line with BS 7385 Part 2 (1993) "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" As the Tank Stream does not correspond to the structural types provided in DIN 4150, a site specific vibration monitoring strategy will need to be developed by the contractor in order to ensure this location is safeguarded against structural damage.

4 Assessment

4.1 Construction Equipment and Staging

In consultation with Turner & Townsend, Thinc and Wanda a list of proposed construction activities and associated items of equipment has been developed along with likely staging and simultaneous operation throughout each stage of construction. The locations of equipment have been decided based on *Construction Management Plan Rev 2 dated 26 Oct 2016 by* PTW Architects. This forms the basis of assessment of construction noise impacts. It is noted that the construction activities and appliances mentioned in this document are indicative and are provided for information only.

The sound power levels of the proposed appliances have been derived with reference to the AS 2436:2010 and DEFRA documents. Where an appliance is shown in both documents, the highest sound power level has been used for the purpose of this assessment.

The sound pressure level of an appliance within Group B to F is taken to be not higher than the allowable noise levels specified in Schedule 1 (refer Figure 5).

Table 11: Sound power levels of proposed appliances

Appliances	**Assumed Sound Power Level per equipment, dB(A)**	**Predicted Sound Pressure Level @7m per equipment, dB(A)**
Gold Fields House Major Demolition		
Tower Crane	105	80
Mobile Crane	105	80
12t Excavator with Pulverisor [1]	111	86
13t Excavator with Pulverisor hammer grapple [1]	111	86
5t Excavator with whipper & grapple [1]	107	82
Skid steer Loader x2	105	80
Tipping Semi Trailer	103 [2]	78
Rugby Club/Fairfax House Demolition		
Tower Crane	105	80
Mobile Crane	105	80
12t Excavator with Pulverisor [1]	111	86
13t Excavator with Pulverisor hammer grapple [1]	111	86
5t Excavator with whipper & grapple [1]	107	82
Skid steer Loader x2	105	80
Tipping Semi Trailer	103 [2]	78
Basement Excavations		

Appliances	Assumed Sound Power Level per equipment, dB(A)	Predicted Sound Pressure Level @7m per equipment, dB(A)
Excavators x 4	115	90
Excavator Hammer	118	93
Rigid Trucks x 4	105	80
Constructions of Tower A and B		
Tower Crane x 2	105	80
Static Concrete Pump x2	105	80
Rigid Trucks x 4	105	80
Concrete Saw (inside the building)	105	80

Notes:

[1] Appliance of a class not specified in Group B to F (inclusive) of Schedule 1 (refer to Figure 5)

[2] The sound power level and sound pressure level for trucks are assumed to be measured when it is passing by. A time correction has therefore been applied to correct for each 15 minute period.

The base data shown above has been used in calculations of the resulting noise levels. It is noted that out of necessity, the assessment has to be made using generic equipment noise data and checks should be made when specific plant selections are available.

4.2 Predicted Noise Levels For Demolition Stage

Noise levels at external noise-sensitive receivers have been predicted taking into account distance loss and any acoustic screening from intervening structures where appropriate.

For works at high and mid-levels, demolition will be contained within the building footprint of the existing Gold Fields House, Rugby Club and Fairfax House. For works at low levels, there is a potential for works to be undertaken right across and up to the site boundary. This has been taken into account when calculating noise impacts to nearby receivers.

The level on noise impact will vary depending on the specific location of each piece of equipment in relation to the nearest noise sensitive receivers. When an item of equipment is closer to the receiver location, the noise impacts will be higher. A distribution of equipment has therefore been adopted across the site when predicting noise impacts with a range of predicted noise levels being presented.

For calculation of noise impacts, the screening effect of the Rugby Club and Fairfax House buildings has not taken into account conservatively.

Predicted noise levels at the nearest affected noise sensitive receivers for each stage of demolition are provided in Table 13.

