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LORETO KIRRIBILLI REDEVELOPMENT

Stage 1 (Western Precinct) DA Operation and Construction Noise and Vibration Assessment

17 August 2017

Artazan Property Group

TJ415-01F05 Acoustic Stage 1 DA Assessment (r7)

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1 Introduction

Renzo Tonin & Associates was engaged to prepare an acoustic assessment to support the Development Application (DA) for the proposed Stage 1 (Western Precinct) redevelopment of Loreto Kirribilli (Loreto), located at 85 Carabella St, Kirribilli.

This report addresses operational and construction noise and vibration from the Stage 1 (Western Precinct). The report has been prepared in accordance with the acoustic requirements of Secretary's Environmental Assessment Requirements (SEARs), North Sydney Council and NSW Environmental Protection Authority (EPA).

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Project description

2.1 Site location

Loreto Kirribilli is located at 85 Carabella St, Kirribilli. The site currently contains two road frontages, with Elamang Avenue to the north and Carabella Street to the south. Multi-storey residential apartments are located along the western site boundary and free standing residential dwelling are located along the eastern site boundary. Both multi-storey residential apartments and free standing dwelling are located across Elamang Avenue and Carabella Street.

Figure 1 presents an aerial photograph of the subject site and surrounding area.

2.2 Hours of operation

The hours of operation for the Stage 1 (Western Precinct) are 8:30am to 3:30pm Monday to Friday.

Figure 1: Subject site and surrounding area (Source – Nearmap_Jan_2017)

2.3 Development proposal

The preliminary draft of the site masterplan was issued in May 2016. The major areas of works along with the existing school layout is shown in Figure 2. Whilst this assessment pertains to the Western Precinct works, the other precinct works have also been considered to account for cumulative impacts. The works can generally be summarised as follows;

- Western Precinct
  - Demolition of B-Block
  - Construction of Learning Hub & Gymnasium Extension
- Northern Precinct
  - Construction of Vertical Connector
- Eastern Precinct –
  - Demolition of Music & Performing Arts & Mary Ward
  - Construction of New Junior School and 2 storey carpark
- Southern Precinct –
  - Construction of Vertical Connector between Chapel and J-Block
  - Demolition of Junior School
  - Construction of Music & Performing Arts (inc. 500 seat auditorium).

Figure 2: Precinct Plan - Source Loreto Kirribilli Masterplan

The acoustic assessment has been prepared on the basis on the following documentation:

Table 1: Reference documentation

Discipline	Ref no.	Rev	Title	Date
Architectural - Francis-Jones Morehen Thorp	-	-	160502 Loreto Kirribilli Masterplan (89 page document)	May 2016
	DA-1001	01	Cover Sheet	7/07/2017
	DA-1002	01	Site Plan - Precincts	7/07/2017
	DA-2001	01	Masterplan Demolition Plan - LG4 LG3	7/07/2017
	DA-2002	01	Masterplan Demolition Plan - LG2 LG1	7/07/2017
	DA-2003	01	Masterplan Demolition Plan - G L1	7/07/2017
	DA-2004	01	Masterplan Demolition Plan - L2 L3	7/07/2017
	DA-2005	01	Masterplan Demolition Plan - L4 L5	7/07/2017
	DA-2101	01	Masterplan Proposed Plan - LG4 LG3	7/07/2017
	DA-2102	01	Masterplan Proposed Plan - LG2 LG1	7/07/2017
	DA-2103	01	Masterplan Proposed Plan - G L1	7/07/2017
	DA-2104	01	Masterplan Proposed Plan - L2 L3	7/07/2017
	DA-2105	01	Masterplan Proposed Plan - L4 L5	7/07/2017
	DA-2201	01	Western Precinct Learning Hub - Lower Ground 4	7/07/2017
	DA-2202	01	Western Precinct Learning Hub - Lower Ground 3	7/07/2017
	DA-2203	01	Western Precinct Learning Hub - Lower Ground 2	7/07/2017
	DA-2204	01	Western Precinct Learning Hub - Lower Ground 1	7/07/2017
	DA-2205	01	Western Precinct Learning Hub - Ground Level	7/07/2017
	DA-2206	01	Western Precinct Learning Hub - Level 1	7/07/2017
	DA-2207	01	Western Precinct Learning Hub - Roof - Outdoor Terrace	7/07/2017
	DA-2301	01	Northern Precinct - Lower Ground 4	7/07/2017
	DA-2302	01	Northern Precinct - Lower Ground 3	7/07/2017
	DA-2303	01	Northern Precinct - Lower Ground 2	7/07/2017
	DA-2304	01	Northern Precinct - Lower Ground 1	7/07/2017
	DA-2305	01	Northern Precinct - Ground Level	7/07/2017
	DA-2306	01	Northern Precinct - Level 1 (Roof)	7/07/2017
	DA-2401	01	Eastern Precinct - Lower Ground 2 - Stage 1	7/07/2017
	DA-2501	01	Southern Precinct - Lower Ground 1	7/07/2017
	DA-2502	01	Southern Precinct - Ground Level	7/07/2017
	DA-2503	01	Southern Precinct Level 1	7/07/2017
	DA-2504	01	Southern Precinct Level 2	7/07/2017
	DA-2505	01	Southern Precinct Level 3	7/07/2017

Discipline	Ref no.	Rev	Title	Date
	DA-2506	01	Southern Precinct Level 4	7/07/2017
	DA-2507	01	Southern Precinct Level 5	7/07/2017
	DA-2508	01	Southern Precinct Roof	7/07/2017
	DA-3001	01	Elevations - Site	7/07/2017
	DA-3002	01	Elevations 1- Western Precinct Learning Hub	7/07/2017
	DA-3003	01	Elevations 2 - Western Precinct Learning Hub	7/07/2017
	DA-3004	01	Elevations - Northern Precinct Connector	7/07/2017
	DA-3005	01	Elevations - Southern Precinct Connector	7/07/2017
	DA-4001	01	Sections 1 - Western Precinct Learning Hub	7/07/2017
	DA-4002	01	Sections 2 - Western Precinct Learning Hub	7/07/2017
	DA-4003	01	Sections - Northern Precinct Connector	7/07/2017
	DA-4004	01	Sections - Southern Precinct Connector	7/07/2017
Traffic - McLaren Traffic Engineering	16575.01DA	A	Traffic and Parking Impact Assessment of Loreto School at 85 Carabella Street, Kirribilli	13 March 2017

2.4 Acoustic aspects, methodology

In order to assess the potential noise impact from the development proposal, the following methodology was adopted:

- Identify nearest sensitive receiver locations to the subject site.
- Determine existing background noise levels at the receiver locations.
- Use ambient noise and background levels to establish noise goals in accordance with the acoustic requirements of SEARs, North Sydney Council and NSW EPA.
- Using predictive noise modelling to determine the extent of noise impact from the proposal on the nearest sensitive receivers. Including, noise generated by all external and internal student areas, loading docks, noise generated from onsite car parks and vehicle movements, as well as noise generated from potential increased traffic on the surrounding road network,
- Identify where noise emission from the proposal may exceed the noise goals, and
- Where noise emission from the proposal may exceed the noise goals, provide recommendations to reduce noise impacts from the site.

3 Noise criteria and SEARs

The following sections presents criteria applicable to noise generated by the school students within classrooms and external areas, on-site vehicle movements, loading dock, carparks, music noise (Music and Performing Arts building), mechanical equipment, as well as noise generated from potential increased traffic on the surrounding road network.

3.1 SEARs

The Department of Planning and Environment have prepared Secretary's Environmental Assessment Requirements (SEARs) for the project.

For the Concept Proposal, the SEARs state:

- ***Noise and Vibration***

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

- *Relevant Policies and Guidelines:*
- *NSW Industrial Noise Policy (EPA)*

For Stage 1, the SEARs state:

- ***Noise and Vibration***

Identify and provide a quantitative assessment of the main noise and vibration generating sources and activities during the construction of Stage 1. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.

- *Relevant Policies and Guidelines:*
- *Interim Construction Noise Guideline (DECC)*
- *Assessing Vibration: A Technical Guideline 2006*

In addition:

The EPA has identified the following site specific concerns base on the information (including the draft SEARs) supplied to it by Department of Planning and Environment in its letter dated 29 August 2016:

(c) demolition, site preparation and construction phase noise and vibration impacts (including recommended standard construction hours and intra-day respite periods for highly intrusive noise generating work) on noise sensitive receivers such as surrounding residences:

(f) operational noise and vibration impacts on noise sensitive receivers (especially surrounding residences) arising from operational activities such as public address/school bell systems, community use of school facilities, waste collection services and mechanical services (especially air conditioning plant).

3.2 Industrial Noise Policy (INP)

In accordance with the SEARs conditions, noise emission from school students within classrooms and external areas, on-site vehicle movements, loading dock, carparks, music noise (Music and Performing Arts building) and mechanical equipment are assessed in accordance with the NSW Industrial Noise Policy (INP). The assessment procedure of the NSW INP has two components, being:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for particular land uses for residences and other land uses.

3.2.1 Intrusive noise criteria

The intrusiveness criteria is applicable to residential premises only. According to the INP, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A).

The intrusiveness criterion is summarised as follows:

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

3.2.2 Amenity noise criteria

The INP amenity criteria are designed to maintain noise level amenity for particular land uses, including residential and other land uses. The INP recommends base acceptable noise levels for various receivers, including residential, commercial, industrial receivers and other sensitive receivers in Table 2.1 of the INP. Noise from new sources need to be designed such that the cumulative effect does not produce levels that would significantly exceed the criterion.

Table 2: INP Amenity Criteria - Recommended L_{Aeq} noise levels from industrial noise sources [NSW INP Table 2.1]

Type of receiver	Indicative Noise Amenity Area	Time of day	Recommended $L_{Aeq(Period)}$ noise level	
			Acceptable	Recommended maximum
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45

Note:

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

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

The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

3.2.3 Draft Industrial Noise Policy (DINP)

Whilst still in draft form EPA's Draft Industrial Noise Policy (DINP) September 2015 has been referred to for guidance. In particular, '*Fact Sheet C: Adjustments for annoying noise characteristics*' has been referred to when assessing music noise.

3.3 Sleep disturbance

No operational activities associated with the Western Precinct will occur during the night-time period. Sleep disturbance is not addressed further in this report.

3.4 NSW Road Noise Policy (RNP)

Noise impact from the potential increase in traffic on the surrounding road network is assessed against the NSW Road Noise Policy (RNP, Department of Environment, Climate Change and Water NSW, 2011). The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impact and determining mitigation measures for developments that are potentially affected by road traffic noise, with the aim of preserving the amenity appropriate to the land use.

With regard to the surrounding road network, Carabella Street and Elamang Avenue are classified as local roads. The criteria for residential receivers are presented in the Table 3 below. These criteria are for noise levels assessed in front of a building facade.

