BESIX Watpac

Construction Noise and Vibration Impact Statement (CNVIS) Station Box

N217

BR COP

22 December 2022

Project overview

Project Site Address:
Hickson Road
BARANGAROO
NSW 2000

Project Commencement Date:
12 March 2021

BESIX Watpac State Division Address:
Level 24, 44 Market Street
SYDNEY
NSW 2000

ABN:
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Revision history

Version	Date	Revision Description	Project/Site Manager Sign off
00	29/09/21	Approved for construction	Luke Hunter / Project Director
01	03/11/22	6 monthly update - endorsed	Luke Hunter / Project Director
06	22/12/22	Final approved update for construction	Luke Hunter / Project Director

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Acoustics
Vibration
Structural Dynamics

BARANGAROO METRO STATION

Construction Noise and Vibration Impact Statement: Underground station fit-out works

19 December 2022

BESIX Watpac

TM031-03F01 STATION CNVIS (r6)

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Document details

Detail	Reference
Doc reference:	TM031-03F01 STATION CNVIS (r6)
Prepared for:	BESIX Watpac
Address:	Level 24, 44 Market Street Sydney NSW 2000
Attention:	[redacted]

Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Reviewed / Authorised
21.07.2021	First issue	0	1	[redacted]	[redacted]	[redacted]
31.08.2021	AA, ER, SM's comments	-	2	[redacted]	[redacted]	[redacted]
07.09.2021	ER additional comments (section 4.1.5)	-	3	[redacted]	[redacted]	[redacted]
11.10.2021	ER additional comments	-	4	[redacted]	[redacted]	[redacted]
03.11.2022	Table 2-1	-	5	[redacted]	[redacted]	[redacted]
19.12.2022	Inclusion of WTP and personnel hoist, removal of material delivery to northern shed	-	6	[redacted]	[redacted]	[redacted]

File Path: \\syd-server\rtagroupsyd\AssocSydProjects\TM001-TM050\TM031 mt Barangaroo Metro Station\1 Docs\03 CNVIS STATION\TM031-03F01 STATION CNVIS (r6).docx

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1 Introduction

This Construction Noise and Vibration Impact Statement (CNVIS) has been prepared on behalf of BESIX Watpac in accordance with the Construction Noise and Vibration Management Plan (CNVMP) [TM031-01F01 Barangaroo Metro Station NVMP] [1] for the Sydney Metro Barangaroo Station (the Project).

1.1 Relevant requirements and purpose of this CNVIS

The Minister approved the Stage 2 (Chatswood to Sydenham) Metro application lodged by Transport for NSW (TfNSW) as a Critical State Significant Infrastructure (CSSI) project (under Section 115ZB of the Environmental Planning Act 1979, application no SSI 15_7400) on 9 January 2017. The construction of Barangaroo station forms part of the Sydney City Metro & Southwest (SMCSWCS) project. This project falls under the construction and operation of the section between Chatswood and the Sydenham dive site known as "CSSI_7400".

BESIX Watpac have been contracted by Sydney Metro for the construction of the Sydney Metro Barangaroo station, including underground station fit-out, building a station entrance next to Nawi Cove and reinstatement of Hickson Road. The two major stages for the Project are:

1. Underground station fit-out works (this CNVIS);
2. Civil works including all utility and road reinstatement works (addressed in a separate CNVIS).

Condition E33 from the Project Planning Approval SSI 15_7400 requires that:

Construction Noise and Vibration Impact Statements must be prepared for each construction site before construction noise and vibration impacts commence and include specific mitigation measures identified through consultation with affected receivers.

This CNVIS applies to the proposed Underground station fit-out works at Barangaroo worksite during standard construction hours as well as works outside of standard construction hours. The construction hours of work are defined by the Project Planning Approval conditions as outlined in the CNVMP. The civil works are addressed in a separate CNVIS (*Civil CNVIS*) [2].

This CNVIS forms part of the CNVMP for the Project.

1.2 Structure of this CNVIS

This CNVIS is structured as follows:

- **Section 2** - Description of construction works and hours
- **Section 3** - Nearest sensitive receivers
- **Section 4** - Construction noise and vibration objectives

- **Section 5** - Construction noise assessment
- **Section 6** - Construction vibration impacts
- **Section 7** - Ground-borne noise assessment
- **Section 8 –** Traffic noise assessment
- **Section 9 –** Cumulative impacts

1.3 Quality assurance

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 Description of construction works and hours

2.1 Summary of works addressed in this CNVIS

2.1.1 Construction activities

This CNVIS provides an assessment of noise and vibration impacts from activities associated with the underground station fit-out works for the construction of the Sydney Metro Barangaroo station. The works assessed in this CNVIS are identified in APPENDIX C Table C1. An overview of the project extent is shown in Figure 2.1. The detailed description of the proposed work is presented in APPENDIX C. The works are anticipated to commence approximately in September 2021 and expected to finish in May 2023. The timing of each construction activity is also included in APPENDIX C.