Table 12: Predicted Noise Levels at Noise Sensitive Receivers - Unmitigated

Stage of Demolition	Most Affected Noise Sensitive Receivers	Predicted Noise Levels, dB(A)	Assessment Criteria, dB(A)	Compliance
High Level (Level 19 – Level 26)	Four Seasons	71 - 73	71-72	N
	200 George St.	71 - 73	71-72	N
	1 Macquarie Place	73 - 75	70-72	N
	Marriott	72 - 74	70-72	N
Mid Level (Level 5 – Level 18)	Four Seasons	71 - 73	66-67	N
	182 George St.	82 - 86	66-67	N
	33-35 George St.	86 - 94	66-67	N
	1 Macquarie Place	73 - 75	65-67	N
	Marriott	72 - 74	65-67	N
Low Level (Basement to Level 5)	Four Seasons	74 - 78	66-67	N
	Jackson on George [1]	85 - 93	66-67	N
	33-35 George St.	79 - 91	66-67	N
	22 Pitt Street	76 - 82	65-67	N
	Export House	77 - 84	65-67	N
	Site Boundary	85 - 94	85	N

[1] Noise levels predicted at the location of window on Level 2 (outside)

In the base case, exceedances are predicted to all noise sensitive receiver locations for demolition scenario.

In line with the procedures of the NSW ICNG, Section 5 discusses potential mitigation measures for implementation.

4.3 Predicted Noise Levels For Basement Excavation and Construction Stage

The basement excavation of rock will be conducted at 5m below the ground level, which provides acoustic barrier effect to reduce the noise level on low floors of noise sensitive receivers. The higher floors of noise sensitive receiver will receive less benefit from acoustic barrier effect. However, the noise attenuates as the distance to the source increases, which has been taken into consideration in the calculations.

The hoarding and concrete barriers around the site have been modelled as an acoustic barrier.

The level of noise impact will vary depending on the specific location of each piece of equipment in relation to the nearest noise sensitive receivers.

Predicted noise levels at the nearest affected noise sensitive receivers for each stage of construction are provided in Table 13.

Table 13: Predicted Noise Levels at Noise Sensitive Receivers - Unmitigated

Stage of Constructions	Most Affected Noise Sensitive Receivers	Predicted Noise Levels, dB(A)	Assessment Criteria, dB(A)	Compliance
Basement Excavation	Four Seasons	65	66-67	Y
	Jackson on George	72	66-67	N
	33-35 George St.	75	66-67	N
	Export House	73	65-67	N
	182 George St.	71	66-67	N
	200 George St.	63	66-67	Y
	Marriott Hotel	63	65-67	Y
	1 Macquarie Place	67	65-67	N
	Site Boundary	80	85	Y
Construction Low Level (Basement – Level 4)	Four Seasons	65	66-67	Y
	Jackson on George	73	66-67	N
	33-35 George St.	74	66-67	N
	Export House	76	65-67	N
	182 George St.	71	66-67	N
	200 George St.	64	66-67	Y
	Marriott Hotel	65	65-67	Y
	1 Macquarie Place	70	65-67	N
	Site Boundary	88	85	N
Construction Mid Level (Level 21 – Level 25)	Four Seasons	65	71-72	Y
	182 George St.	65	71-72	Y
	200 George St.	67	71-72	Y
	Marriott	65	71-72	Y
	1 Macquarie Place	68	70-72	Y
Construction High Level (Level 40 and above)	Four Seasons	49	71-72	Y
	182 George St.	55	71-72	Y
	200 George St.	62	71-72	Y
	Marriott	54	70-72	Y
	1 Macquarie Place	61	70-72	Y

In the base case, exceedances are predicted to some noise sensitive receiver locations for both the excavation and construction scenarios.

In line with the procedures of the NSW ICNG, the following section discusses potential mitigation measures for implementation.

5 Construction Noise and Vibration Management

In order to address potential exceedance, the following management measures are recommended for consideration. These recommendations are provided for information to contractors for tendering purposes. A final construction noise and vibration management plan will be developed for the site by the successful contractor and should include provisions for community engagement and noise and vibration monitoring.