Table 3: Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment Criteria, dB(A)	
		Day 7:00am-10:00pm	Night 10:00pm-7:00am
Local Roads	Existing residences affected by additional traffic on existing local roads generated by land use developments.	$L_{Aeq,(1\ hour)}$ 55 (external)	$L_{Aeq,(1\ hour)}$ 50 (external)

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for residences near busy roads (see RNP Appendix C10).

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.

In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

4 Assessment locations and existing noise environment

4.1 Assessment locations

The residential areas surrounding the project have been divided into Noise Catchment Areas (NCAs) which are outlined in Table 4 and Figure 3. Depending the project noise source, the nearest noise sensitive receiver locations within these catchments has been identified for assessment.

Table 4: Assessment locations

ID	Receiver Type	Address/location	Approx. Distance to Western Precinct
NCA_1	Residential Noise Catchment	Multi-storey residential dwellings located along the Western site boundary.	Adjacent
NCA_2	Residential Noise Catchment	Multi-storey and free standing residential dwellings located directly opposite Elamang Ave.	20m
NCA_3	Residential Noise Catchment	Free standing residential dwellings located along the Eastern site boundary and multi-storey dwellings located further to the east.	>100m
NCA_4	Residential Noise Catchment	Multi-storey and free standing residential dwellings located directly opposite Carabella St.	15m

4.2 Existing noise environment

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

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

As the noise environment of an area almost always varies over time, background and ambient noise levels need to be determined for the operational times of the proposed development. For example, in a suburban or urban area the noise environment is typically at its minimum at 3am in the morning and at its maximum during the morning and afternoon traffic peak hours. The INP outlines the following standard time periods over which the background and ambient noise levels are to be determined:

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

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

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

The INP also outlines methods for assessing 'shoulder periods' being shorter periods on either side of a standard period, where the standard period noise levels are not representative. For example a 'shoulder period' may be warranted for 22:00-00:00 where the night time period background noise level is not representative.

4.2.1 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. Section 3.1.2 of the INP specifies that often several locations will be affected by noise from the development. In these cases, locations that can be considered representative of the various affected areas should be monitored.

An alternative, representative location should be established in the case of access restrictions or a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site. The long-term measurement location is outlined in Table 5 and shown in Figure 3. The noise monitoring locations undertaken were taken in close proximity and at a similar RL to the nearest sensitive receivers and are considered representative.

Table 5: Noise monitoring locations

ID/Location	Description
Long-term noise monitoring	
L1 - Loreto Kirribilli Western boundary	The monitor was located at the façade, near the western edge of the top floor northern facing balcony of the Marian Centre. The noise monitoring location is considered representative of NCA_1.
L2 - Loreto Kirribilli Eastern boundary	The monitor was located in the free-field, on the second-tier triangular shaped terrace of the Music and Performing Arts building. The noise monitoring location is considered representative of NCA_2 and NCA_3.
L3 - Loreto Kirribilli Southern boundary	The monitor was located at the free-field, 15 metres north-east of the Carabella Road main entry. The noise monitoring location is considered representative of NCA_4.

Figure 3: Site, receiver and noise monitoring locations (Source – Nearmap_Jan_2017)

4.3 Long-term noise measurement results

Long-term noise monitoring at locations L1, L2 and L3 was carried out from Monday, 23 January 2017 to Saturday, 11 February 2017. School returned to typical operation on Wednesday, 1 February 2017. The monitoring was conducted so that comparison could be made between a non-operational school and an operational school. The long-term noise monitoring methodology is detailed in Appendix B, and noise level-vs-time graphs of the data are included in Appendix C.

Table 6 presents the overall single Rating Background Levels (RBL) and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the INP.

Table 6: Long-term noise monitoring results, dB(A)

Monitoring Period	School Operation	L_{A90} Rating Background Level (RBL)				L_{Aeq} Ambient noise levels			
		Day	Evening	10pm-Midnight	Night	Day	Evening	10pm-Midnight	Night
L1 - Loreto Kirribilli Western boundary									
Weekdays	School Holidays	47	48	44	41	51	51	45	45
	School Operational	47	45	42	40	54	49	45	43
Week (7 days)	School Holidays	47	48	44	41	51	51	45	45
	School Operational	46	46	42	41	54	49	45	44
L2 - Loreto Kirribilli Eastern boundary									
Weekdays	School Holidays	43	45	39	35	53	52	46	45
	School Operational	45	42	39	35	54	51	46	45
Week (7 days)	School Holidays	43	45	39	35	53	52	46	45
	School Operational	44	43	39	36	53	51	46	45
L3 - Loreto Kirribilli Southern boundary									
Weekdays	School Holidays	44	47	43	41	56	58	49	48
	School Operational	45	43	42	40	56	53	48	49
Week (7 days)	School Holidays	44	49	43	41	55	58	49	48
	School Operational	45	44	42	40	55	53	48	49

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

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

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

The shoulder period has been established for 22:00-24:00. The shoulder period rating background level has been calculated from the measurement data.

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

The data above shows that there is little difference in background noise levels between an operational and non-operational school and little difference between a weekday (5 days) and whole week (7 days) data set. For a conservative assessment, the lowest background noise level for each period has been adopted for the noise goal. With regard to the shoulder period, noise levels from monitoring location L2 have been adopted for all locations, as L1 and L3 was affected from existing mechanical plant during the night-time.

4.4 Project noise goals

The project noise goals have been established from the criteria presented in Section 3 and the background noise measurements presented in Table 6 above.

4.4.1 NSW EPA's INP noise goals

The INP noise goals presented in Table 7 are established for the assessment of school students, music noise, mechanical equipment, loading docks and carparks. For information purposes, the evening and shoulder period criteria has been reiterated from the Renzo Tonin masterplan assessment ' TJ415-01D04 Acoustic Masterplan Assessment (r2)'.

Table 7: NSW EPA Industrial noise criteria, dB

Location	Intrusiveness criteria $L_{Aeq,15min}$			Amenity criteria $L_{Aeq,period}$		
	Day	Evening	10pm-Midnight	Day	Evening	10pm-Midnight
NCA_1	51	50	44	55	45	40
NCA_2 & NCA_3	48	47	44	55	45	40
NCA_4	49	48	44	55	45	40

Notes: All residential locations have been categorised as 'Suburban'.

The shoulder period has been established for 22:00-24:00. The shoulder period rating background level has been calculated from the measurement data.

5 Operational noise assessment

5.1 Noise sources,

The primary operational noise sources associated with the development are considered to be:

- Classrooms and students (see Section 5.2.1)
    - Breakout noise from internal classrooms/studios/gymnasium;
    - External outdoor learning areas/balconies;
    - External multi-purpose/tennis court sports activities;
    - External recess/lunchtime eating areas/courtyards;
- Vehicular movement on site (see Section 5.2.2);
- Loading dock activities (see Section 5.2.3);
- Carpark (see Section 5.2.4);
- Music and Performing Arts building (see Section 5.2.5);
- Mechanical plant and equipment (see Section 5.2.6);

This section of the report addresses noise emission associated with these sources at the nearest noise-sensitive receivers. Where necessary, noise mitigation and/or management measures will be identified

5.2 Noise predictions

5.2.1 Classrooms and students

Classroom and areas of student occupation for the Masterplan have been summarised in Table 8. Also, provided in the maximum number of students for each particular area and if the building will operate with windows closed or open. Also provided is a breakdown of where students are typically located during lunch breaks. This information along with the Architectural package has been utilised to undertake the classroom and student noise predictions.

Table 8: Classrooms and areas of student occupation

Existing Building	Proposed Building	Levels/Classrooms	Number of Students	Ventilation	Building Operates with Windows Open/Closed[1]
Western Precinct (Stage 1 DA)					
Marian Centre	Marian Centre	LG - Photography	30 for all studios/classrooms	Natural	Potentially Open
		GRD - Visual Arts			
		LV1 - English			
		LV2 - English			
		LV3 - Apartment	-	-	-
B-Block	Learning Hub Five Storey building Roof Terrace	LG1 - PDHPE Studios/Outdoor Learning	Typically, 24 students max.30 for all studios/classrooms 30 for LG1 Outdoor Learning 10 for all other Outdoor Learning 30 for Roof Terrace	Mixed Mode	Mixed Mode
		LG2 - Void			
		LG3 - Food Technology/Outdoor Learning			
		LG4 - Metalwork/Jewellery/Woodwork/Outdoor Learning			
		GRD - Robotics/Presentation/Outdoor Learning			
		LV1 - Design Art/Textiles/Outdoor Learning			
		Roof - Outdoor Terrace/Mech Plant			
Gymnasium	Gymnasium Extension	LG1 - GYM	150	Air Conditioning	Closed
		LG2 - PDHPE Staff/GYM Void	-		
Multi-Purpose Court	Multi-Purpose Court	LG3 - Multi-Purpose Court	30	-	-
Junior School Play Terrace	Extended Junior School Play Terrace	GRD - Terrace	80	-	-
Northern Precinct (Masterplan - Future DA)					
Centenary Hall	Centenary Hall	LV1 - Centenary Hall	1200 (includes 1100 students and staff/visitors)	Air Conditioning	Closed
		LV2 - Mezzanine			
Multi-Purpose Court	Multi-Purpose Court	Roof - Multi-Purpose Court	30	-	-
Science Building	Science Building	LV1 - Science Rooms	30 for all studios/classrooms	Air Conditioning	Closed
		LV2 - Science Rooms			
Multi-Purpose Court(s)	Multi-Purpose Court(s)	Roof - Multi-Purpose Court/Lunch Break Space	30	-	-
Eastern Precinct (Masterplan - Future DA)					
Music & Performing Arts Mary Ward	New Junior School 4 Storey building 2 storey carpark	B1 - Carpark	-	Mechanically Ventilated	-
		B2 - Carpark	-	Mechanically Ventilated	-
		GRD - Junior School	30 for all studios/classrooms	Air Conditioning	Closed

Existing Building	Proposed Building	Levels/Classrooms	Number of Students	Ventilation	Building Operates with Windows Open/Closed[1]
		LV1- Junior School			
		LV2-Junior School			
		ROOF- Outdoor Learning			
Southern Precinct (Masterplan - Future DA)					
Elamang Administration	Elamang Administration	GRD -Staff	-	Air Conditioning	Closed
		LV1 -Staff	-		
J-Block	J-Block	GRD - Courtyard & Canteen, Toilets	30 for all studios/classrooms	Air Conditioning	Closed
		LV1- General Teaching			
		LV2- General Teaching			
		LV3- Library			
Chapel	Chapel	GRD -General Teaching	30 for all studios/classrooms	Air Conditioning	Closed
		LV1- Chapel	150		
Junior School	Music & Performing Arts Including 500 Seat Auditorium 5 Storey building	GRD	30 for all studios/classrooms 500 for Auditorium	Air Conditioning	Closed
		LV1			
		LV2			
		LV3			
		LV4			
During Lunch Break					
Gym - Multi-Purpose Court	Gym - Multi-Purpose Court	Multi-Purpose Court	50	-	-
Junior School Play Terrace	Extended Junior School Play Terrace	Terrace	80	-	-
Centenary Hall - Multi-Purpose Court	Centenary Hall - Multi-Purpose Court	Multi-Purpose Court	50	-	-
Science building - Multi-Purpose Court	Science building - Multi-Purpose Court	Multi-Purpose Court	50	-	-
Science building - Roof Top	Science building - Roof Top	Roof top	50	-	-
J-Block Courtyard	J-Block Courtyard	Court Yard	400	-	-
Junior School - Roof Top	Music & Performing Arts Roof Top	Roof top	100	-	-
Remainder of students within Library/other classrooms or scattered throughout school in small groups			320 (based on 1100 students)	-	-