Figure 2.1: Sydney Metro Barangaroo Station – project overview

Note: civil works in the green and blue areas, underground station works in the blue area.

2.1.2 Construction traffic

The Barangaroo site construction works 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 materials, plant and equipment to the worksite.

Construction traffic on-site (i.e. within the Project footprint) is included as part of the construction noise assessment of the works activities identified in APPENDIX C. When construction related traffic moves onto the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as 'additional road traffic' rather than as part of the construction site's activities. Construction traffic noise is addressed in Section 8.

2.1.3 Cumulative construction impacts

CSSI 7400 Condition of Approval E39 requires BESIX Watpac to consult with proponents of other construction works in the vicinity of the worksite and take reasonable steps to coordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receivers. Further to this, Condition E40 requires works to be coordinated to provide the required respite periods identified in accordance with the terms of the CSSI 7400 approval.

Potentially concurrent construction activities within the vicinity of the Barangaroo site have also been considered, as discussed in Section 9.

2.2 Construction methodology (PPA Condition E35)

The proposed works do not include any excavation works with rock hammers or blasting.

2.3 Construction hours

The construction hours for the Project are defined by Project Planning Approval (PPA) Conditions E36, E37, E38, E41, E42 and E44. The standard hours and out-of-hours work (OOHW) periods are depicted in Table 2-1 below. The OOHW periods are further defined as OOHW Period 1 and 2 based on the Transport for NSW Construction Noise Strategy (TfNSW CNS), as noted in the NVMP.

Table 2-1: Construction hours

Day/ Time	12am – 1am	1am – 2am	2am – 3am	3am – 4am	4am – 5am	5am – 6am	6am – 7am	7am – 8am	8am – 9am	9am – 10am	10am – 11am	11am – 12pm	12pm – 1pm	1pm – 2pm	2pm – 3pm	3pm – 4pm	4pm – 5pm	5pm – 6pm	6pm – 7pm	7pm – 8pm	8pm – 9pm	9pm – 10pm	10pm – 11pm	11pm – 12am
Monday to Friday										Standard construction Hours									OOHW Period 1					
Saturday																								
Sunday or Public Holiday		OOHW Period 2										OOHW Period 1								OOHW Period 2				

2.4 Justification for OOHW

Any work outside standard construction hours must be undertaken in accordance with the Out of Hours Works Protocol and the CNVMP [1].

2.4.1 Station works

In accordance with CoA E48(d), underground station fit out work may be undertaken 24 hours per day, seven days per week. These works will be completed underground inside the station box which would be enclosed with a concrete roof.

2.5 COVID-19 extended construction hours

The Environmental Planning and Assessment (COVID-19 Development – Infrastructure Construction Work Days) Order 2020 commenced on 9 April 2020 and will continue until 31 March 2022. The order permits standard construction hours on this project to be extended as follows:

- Saturday from 7am to 8am and from 1pm to 6pm (no high noise work permitted)
- Sundays from 7am to 6pm (no high noise work permitted)
- Public holidays from 7am to 6pm (no high noise work permitted).

High noise work means activities such as rock breaking, rock hammering, sheet piling, pile driving or similar noisy activities, unless an existing consent or approval already allows these works to occur on any of the extended days.

Appropriate noise management levels for the extended hours period (i.e. Sundays/ Public Holidays 7am to 6pm) are as outlined for the Day (D/ D(O)) period in Section 4.1.1.

3 Nearest sensitive receivers

3.1 Residential receivers

To assess and manage construction noise and vibration impact, the residential areas surrounding the Project worksites have been divided into Noise Catchment Areas (NCAs) based on each area's similar acoustic environment prior to the commencement of construction work. The NCAs are based on those established in the EIS for the Project [3], with some modifications to allow for site specific characteristics.

All relevant residential sensitive receivers near the worksite are identified on aerial photographs located in APPENDIX B.

3.2 Other sensitive receivers (PPA Condition E34)

Additional to residential receivers above, 'other' noise and vibration sensitive receivers such as passive recreation areas and places of worship surrounding the construction area have been identified and are summarised on an aerial photograph located in APPENDIX B.