5.1 General

- Where possible, it is recommended to concentrate high noise activities in one location and move to another as quickly as possible. This will help to minimise the duration of noise disturbance to any given receiver. Equipment should be turned off when not in use.
- The equipment shall be well maintained and a noise monitoring audit program should be put in place to confirm that high noise intrusive appliances remain within specified limits.
- Consideration shall be given to the use of non-“beeper” reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise-sensing alarms.

5.2 Project Specific

- When demolishing mid and upper levels, consideration should be given that the building façade remains in place as long as practicable to afford acoustic shielding to nearby residences where possible.
- An acoustic enclosure for the concrete pump could be considered where possible.
- Consideration could be given to staging of demolition and construction of the various buildings to maintain as much acoustic shielding as possible to neighbouring receivers.
- Noise barriers at the site boundary are recommended.

5.3 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.

5.4 Noise Monitoring

Once a detailed construction programme is developed an environmental noise monitoring plan will be developed by the successful contractor to coincide with potentially noisy activities and determine noise levels experienced on site. This can be via a combination of either operator attended or unattended noise monitoring.

Selection of monitoring locations will take into account the locations of the noise sensitive receivers identified in Figure 2. Additional attended noise monitoring at other locations and plant and equipment monitoring on-site should also take place as and when necessary.

5.4.1 Reporting

Reports covering the attended monitoring will be prepared after each monitoring session. The reports will summarise and interpret the results of each session of noise monitoring.

5.5 Complaints Handling

Active communication with nearby noise sensitive receivers will be key in managing potential noise impacts.

A communications register will be established to record incoming complaints. The registration of a particular item shall remain open until the complaint has been appropriately dealt with. It will be the responsibility of the successful contractor to develop an appropriate communications strategy for excavation and construction works, the following sections are provided for information.

5.5.1 Communication and Complaints

Throughout the construction period, Building Managers/occupiers of the main adjoining noise sensitive properties likely to be most affected by site works and the operation of plant/machinery particularly during the demolition, excavation and construction phases will be notified of impending noisy activities, any changes to the works, and reports on progress.

A contact telephone number for the project will be established and be clearly stated in the communication to nearby receivers. The person who answers this number should have a noise complaints pro-forma specifically developed for the project. The complainant will be asked specific questions in order to get all the relevant information that will allow the complaint to be dealt with expediently and effectively.

When a complaint is received, the complainant will be notified when they can expect a follow-up call after their lodging of the complaint. This call should give details of the proposed or actual resolution to the complaint.

If actions have not been taken to resolve the complaint within the specified time period, the complainant will be notified on completion of the actions in addition to the acknowledgement call to advise progress with the complaint.

Upon completion of the proposed actions to resolve the complaint the complainant will be notified and asked whether the complaint has been resolved to their satisfaction and/or whether the complaint now meets the relevant project criteria.

Upon receipt of a complaint in relation to noise it is the responsibility of the successful contractor to coordinate the project team to:

- Ascertain from the complaint what appliance / activity is causing the problem.
- Establish, by way of monitoring, if the allowable noise level has been exceeded for specific plant and general site noise.
- Terminate activity or offending item of plant / machinery if the allowable levels have been exceeded, or take other acoustic remedial action to reduce noise levels to within allowable limits.

Where stopping the activity would create a safety issue the contractor should permit the activity to continue only as long as is necessary to make the area safe. The activity should then be directed to cease.

Any activity that is directed to cease due to excessive noise should not recommence until the contractor is satisfied that the requirements of this plan can be met and has given permission to recommence the activity.

The contractor should ensure that a report of any incident is included in the site records and provided to any relevant stakeholders.

5.5.2 Dispute Resolution

Should any complaint not be resolved satisfactorily and results in a dispute, the offending activity of the works should be stopped and not allowed to continue until at least one of the following conditions has been met:

- The complaint has been resolved and communicated to the complainant.
- It has been demonstrated that the relevant noise criteria is met.