Existing Building	Proposed Building	Levels/Classrooms	Number of Students	Ventilation	Building Operates with Windows Open/Closed[1]

Notes 1. All windows assumed to be 6mm laminated glass except for the following:

- Metalwork Workshop/Woodwork Workshop/Music Practice Studios - double glazing 10.38mm laminated with 100mm air gap.
- Operable glazed partitions separating 'Studios and Outdoor Learning areas' and 'Studios and Circulation/Collaboration areas' – Single glazing 12.5mm laminated
- Connector stairs – 16mm glazing

With the exception of the Metalwork Workshop and Woodwork Workshop within the Learning Hub, noise emanating from classrooms and areas will primarily be due to student voices. Note the Auditorium and Music classrooms within the new Music and Performing Arts building, which is part of the Masterplan Future DA, is considered in Section 5.2.5. The noise levels used for this assessment are shown in Table 9. Conservatively, the assessment is based on a worst-case scenario, which assumes all classrooms/learning spaces, multi-purpose courts and gymnasium and are fully occupied and the Centenary Hall has live music playing inside.

Table 9: Sound power level used for classrooms and students

Noise Source	L_{Aeq} [dB(A) re: 1pW]
Classrooms/studios and outdoor learning - A normal (female)[1,2]	60
Multi-Purpose Court - Tennis/netball game	88
Gymnasium - Basketball game	93
Centenary Hall – Live Music and Patrons	102[2]
Metalwork and Woodwork Workshop	107

Notes: 1. For classrooms/studios and outdoor learning, assessment is based on 50% of people talking at one time. Source reference – Handbook of Acoustical Measurements and Noise Control, Third Edition, Cyril M. Harris.

2. With reference to the EPA DING a maximum adjustment of 7 dB was added for Tonal noise (5dB) and Low Frequency noise (2 dB – just daytime operation)

The nearest most potentially affected residential receiver during standard class times and during the lunch break is respectively located to the west of the site, within NCA_1 and to the north of the site, within NCA_2. The assessment at the identified locations is presented in Table 10 below. Noise compliance is achieved at all residential receivers for the period of use.

Table 10: Classroom and Student assessment

Assessment Location	Predicted Noise Level $L_{Aeq,15min}$			Project Specific Noise Goal $L_{Aeq,15min}$		
	Day	Evening	Night	Day[1]	Evening[2]	Night[1]
During standard class times						
NCA_1 - 22 Elamang Avenue, Kirribilli	48	-	-	51	45	40
During lunch break						
NCA_2 - 21 Elamang Avenue, Kirribilli	42	-	-	48	45	40

Notes: Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.
1 INP Intrusive Criteria
2 INP Amenity Criteria

5.2.2 On-site vehicular movements

On-site vehicular movements for Loreto are limited. The site's existing carpark entrance/exit along Elamang Ave will be maintained and used for access for the existing underground carpark located below the Music & Performing Arts building/Science Building. The only other on-site vehicle movements will be for the loading dock activity operations, which is assessed in Section 5.2.3, and the carpark operations which is assessed in Section 5.2.4.

Noise predictions have been undertaken for the Elamang Ave entrances/exit based upon the carpark capacity of 80 spaces. The peak hour movements have conservatively been predicted to be 80 vehicles two-way. On this basis it was considered reasonable to average the peak hour movements for the 15-minute noise assessment period, resulting in an average 20 vehicles in and out.

To assess on site vehicle movement noise, the L_{Aeq} noise level was determined for the relevant time period based on the number of vehicle activities expected to occur during that period at the nearest affected residential premises. Noise level measurements from our database and library files were used for the purpose of this assessment.

The nearest most potentially affected residential receiver has been established as located to the north of the site, within NCA_2. The assessment at the identified location is presented in Table 11 below. Noise compliance is achieved at all residential receivers for the period of use.

Table 11: On-site vehicular noise assessment, 13 Elamang Ave, Kirribilli

Assessment Location	Predicted Noise Level $L_{Aeq,15min}$			Project Specific Noise Goal $L_{Aeq,15min}$		
	Day	Evening	Night	Day[1]	Evening[2]	Night[1]
NCA_2 - 13 Elamang Ave	31	-	-	48	45	40

Notes: Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.
1 INP Intrusive Criteria
2 INP Amenity Criteria

5.2.3 Loading dock activity

The loading dock will be situated towards the middle of the site, near the eastern façade of the proposed Learning Hub. Access to the loading dock is via a driveway located adjacent to the eastern façade of the Marian Centre, which connects to Carabella Street. Truck movements associated with the loading dock will be limited to 7:00am to 6:00pm Monday to Saturday and 08:00am to 6:00pm Sundays & Public Holidays. The loading dock will be approximately 35 metres from the developments southern boundary.

The following noise levels from Renzo Tonin & Associate's database have been used for the assessment and are shown in Table 12.

Table 12: Loading dock activity – Sound power levels

Activity	Sound Power Level dB(A) re: 1pW
	$L_{Aeq\ 15\ minute}$
Loading and Unloading	85
Small Truck Moving (10km/h) – LW / m	61

The most exposed residential receptor has been established as located to the south of the site, within NCA_4. The assessment at the identified location is presented in Table 13, below. Noise compliance is achieved at all residential receivers for the period of use.

Table 13: Loading dock assessment, NCA_4 - 60 Carabella St, Kirribilli

Assessment Location	Predicted Noise Level $L_{Aeq,15min}$			Project Specific Noise Goal $L_{Aeq,15min}$		
	Day	Evening	Night	Day[1]	Evening[2]	Night[1]
NCA_4 -60 Carabella St, Kirribilli	41	-	-	49	45	40

Notes: Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.
1 INP Intrusive Criteria
2 INP Amenity Criteria

5.2.4 Car park

The existing underground carpark located below the Music & Performing Arts building/Science building has a capacity of 80 spaces. This carpark is not proposed to change as part of the Masterplan Future DA. The carpark is enclosed except for openings along Elamang Avenue. Calculations been undertaken to assess the breakout noise from these openings at the nearest sensitive receivers.

The noise sources generated by carparks include, vehicle doors closing, vehicle engines starting, vehicles accelerating and vehicles moving. Noise level measurements from our database and library files were used for the purpose of this assessment.

For this assessment, the entire carpark (80 spaces) has been estimated to be filled or emptied within any hour, during the day, evening and night. Carpark usage during the evening and night is only anticipated to be used for Auditorium events.

The nearest most potentially affected residential receiver has been established as located to the north of the site, within NCA_2. The assessment at the identified location is presented in Table 14 below. Noise compliance is achieved at all residential receivers for the period of use.

Table 14: Car park noise Assessment, NCA_2 - 15 Elamang Ave, Kirribilli

Assessment Location	Predicted Noise Level $L_{Aeq,15min}$			Project Specific Noise Goal $L_{Aeq,15min}$		
	Day	Evening	Night	Day[1]	Evening[2]	Night[1]
NCA_2 - 15 Elamang Ave	35	-	-	48	45	40

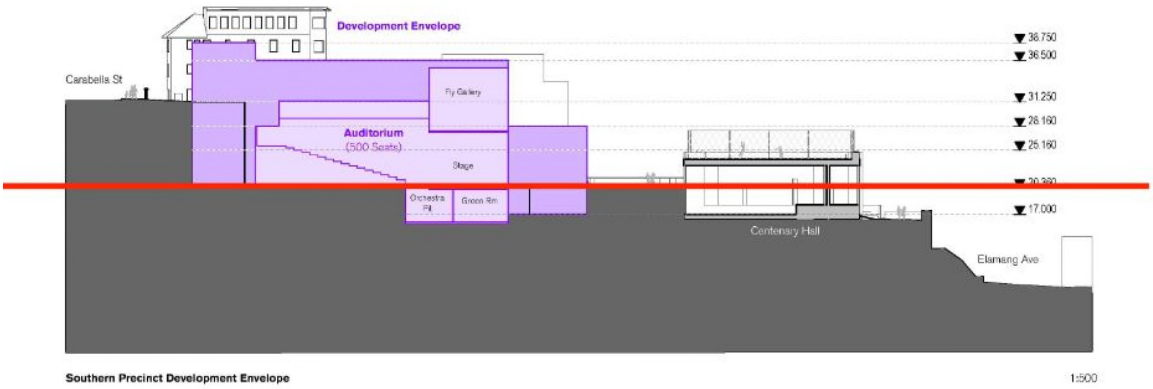
Assessment Location	Predicted Noise Level $L_{Aeq,15min}$			Project Specific Noise Goal $L_{Aeq,15min}$		
	Day	Evening	Night	Day[1]	Evening[2]	Night[1]

Notes: Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.
1 INP Intrusive Criteria
2 INP Amenity Criteria

5.2.5 Music and Performing Arts building (Masterplan - Future DA)

Below is a section drawing taken from the masterplan architectural masterplan documents.

Figure 4: Southern precinct – Performing Arts Level C



The nearest residential receivers to the Performing Arts Building are located to the south along Carabella Street, which is to the left of the building in Figure 4. Based on this concept drawing, there will be will be internal spaces located to the south and above the auditorium which will provide acoustic shielding to the nearest residences. Furthermore, to maximum acoustic shielding, it is recommended that the proposed music rehearsal rooms be located below street level, to the south of the auditorium.

A detailed review of the building envelope will be carried out during the design development process, inclusive of walls and roof constructions to ensure compliance with the noise goals is achieved.

5.2.6 Mechanical plant

Detailed specifications of mechanical services equipment that would otherwise allow an acoustic assessment of noise emission from the site are not available at this stage. This is common for a development of this size, as detailed design of the mechanical services system would not typically be undertaken until after approval. In most cases, detailed assessment of operational noise emission from mechanical services equipment would form a conditional requirement of the development, to be satisfied prior to the issue of the construction certificate.

While the intent of this report is to identify potential impacts at sensitive receivers surrounding the site, it is noted that the acoustic objectives of the *NSW Department of Education - Acoustic Performance Guidelines* and *AS:2107: Recommended Design Sound Levels and RT for Building Interiors* may also be desired to be met at classrooms and areas within the development. If this is the case, the classrooms and areas within the development may also be the determining locations for the acoustic design as they could be situated in closer proximity to the mechanical plant equipment than the surrounding receiver locations.