5.6 Vibration management

The following guidance provides recommended minimum working distances for vibration intensive plant. These are based on international standards and guidance and reproduced in Table 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)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

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

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

6 Conclusion

A preliminary construction noise and vibration management plan has been provided to demonstrate potential noise impacts associated with proposed demolition, basement excavation and construction works for the Wanda Sydney development.

Appendix A

Glossary

Ambient Noise Level

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

Background Noise Level

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

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background LA90 noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / minLA90,1hour)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and minLA90,1hour in QLD.

Decibel

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

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

dB(A)

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

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

Some typical dB(A) levels are shown below.

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

L1

The L1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB LA1,15min is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L10

The L10 statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L10 level is the sound level exceeded for 10% of the measurement duration. L10 is often used for road traffic noise assessment. As an example, 63 dB LA10,18hr is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L90

The L90 statistical level is often used as the “average minimum” or “background” level of a sound level that varies with time.

Mathematically, L90 is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB LA90,15min is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

Leq

The ‘equivalent continuous sound level’, Leq, is used to describe the level of a time-varying sound or vibration measurement.

Leq is often used as the “average” level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB LAeq. Often the measurement duration is quoted, thus LAeq,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” or “low-pitched” and sounds with a higher frequency are perceived as “treble” or “high pitched”.

Peak Particle Velocity (PPV)

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

PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the Lmax or Lmax,spec index.

Sound Power and Sound Pressure

The sound power level (Lw) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (Lp) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Appendix B

Noise Logging Data

B1 24hr Representative Noise Logging Graphs

The following graphs are derived by taking the arithmetic average for the L_{A1}, L_{A10} and L_{A90} indices and the logarithmic average of L_{Aeq} of each 15 minute measurement period. Data is presented for each logging location and has been separated into weekday and weekend data for reference.

B1.1 Monitoring Location 1 – Gold Fields House

As discussed in Section 2.3 measurements at this location were severely affected by weather data. Due to heavy storms, this logger stopped logging after 4 days. Usable data was extracted from the measurements. Missing data has been supplemented by additional attended measurements as discussed in Section 2.5.

The peak in L_{Aeq}, L_{A10}, and L_{A1} noise indices from 9:00 to 13:00 is due to adverse weather and has been removed when deriving assessment criteria. It is noted that the L_{A90} noise levels are remain largely constant through this period.