Notwithstanding the above, the following review of proposed development has been carried out and noise management measures are provided for mechanical plant servicing the proposed development.

The proposed development is to include the following primary mechanical plant and equipment:

- Air-conditioning;
- Kitchen and toilet exhausts;
- Woodwork, metalwork, food technology room(s) exhausts;
- Laundry exhaust and supply systems;
- Garbage and bin store exhaust systems;
- Refrigeration equipment; and
- Carpark exhaust and supply fans.

Recommendations

For the Learning Hub (western precinct) the majority of plant and equipment is to be located within a plant room on the western side of the roof. The plant room will be enclosed, with provision for silencers for the condenser units and acoustic louvres for fresh air intake, therefore reducing noise emission from the site to surrounding areas. For other plant rooms a partial or complete roof can be adopted and acoustic louvres and silencers can be incorporated to allow adequate heat dissipation and air flow for equipment. Where possible, the outlet of the equipment should point east, towards the centre of the site, to maximise acoustic directivity and limit noise emission to surrounding residences along the western boundary.

For the remaining stages of development, mechanical equipment should be located towards the centre of the site away from the surrounding residential receivers. Further recommendations are provided in Section 5.3.

5.2.7 Cumulative noise impact

Based on the predicted noise level for the relevant on-site activities, as well as the relevant times periods for each activity, a cumulative noise impact assessment has been carried out and is summarised for the two most sensitive receivers in Table 15.

The cumulative noise predictions to the nearest residential receptors show that noise compliance is achieved at all residential receivers for the period of use. For a comprehensive set of predictions for all surrounding receivers refer to Appendix D.

Table 15: Cumulative predicted noise levels $L_{Aeq,15min}$

	Activity	NCA_1 22 Elamang Ave			NCA_2 21 Elamang Ave		
		Day	Evening	Night	Day	Evening	Night
Predicted Noise Levels	Classrooms/students - Standard	48	-	-	45	-	-
	Classrooms/students - Lunchbreak	39	-	-	42	-	-
	Onsite Vehicle Movements	<20	-	-	29	-	-
	Loading Dock Activities	<20	-	-	<20	-	-
	Car Park	<20	-	-	29	-	-
	Total - Standard	**48**	-	-	**45**	-	-
	Total - Lunchbreak	**39**	-	-	**42**	-	-
	Criteria	***51***[1]	*45*[2]	*40*[1]	***48***[1]	*45*[2]	*40*[1]

Notes: Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.
^ Allowable noise contribution.
1 INP Intrusive Criteria
2 INP Amenity Criteria

5.3 Recommendations

5.3.1 Acoustic performance of building envelope

- A detailed review of the building envelope should be carried out during the design development process, inclusive of walls and roof constructions.
- This assessment has assumed the glazing performances outlined in Table 8. Higher acoustic performance can be readily achieved and may be required, in particular for the Auditorium and Music rooms.
- Incorporation of acoustically absorptive finishes both within internal areas and outdoor areas is recommended to assist in controlling noise emission from the development.
- Floor to ceiling partitions along the western side of the Learning Hub balconies (only the balconies located west of the stairs) is recommended to provide shielding to 111 Carabella St.
- Operation of outdoor learning terraces/spaces will need to be managed so that raised voices are kept to a minimum. Group conversations will be encouraged to be undertaken indoors.

5.3.2 Mechanical Plant

- Acoustic assessment of mechanical services equipment should be undertaken during the detail design phase of the development to ensure that the cumulative noise of all equipment does not exceed the applicable noise criteria. Development Consent Conditions typically require detailed assessment of mechanical plant and equipment prior to issue of the Construction Certificate.
- Noise control treatment can affect the operation of the mechanical services system. An acoustic engineer should be consulted during the initial design phase of mechanical services system to reduce potential redesign of the mechanical system.
- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
  - Procurement of 'quiet' plant.
  - Air-conditioners and condensers should include day/night modes to further reduce noise emission.
  - Strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises.
  - Commercially available acoustic attenuators for air discharge and air intakes of plant.
  - Acoustically lined and lagged ductwork.
  - Acoustic barriers between plant and sensitive neighbouring premises.
  - Partial or complete acoustic enclosures over plant.
  - Acoustic louvres.
- The specification and location of mechanical plant should be confirmed prior to installation on site, and
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 '*Rotating and Reciprocating Machinery – Mechanical Vibration*'.

5.4 Road traffic generated by development

Additional noise from traffic generated by a development on the local road network is assessed against the EPA Road Noise Policy. The assessment involves consideration of the existing traffic noise levels and the potential change in noise as a result of the development.

Based on the data presented in Table 13 of the McLaren Traffic Engineering report 'Traffic and Parking Impact Assessment of Loreto School at 85 Carabella Street, Kirribilli', dated 13 March 2017, the below table presents the existing and future peak two-way volumes.

Table 16: Existing and future peak two-way traffic volumes

Street	Peak	Existing Two-way Peak (vehicles)	Additional Traffic (vehicles)	Future Two-way Peak (vehicles)
Carabella Street	AM	122	38	160
	PM	150	21	171
Elamang Avenue	AM	82	18	100
	PM	89	12	101

Based on data within Table 16, the peak hour traffic generation, that is attributed to the Masterplan Future DA, corresponds to a potential noise increase of 1.2 dB(A) along Carabella Street and 0.9 dB(A) along Elamang Avenue. On this basis, the additional traffic noise generated by the development is less than 2dB(A) and is therefore acceptable.

In addition, the existing waste management procedures of the site will not be altered by the proposed development.

6 Construction noise

6.1 Background

Construction activities associated with the proposed development will result in increased noise levels during construction hours. The works undertaken in the various stages consist of a mixture of both high and low noise activities. This assessment identifies potentially noisy activities, their impacts on surrounding receivers and outlines management strategies to control the impacts of noise and vibration during the civil (piling), excavation works, structure construction, building fit out, landscaping and precinct works.

6.2 Hours of operation

This assessment applies to the standard construction hours from 7:00am to 6:00pm Monday to Friday, 8:00am to 1:00pm on Saturday with no work performed on Sundays and Public Holidays.

6.3 Summary of works

A preliminary program summary, and site plans for the Stage 1 works have been developed by Grindley Construction Pty Ltd, as presented in Table 17, Figure 5, Figure 6 and Figure 7.

Table 17: Indicative schedule

Stage	Description	Estimated Duration
PHASE 1 – Demolition		
1a. Site Establishment	• Hoardings, isolation and/or re-routing services and preparation of the access lane	2 weeks
1b. Demolition	• Demolition of B-Block	6 weeks
PHASE 2 - Excavation		
2a. Excavation and shoring	• Retention wall piling • Bulk excavation and detailed excavation	18 weeks
2b. Substructure & inground works	• Foundation piling • Slab construction	5 weeks
PHASE 3 – Construction		
3a. Structure	• Construction of Learning Hub	21 weeks
3b. Roofing, cladding & façade	• Installing roofing & façade	18 weeks
3c. Finishes & services	• Fit out works	28 weeks
3d. External works, landscape, & completion	• External works & landscape • Commissioning and completion	14 weeks