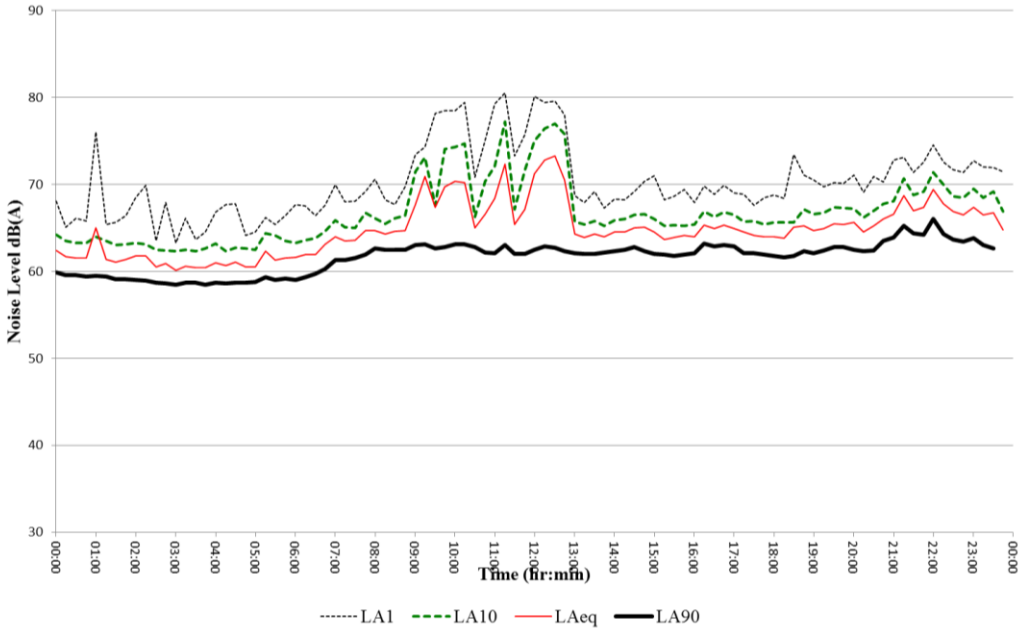

Figure 6: Average Weekday Measured Ambient Noise Levels – Gold Fields House

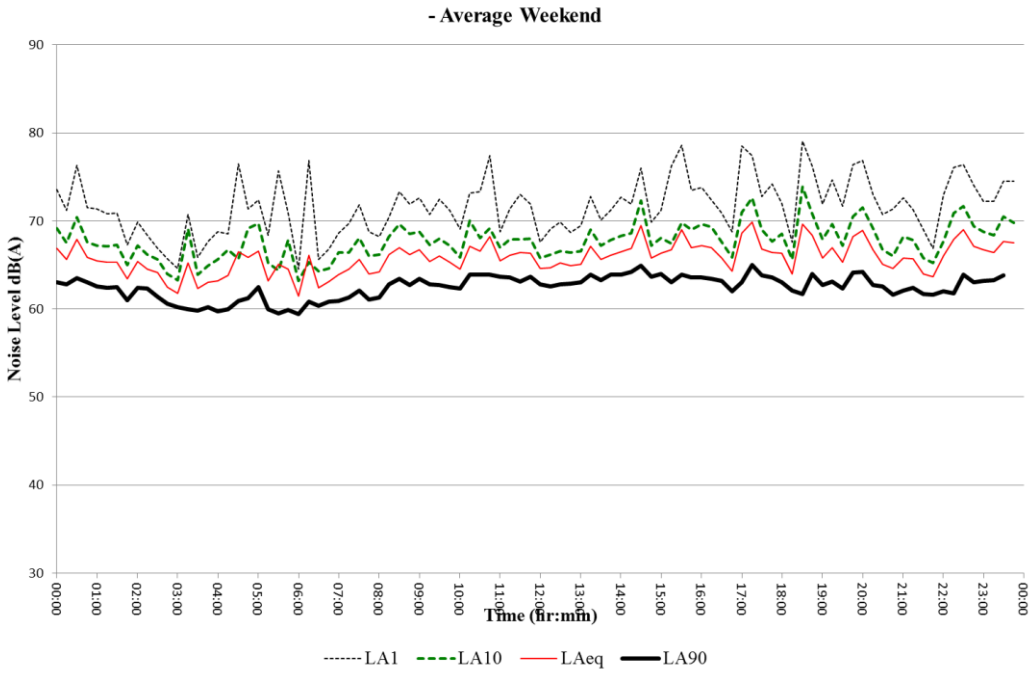

Figure 7: Average Weekend Measured Ambient Noise Levels – Gold Fields House

B1.2 Monitoring Location 2 – Fairfax House

Measured data at this location is noted to have lower noise levels during the night-time period. A steady increase in ambient noise levels is observed from approximately 18:00 and is more significant in the weekend data. This is attributable to noise impacts associated with Vivid Sydney and this has been taken into account when deriving assessment criteria.

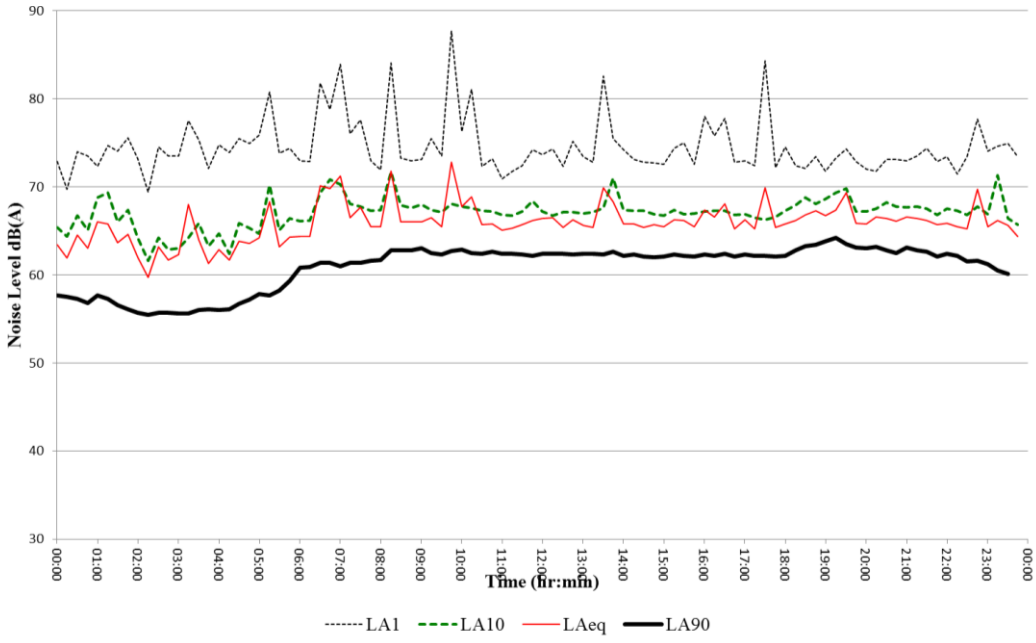

Figure 8: Average Weekday Measured Ambient Noise Levels – Fairfax House

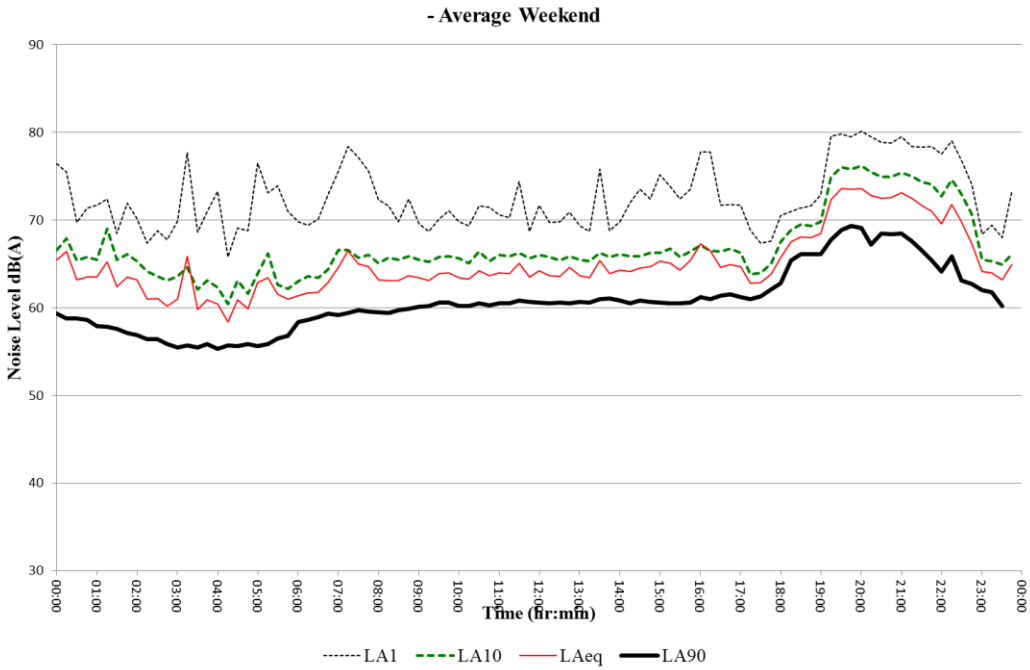

Figure 9: Average Weekend Measured Ambient Noise Levels – Fairfax House