Figure 5: Phase 1 - Site establishment plan - Demolition

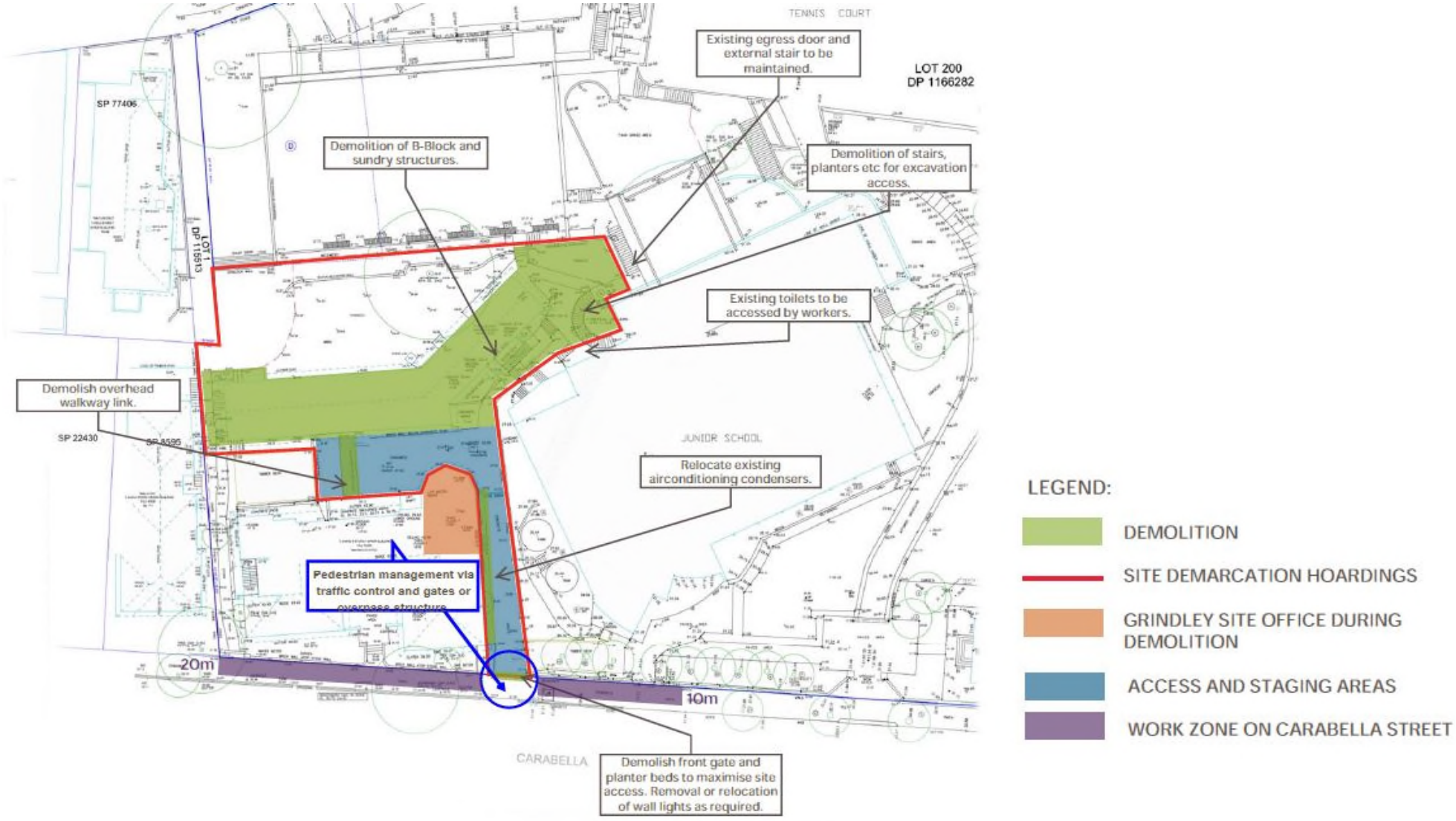


Figure 6: Phase 2 - Site establishment plan - Excavation & bulk earthworks

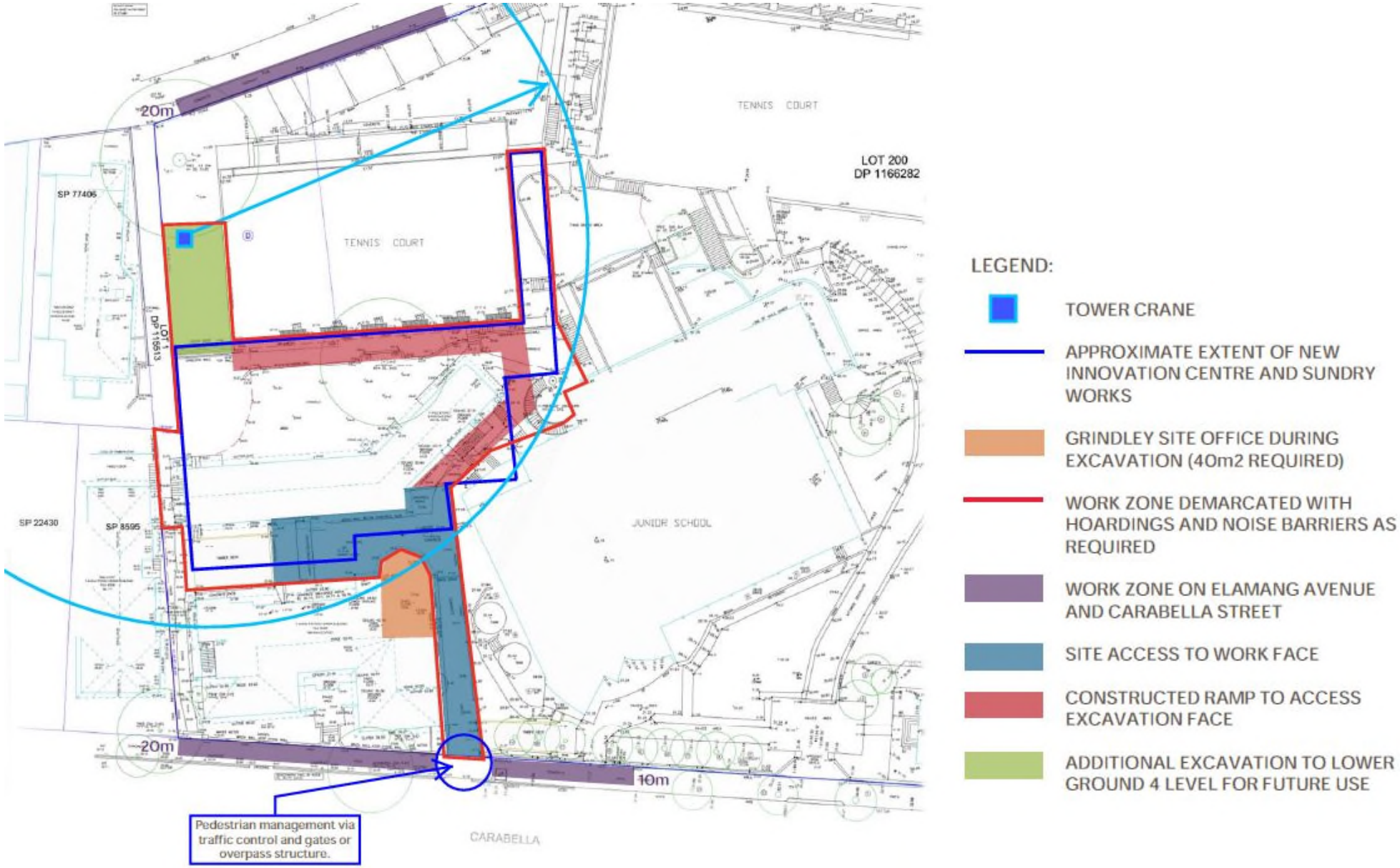
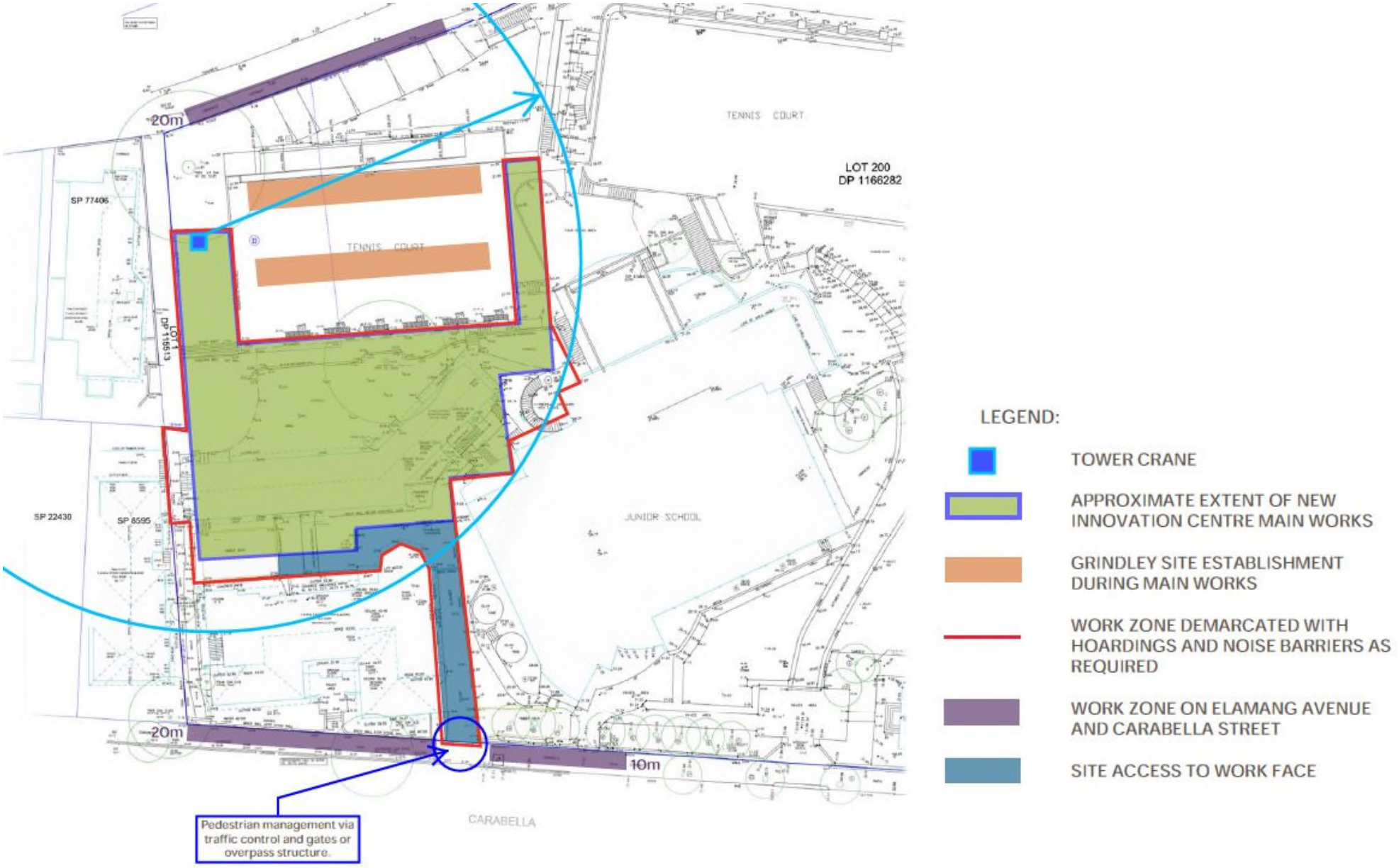


Figure 7: Phase 3 - Site establishment plan - Construction Learning Hub



6.4 Construction traffic

The worksite will generate additional traffic movements in the form of:

- Light vehicle movements generated by construction personnel travelling to and from work
- Heavy vehicle movements generated by:
  - Delivery vehicles bringing raw materials, plant, and equipment to the site
  - Spoil trucks removing spoil from the site
  - Concrete trucks bringing concrete to the site

Construction traffic on the site is included as part of the construction noise assessment of the work activities identified in Section 6.3. When construction-related traffic moves on the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as additional road traffic on public roads rather than as part of the construction site's activities.

Access to the site will be from Carabella Street via the lane located between the Marian Centre and Junior School.

Grindley Construction Pty Ltd have advised that the cumulative average peak vehicle truck movements to/from the site are anticipated to occur during excavation and will be in the order of 15-20 per day (approx. 3 movements per hour). This volume of truck traffic is not expected to significantly alter existing traffic noise. Furthermore, for the majority of the construction works, either side of the excavation, movements are anticipated to be less than 15 per day.

There are no truck movements during the evening (between 6 pm and 10 pm) or night (between 10 pm and 7am) periods. The first round of trucks are planned to arrive at site between 7:15am and 7:30am, this will prevent trucks arriving/parking on Carabella St before 7am and will alleviate sleep disturbance impacts.

Construction traffic from the site on public roads is predicted not to be a significant noise impact and is not further addressed in this report.

6.5 Construction noise criteria

6.5.1 Noise management levels

The NSW *Interim Construction Noise Guideline* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.

NSW noise policies, including the INP, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- Application of reasonable and feasible noise mitigation measures
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

Table 18 reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 18: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq (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: 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 + 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.*

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply

* 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 19 sets out the ICNG noise management levels for other noise sensitive receiver (OSR) locations. As identified for residential receivers, a 'highly affected' noise objective of $L_{Aeq(15min)}$ 75dB(A) is adopted for all noise sensitive receivers, with exceedances addressed as described in Table 18.

Table 19: Noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
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)
Cinema[1]	Internal noise level	35 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)

Notes: Noise management levels apply when receiver areas are in use only.

1. Design noise levels specified in AS 2107 internal noise levels

Table 20 presents the construction noise management levels established for the nearest noise sensitive receivers based upon the long-term noise monitoring outlined in Section 4.3. The assessment locations are marked in Figure 3

Table 20: Construction noise management levels at receivers

NCA/ID	Representative receiver within catchment	L_{A90} rating background level (RBL)			Noise management level $L_{Aeq(15min)}$[1]		
		Day	Evening	Night	Day	Evening	Night
NCA_1	111 Carabella St, Kirribilli	46	45	35	56	50	40
NCA_2	31-39 Elamang Ave, Kirribilli	43	42	35	53	47	40
NCA_3	69 Carabella St, Kirribilli	43	42	35	53	47	40
NCA_4	60 Carabella St, Kirribilli	44	43	35	54	48	40
OSR_5	St Aloysius' College Junior School, 29 Burton St, Milsons Point NSW 2061	55[2,4]					
OSR_6	Ensemble Theatre, 78 McDougall St, Kirribilli NSW 2061	55[2,3]					

NCA/ID	Representative receiver within catchment	L_{A90} rating background level (RBL)			Noise management level $L_{Aeq(15min)}$[1]		
		Day	Evening	Night	Day	Evening	Night

Notes:
1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.
2. External noise level - conservatively assumed to have open windows providing a outside-to-inside attenuation of 10 dB
3. External noise level - these receivers are typically well insulated from external noise break-in. For the purposes of this assessment, a minimum (conservative) outside-to-inside attenuation of 20 dB can be assumed.
4. Noise management levels apply when receiver areas are in use only.

6.5.2 Loreto Kirribilli

The staging of construction works for Loreto Masterplan will result in the existing Marian Centre and the Junior School building being occupied during the Stage 1 (Western Precinct) works. Noise and vibration management strategies for these receptors will be provided in Section 6.9. Loreto Kirribilli can then determine the most appropriate course of action to adopt.

6.6 Proposed construction noise sources

The schedule of items of plant and equipment likely to be used during the demolition, excavation and construction of the proposed development is presented in Table 21 below.

Table 21: Typical construction equipment & sound power levels, dB(A) re 1pW

Plant item	Plant description	Sound power levels
Phase 1 - Demolition		
1.	Truck and dog	108
2.	20-tonne excavator with bucket	107
Phase 2 - Excavation		
3.	Concrete saw	119
4.	20-tonne excavator with hydraulic breaker	115
5.	Piling / Drill rig	111
6.	Mobile/Tower crane	110
7.	Truck and dog	108
8.	Concrete trucks	108
9.	20-tonne excavator with bucket	107
10.	Delivery Trucks	105
11.	Concrete Pump	102
Phase 3 - Construction		
12.	Mobile/Tower crane	110
13.	Truck - cement mixer	108
14.	Hand tools	107
15.	Delivery Trucks	105

Plant item	Plant description	Sound power levels
16.	Concrete pump	102
17.	Bobcat	102
18.	Concrete vibrator	100

The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the Interim Construction Noise Guideline (ICNG), information from past projects and/or information held in our library files.

6.7 Structure-borne noise

Structure-borne noise results from vibration excitation on a building element or surface causing the element to vibrate, generating noise within the receiving buildings.

Vibration resulting from the use of high impact plant equipment such as hydraulic drills may generate structure-borne noise within the nearby buildings in addition to airborne noise. Therefore, consideration should be given to the potential impacts of structure borne noise.

The receiver locations with NCA_1, 111 Carabella St and 22 Elamang Ave have been identified as having the potential to be impacted by structure-borne noise, as the buildings share common boundaries with the site.

It is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from structure-borne construction noise. Details on construction noise mitigation and management measures are provided in Section 6.9 below.

6.8 Predicted Noise Levels

Noise levels at any receiver location resulting from construction works would depend on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Table 22 presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the proposed site. The noise level range presented represents the plant item operating at a location furthest from the receiver and a location closest to the receiver. Noise levels were calculated taking into consideration attenuation due to distance between the construction works and the receiver locations and any intervening structures.

For information purposes, predictions have been undertaken for the Marian Centre (OSR_07) and the Junior School (OSR_08).

Table 22: Predicted $L_{A\ av\ max(15min)}$ noise levels for typical construction plant, dB(A)

Plant Item	Plant Description	Predicted $L_{A\ av\ max(15min)}$ Construction Noise Levels							
		NCA_1	NCA_2	NCA_3	NCA_4	OSR_5	OSR_6	OSR_7	OSR_8
Noise Criteria	*Daytime Period*	*56*	*53*	*53*	*54*	*55*	*55*	-	-
Phase 1 - Demolition									
1.	Truck and dog	65-82	39-60	27-36	40-63	28-42	34-50	64-83	65-88
2.	20-tonne excavator w/bucket	64-81	38-59	26-35	39-62	27-41	33-49	63-82	64-87
Up to 3 (noisiest) plant operating concurrently		**68-85**	**41-63**	**29-39**	**42-65**	**30-45**	**37-53**	**67-85**	**67-90**
Phase 2 - Excavation									
3.	Concrete saw	72-91	61-76	38-48	51-74	39-50	39-58	72-93	75-96
4.	20-tonne excavator with hydraulic breaker	68-87	57-72	34-44	47-70	35-46	35-54	68-89	71-92
5.	Piling / Drill rig	64-83	53-68	30-40	43-66	31-42	31-50	64-85	67-88
6.	Mobile/Tower crane	63-82	52-67	29-39	42-65	30-41	30-49	63-84	66-87
7.	Truck and dog	61-80	50-65	27-37	40-63	28-39	28-47	61-82	64-85
8.	Concrete trucks	61-80	50-65	27-37	40-63	28-39	28-47	61-82	64-85
9.	20-tonne excavator with bucket	60-79	49-64	26-36	39-62	27-38	27-46	60-81	63-84
10.	Delivery Trucks	58-77	47-62	24-34	37-60	25-36	25-44	58-79	61-82
11.	Concrete Pump	55-74	44-59	21-31	34-57	22-33	22-41	55-76	58-79
Up to 3 (noisiest) plant operating concurrently		**74-93**	**63-78**	**40-49**	**53-76**	**40-51**	**40-60**	**74-95**	**77-98**
Phase 3 - Construction									
12.	Mobile/Tower crane	63-82	52-67	29-39	42-65	30-41	30-49	63-84	66-87
13.	Truck - cement mixer	61-80	50-65	27-37	40-63	28-39	28-47	61-82	64-85
14.	Hand tools	60-79	49-64	26-36	39-62	27-38	27-46	60-81	63-84
15.	Delivery Trucks	58-77	47-62	24-34	37-60	25-36	25-44	58-79	61-82
16.	Concrete pump	55-74	44-59	21-31	34-57	22-33	22-41	55-76	58-79
17.	Bobcat	55-74	44-59	21-31	34-57	22-33	22-41	55-76	58-79
18.	Concrete vibrator	53-72	42-57	19-29	32-55	20-31	20-39	53-74	56-77
Up to 3 (noisiest) plant operating concurrently		**66-85**	**55-70**	**32-42**	**45-68**	**33-44**	**33-52**	**67-87**	**69-91**

The predicted noise levels presented above indicate that the noise levels from the majority of the items of plant and equipment are predicted to exceed the established noise criteria within NCA_1, NCA_2 and NCA_4, particularly when operating near the corresponding receiver location. With the exception of sawing activities, no exceedances are predicated at OSR_06 (Ensemble Theatre) and no exceedances are predicted within NCA_3 and at OSR_5 (St Aloysius' College Junior School) during any operations.

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 6.9 below.

6.9 Construction noise mitigation measures

6.9.1 General engineering noise controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', are expected to reduce predicted construction noise levels.

Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 23 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 23: Relative effectiveness of various forms of noise control

Noise control method	Practical examples	Typical noise reduction possible in practice, dB(A)		Maximum noise reduction possible in practice, dB(A)	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers where barrier breaks line-of-sight between the source and receiver	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table 24 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 24: Possible noise control measures for likely construction plant

Plant Description	Screening	Acoustic enclosures	Silencing	Alternative process
Tracked excavator	✔	✖	✔	✖
Machine mounted hydraulic drill	✔	✖	✔	✖
Concrete truck	✔	✖	✔	✖
Delivery trucks	✔	✖	✔	✖
Electric crane	✔	✔	✖	✖
Hand tools	✔	✖	✔	✖

Other potential mitigation measures include:

- All truck movements involved in the demolition, excavation and construction would approach and depart via Carabella Street. The first round of trucks are planned to arrive at site between 7:15am and 7:30am, this will prevent trucks arriving/parking on Carabella St before 7am and will alleviate sleep disturbance impacts.
- All demolition and excavated spoil material will be loaded wholly within the centre of the site, the existing school buildings provide significant shielding to surrounding dwellings.
- Limited piling is not proposed, as the existing sandstone bedrock will be used for foundation. The installation (drilling) of anchor bolts is also expected to be limited. Alterative plant items or methods of construction activity is not deemed to be beneficial.
- The proposal has been carefully considered with regard to the length of time on-site, in order to reduce the amount of rock-breaking operations and to limit the noise exposure period to the identified receivers. A respite period can be agreed upon with the neighbouring premises if the residences are in the dwellings during the construction periods. Potential respite periods would be limiting use of high impact activities, such as rock-breaking, to 9am to 5pm with a 1 hour break during this period.
- All employees, contractors and subcontractors are to receive site induction and toolbox talks and ongoing training so that the above noise management measures are implemented accordingly. Content within toolboxes will include, location of nearest sensitive receivers; relevant project specific and standard noise and vibration mitigation measures; permissible hours of work, truck route and truck loading restrictions and construction employee parking areas.

It is noted that most hand tools will likely be used when a part of the structure has been erected and this in-turn can be used to provide acoustic shielding to the identified receivers.

6.9.2 Noise management measures

The following recommendations provide feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. A strong justification must be provided for not implementing the proposed measures if they are later determined on-site not to be feasible or reasonable.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

General noise management measures

The following general noise management measures are recommended for all receiver locations:

- Use less noisy plant and equipment, where feasible and reasonable.
- Plant and equipment must be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work must be switched off.
- Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be limited/avoided where possible.
- The offset distance between noisy plant and adjacent sensitive receivers is to be maximised where practicable.
- Plant used intermittently to be throttled down or shut down when not in use where practicable.
- Noise-emitting plant to be directed away from sensitive receivers where possible.
- Staging of construction works so as to erect solid external walls first and utilising them to provide noise shielding to the noise sensitive receivers. However, the structural integrity of the external walls should be investigated prior to implementing this measure and should be prioritised over the noise benefits.
- In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint will need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints

seriously and dealing with them expeditiously is critical. The person selected to liaise with the community must be adequately trained and experienced in such matters.

Regular periodic noise monitoring

The following approach must be adopted with regard to noise monitoring procedures during the construction works.

- Where potential noise impacts are predicted to be up to 10dB(A) above the noise criteria, all feasible and reasonable noise reduction measures must be investigated, where necessary.
- Where potential noise impacts are predicted to be 10 to 15dB(A) above the noise criteria, the potential construction noise nuisance is considered to be moderate. Noise monitoring must be carried out to confirm predicted noise impacts within two weeks of commencement of construction. Reasonable and feasible noise reduction measures must be investigated, where necessary.
- Where potential noise impacts are predicted to be more than 15dB(A) above the noise criteria, reasonable and feasible noise control measures must be implemented prior to the commencement of construction works. Noise levels during construction must be monitored and where exceeded, further noise reduction measures (where reasonable and feasible) must be implemented eg. restrict working hours, use silencing equipment, etc.

Long-term Noise Monitoring

The following approach must be adopted with regard to noise monitoring procedures during the construction works.

- Long-term unattended noise monitoring is to be carried out for the duration of the project during which high intrusive noise appliances are anticipated to be used;
- Long-term noise monitors are to be located at representative locations for the nearest receptors at the boundaries of the site. Locations both internal and external to neighbouring buildings are to be used as agreed with the relevant parties during consultation;
- The following long-term noise monitoring locations are proposed:

ID	Address
NCA_1	111 Carabella St, Kirribilli
	22 Elamang Ave, Kirribilli
NCA_2	31-39 Elamang Ave, Kirribilli
NCA_4	60 Carabella St, Kirribilli

- Long-term noise monitors are to generally adopt an alert system to inform the contractor of any excessive noise exposure levels at the various receptor locations. Noise data will be retrieved and reviewed at regular intervals during the project.

6.10 Community consultation

Most construction activities proposed for the site are expected to exceed the noise limits even after noise treatment is applied. This results from the close proximity of the boundary, and does not necessarily indicate that the proposed construction works are excessively noisy. It is imperative that the contractor has an open discussion with those affected at the earliest opportunity to discuss and potentially implement time restrictions to provide periods of respite for residents, where feasible and reasonable.

Information regarding the time restrictions and the proposed works are to be documented and supplied to residents surrounding the development site, eg. newsletter, construction update flyer, etc.

A community consultation meeting can be held to provide the surrounding residents information of the proposed works and noisy activities associated with the construction of the development.

7 Construction vibration

7.1 Vibration criteria

Construction vibration is associated with three main types of impact:

- Disturbance to building occupants;
- Potential damage to buildings; and
- Potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the meter (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is meters per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is meters per second squared (m/s^2).

Construction vibration goals are summarised below.

7.1.1 Disturbance to buildings occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 25 provides definitions and examples of each type of vibration.

Table 25: Types of vibration

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).

Type of vibration	Definition	Examples
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

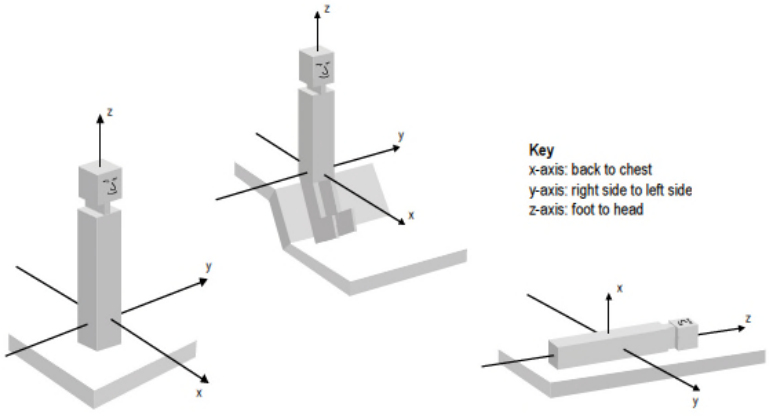
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 8. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 8: Orthogonal axes for human exposure to vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 26.

Table 26: Preferred and maximum levels for human comfort

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

Note: 5. Daytime is 7:00am to 10:00pm

6. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 27.

Table 27: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime[1]	
	Preferred value	Maximum value
Critical areas[2]	0.10	0.20
Residences	0.20	0.40
Offices, schools, educational institutions and places of worship	0.40	0.80

Note: 7. Daytime is 7:00am to 10:00pm

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

7.1.2 Building damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- **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.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for 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', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 28 sets out the BS7385 criteria for cosmetic, minor and major damage.

Table 28: BS 7385 structural damage criteria

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

Notes:
9. Peak Component Particle Velocity is the maximum peak particle velocity (PPV) in any one direction (x, y, z) as measured by a tri-axial vibration transducer
10. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

German Standard

German Standard DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases. The criteria for the structures applicable to the receivers surrounding the site are presented in Table 29.

Table 29: DIN 4150-3 structural damage criteria

Group	Type of Structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	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

7.2 Vibration sources

The vibration generated from construction works will vary depending on the level and type of activity carried out at each site during each activity.

Potential vibration generated at receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver building's construction and structure. As a guide, indicative minimum working distances for typical items of vibration intensive plant and equipment are provided in Table 30. The minimum working distances are quoted for:

- cosmetic damage, based on the British Standard 7385; and
- human comfort, based on the DECC's '*Assessing Vibration; a technical guideline*'.

Table 30: Recommended minimum working distances for vibration intensive equipment

Plant item	Rating / Description	Minimum working distance, m	
		Cosmetic damage (BS 7385)	Human response (DECC Guideline)
Pneumatic Hammer	-	5	Avoid contact with structure
Piling rig (bored)	-	5	20
Excavator	<=20 Tonne (travelling/ digging)	5	20
Excavator	w/Hydraulic Breaker	10	30

Notes: The minimum working distances are indicative and will vary depending on the specific equipment and geotechnical conditions.

They apply to cosmetic damage of buildings and have been derived from measured vibration data from a range of projects available in our database under varying geotechnical conditions. Vibration monitoring should be undertaken to confirm the safe working distances at specific sites where considered necessary.

Site specific buffer distances for vibration significant plant items (eg. piling rig, excavators, etc.) must be determined through on-site measurements. Unlike noise, vibration cannot be 'predicted' due to many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS5228-2:2009). They are not specific to this project as final vibration levels are dependent on many

factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

7.3 Potential vibration impacts

Based on the proposed plant items presented, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 31 below. The assessment is relevant to the identified residential buildings and other similar type structures in the project area.

Table 31: Potential vibration for residential and commercial properties

Receiver location	Approx. distance to nearest buildings from works (m)	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
NCA_1	2	Residential	Medium risk of structural damage from construction works	High risk of adverse comment as a result of construction works	Vibration monitoring should be conducted at commencement of construction
NCA_2	40	Residential	Low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Not required
NCA_3	>100	Residential	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Not required
NCA_4	35	Residential	Low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Not required
OSR_5	>100	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Not required
OSR_6	>100	Commercial	Very low risk of structural damage from construction works	Very low risk of adverse comment as a result of construction works	Not required

Note: 1. The sources of vibration levels are driving piles into the ground and excavator rock breaking/travelling near the property boundaries. If alternative equipment with higher vibration levels are used, there is an additional risk.

Based on the above assessment for the receivers surrounding the site, the adjoining buildings to the west of the subject site (ie. 111 Carabella St and 22 Elamang Ave) would be most at risk from vibration impacts from the construction works due to them sharing common boundaries with the subject site.

The main risks are physical damage are hitting unknown sandstone or structural foundation of building. The risk of damage from excavator moving and digging soil next to a building is very low.

Recommendations for reducing potential vibration impacts are provided in the sections below.

7.4 Vibration mitigation measures

The following vibration mitigation measures are recommended to minimise vibration impact from construction activities to the nearest affected receivers:

1. A management procedure must be implemented to deal with vibration complaints. Each complaint must be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures must be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures must be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Where construction activity occurs in close proximity to sensitive receivers or on material that will cause vibration to all identified receivers, vibration testing of actual equipment on site must be carried out prior to their commencement of site operation to determine acceptable buffer distances to the nearest affected receiver locations.

4. Dilapidation surveys must be conducted at all receivers within close proximity of the construction site. Notification by letterbox drop would be carried out for all buildings in the vicinity of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property. Notification is to be provided to all occupants prior to any works that may cause vibration.

7.5 Complaints management

Noise and vibration levels generated by construction activities associated with the construction of the development must aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

The contractor is responsible for implementing this Demolition, Excavation and Construction Noise and Vibration Management Plan and ensuring that all reasonable measures are implemented such as the provision of a Noise and Vibration Complaints Program, to minimise the generation of excessive noise and/or vibration levels from the site to nearby sensitive areas.

Owners and occupants of nearby affected properties are to be informed, by direct mail, with a direct telephone line and contact person where any noise and/or vibration complaints related to the operation of the construction activities can be reported.

8 Conclusion

An Operation and Construction Noise and Vibration Assessment has been prepared for the Western Precinct (Stage 1) of the Loreto Kirribilli upgrade located at 85 Carabella Street, Kirribilli.

Specifically, this report has quantified operational noise emission from the proposed development and has assessed noise at the nearest sensitive receivers. The report has been prepared in accordance with the acoustic requirements of SEARs and NSW Environmental Protection Authority (EPA).

On the basis of the assessment, recommendations have been made in regard to noise mitigation measures to be incorporated into the design and operation of the development. In addition, further detailed acoustic assessment and design review will be required during the design development. This further detailed assessment may also be required to address specific conditions stipulated by the consent authority.

With regard to construction, noise emission has been quantified from proposed construction activities and recommendations have been provided to limit the potential impact of noise and vibration generated by construction activities. In addition, if deemed risky following the dilapidation surveys, buffer distances must be determined in more detail prior to the start of construction works through on site measurements of vibration. This report outlines procedures regarding construction time restrictions, including complaints notifications to be provided to properties surrounding the site through a letterbox drop.

APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. 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 CBD mall 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 A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in 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.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
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.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Long-term noise monitoring methodology

B.1 Noise monitoring equipment

A long-term unattended noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave band data	Logger location
RTA06 (NTi XL2)	Type 1	1/1	L1
RTA06 (NTi XL2)	Type 1	1/1	L2
RTA06 (NTi XL2)	Type 1	1/1	L3

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 calibrator. No significant drift in calibration was observed.

B.2 Meteorology during monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NSW INP. Determination of extraneous meteorological conditions was based on data provided by the Bureau of Meteorology (BOM), for a location considered representative of the noise monitoring location(s). However, the data was adjusted to account for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10m above ground level, and the microphone location, which is typically 1.5m above ground level (and less than 3m). The correction factor applied to the data is based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

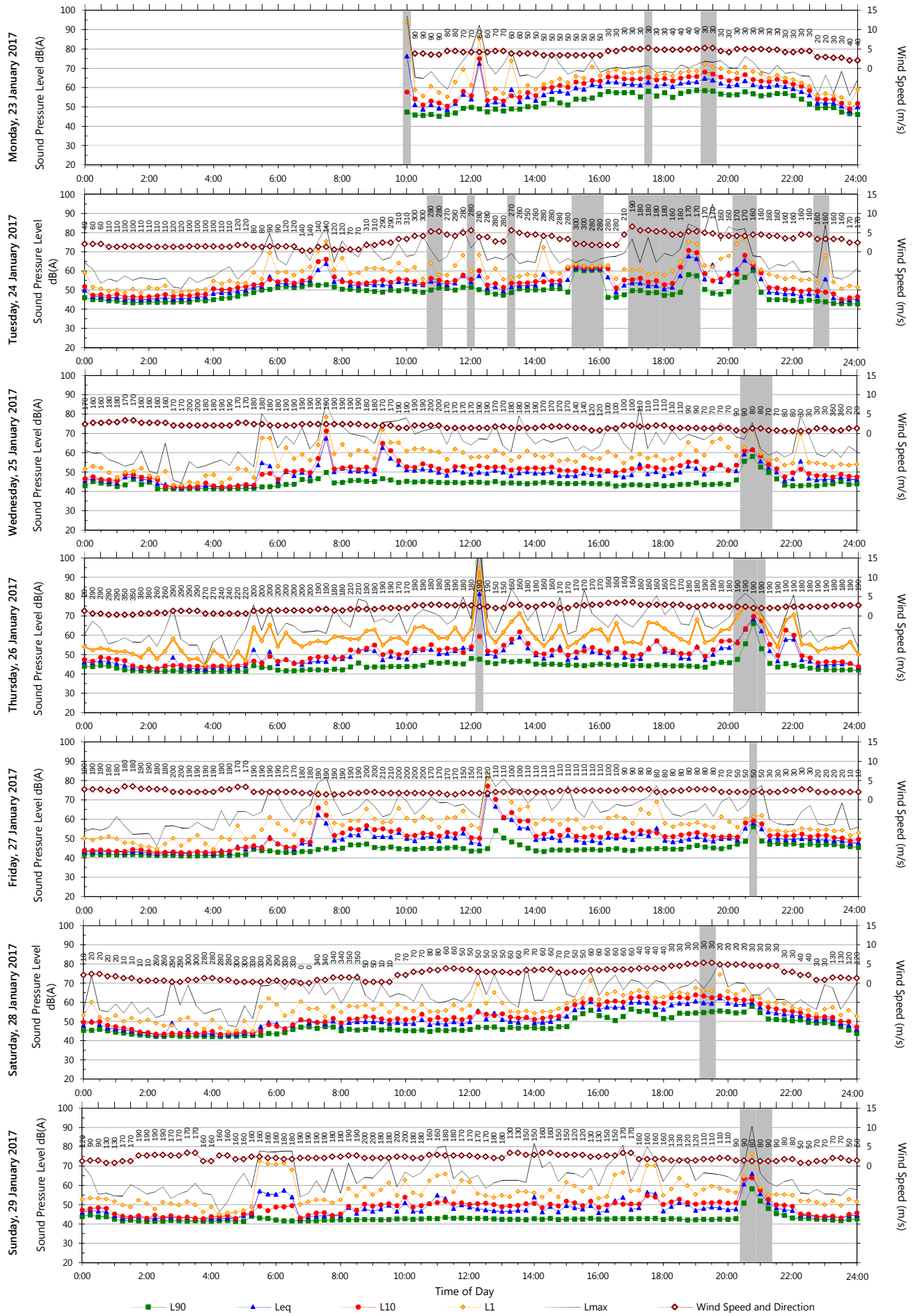
B.3 Noise vs time graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually ten to fifteen minutes. The Noise -vs- Time graphs representing measured noise levels, as presented in this report, illustrate these concepts for the broadband dB(A) results.

APPENDIX C Long-term noise monitoring results

Unattended Monitoring Results

Location: Loreto Kirribilli - Southern side of site

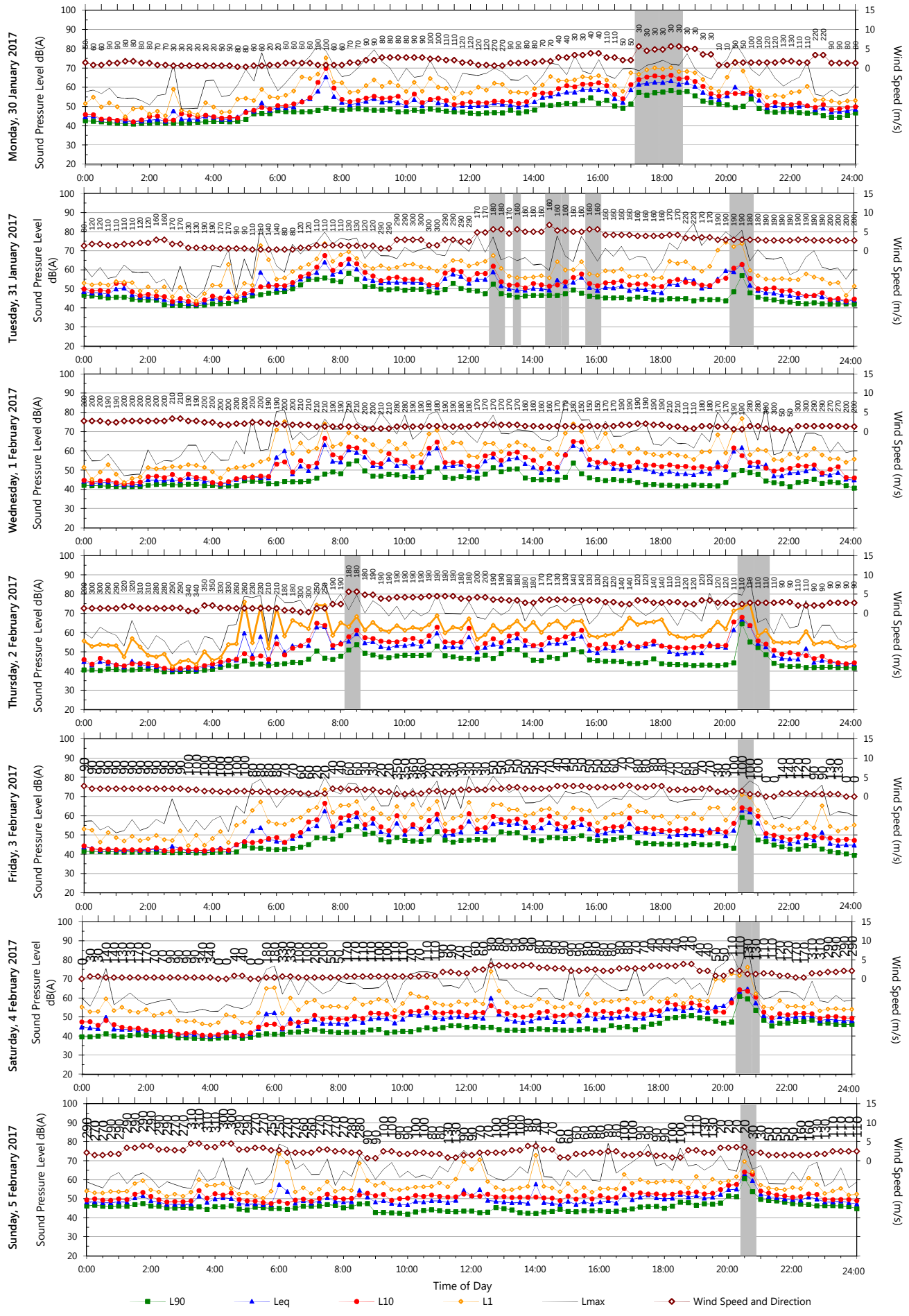


Data File: _123_Rpt_Report.txt

Template: QTE-26 (rev 14) Logger Graphs Program

Unattended Monitoring Results

Location: Loreto Kirribilli - Southern side of site

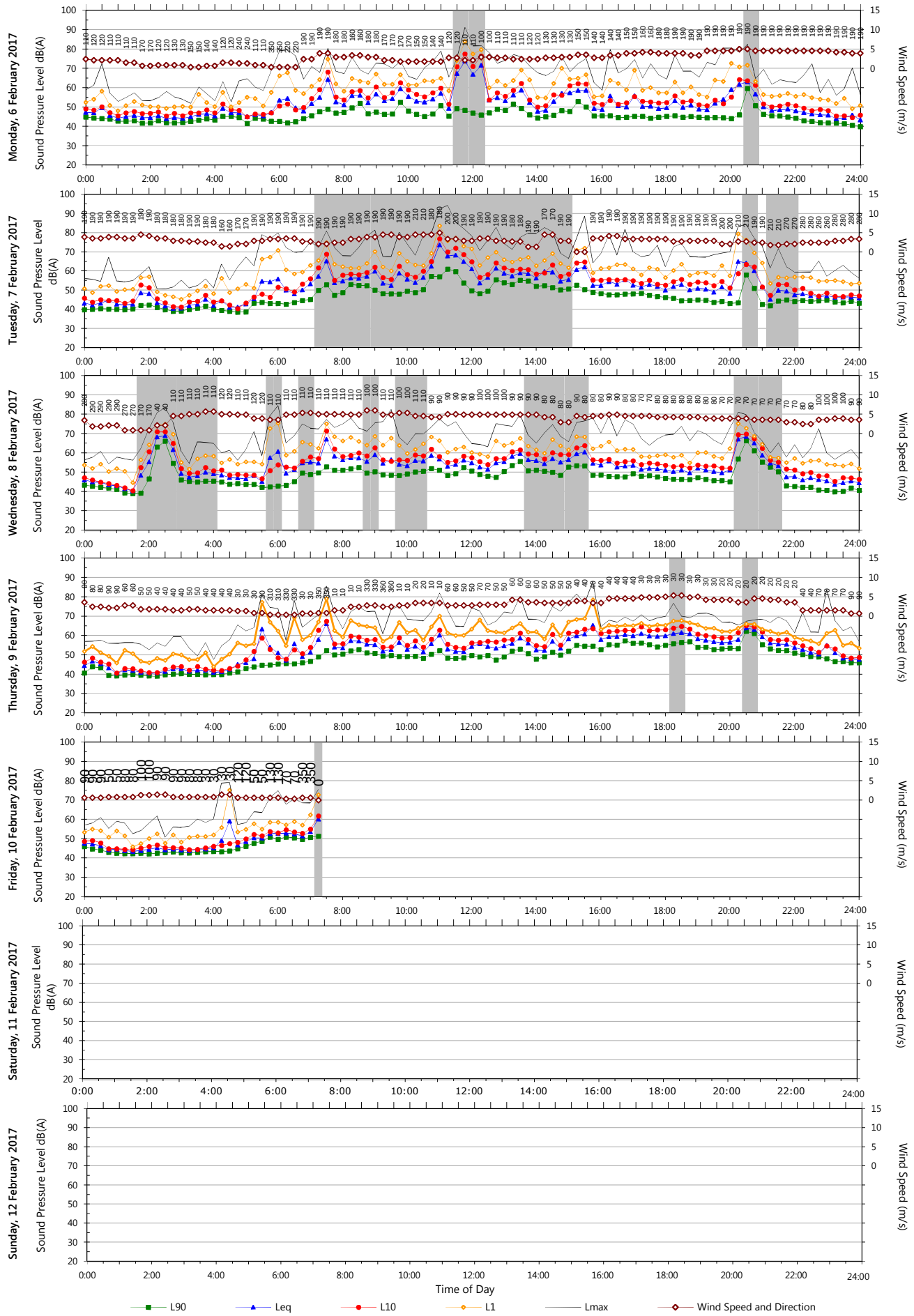


Data File: _123_Rpt_Report.txt

Template: QTE-26 (rev 14) Logger Graphs Program

Unattended Monitoring Results

Location: Loreto Kirribilli - Southern side of site



Data File: _123_Rpt_Report.txt

Template: QTE-26 (rev 14) Logger Graphs Program