CSSI-7400 Condition E34 states:

> *Noise generating works in the vicinity of potentially-affected, religious, educational, community institutions and noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) must not be timetabled within sensitive periods, unless other reasonable arrangements to the affected institutions are made at no cost to the affected institution or as otherwise approved by the Secretary.*

3.3 Commercial and industrial premises

All commercial and industrial premises near the worksite have been considered in this assessment.

3.4 Heritage receivers

Heritage receivers are identified in the Land Use Survey in Annexure B of the CNVMP. Table 3-1 identifies the heritage-listed structures close to work areas:

Table 3-1: Assessment heritage receivers

Site	Item	Address	Significance
Barangaroo	Terrace duplex group including interiors	2–36 High Street	Item 883 City of Sydney LEP ; SHR Item 00920
	Terrace duplex group including interiors	3, 5, 7, 9 High Street	Item 884 City of Sydney LEP ; SHR Item 00918
	Lance Kindergarten including buildings and their interiors, early remnant fencing and grounds	37 High Street	Item 886 City of Sydney LEP

Site	Item	Address	Significance
	Terrace duplex group including interiors	38–72 High Street	Item 888 City of Sydney LEP ; SHR Item 00919
	Terrace duplex group including interiors	74–80 High Street	Item 889 City of Sydney LEP ; SHR Item 00868
	Palisade Hotel including interior and archaeological site	35-37 Bettington Street	Item 874 City of Sydney LEP ; Archaeological site A1191 ; SHR Item 00510
	Bridges over Hickson Road	Argyle Place (and Munn and Windmill Streets)	Item 869 City of Sydney LEP
	Retaining Wall, Palisade Fence and Steps	High Street	Item 881 City of Sydney LEP/Item 882 City of Sydney LEP
	Hickson Steps	16-28 Windmill St	Maritime NSW S170 Register Item 4920007
	Dalgety Terrace	7, 9, 11, 13 Dalgety Terrace	SHR00867
	Terraces	27a, 29a, 31a, 33, 35a Dalgety Terrace	SHR00923
	Terraces	15, 17, 19, 21, 23, 25 Dalgety Terrace	SHR00867
	Dalgety's Bond Stores Group of Buildings	6-20 Munn Street	Maritime NSW S170 Register; SHR Item 00526
	Shops	10, 10a, 12, 12a Argyle Place	SHR00891
	Lord Nelson Hotel	19 Kent Street	SHR00509

4 Construction noise and vibration objectives

4.1 Noise goals

4.1.1 Noise management levels (NMLs)

Construction noise management levels (NMLs) have been determined using the Construction Environmental Management Framework (CEMF) [10], CSSI-7400 Conditions, in accordance with the Sydney Metro City & Southwest Construction Noise and Vibration Strategy (SMCSNVS) [8] and as set out in the NVMP.

For the Barangaroo site, external NMLs are derived from the Interim Construction Noise Guideline (ICNG)[4], as summarised in Table 4-1 below. Internal NMLs are also applicable at residential receiver locations during the 7 am to 8 pm period through CSSI-7400 Conditions E37 and E38; and during the 8 pm to 7 am period per E41 and E42, as summarised in Table 4-1 below.

Table 4-1: Application of NMLs (CSSI 7400 Conditions of Approval)

Time Period	Area	Receiver Type	Reference	Noise management level[3]
ICNG				
Day[1]	All	All	CNVS[3] Section 5.3	ICNG (see Table B1 in APPENDIX B)
Day[1] OOHW Period 1	All	All	CNVS[3] Section 5.3	ICNG (see Table B1 in APPENDIX B)
Evening[1] OOHW Period 1	All	All	CNVS[3] Section 5.3	ICNG (see Table B1 in APPENDIX B)
Night[1] OOHW Period 2	All	All	CNVS[3] Section 5.3	ICNG (see Table B1 in APPENDIX B)
CSSI-7400				
Day[1] (D/ D(O)) Evening[1] 6pm to 8pm (E1)	Identified precincts (including Marrickville)	All	CSSI-7400 E38	Noise levels are required to be less than $L_{Aeq(15minute)}$ 60 dB(A) for at least 6.5 hours between 7am and 8pm, of which at least 3.25 hours must be below $L_{Aeq(15minute)}$ 55 dB(A). Noise equal to or above $L_{Aeq(15minute)}$ 60 dB(A) is allowed for the remaining 6.5 hours between 7am and 8pm.[4]
Evening[1] 8pm to 10pm (E2) Night[1] 10pm to 7am (N) Night[1] 10pm to 7am (N)	Residential zones[2]	Residential	CSSI-7400 E42	$L_{Aeq(15minute)}$ 45 dB(A) (internal)
All	All	All	SSI-7400 E43	$LAeq_{(8hour)}$ 85 dB(A) (external) near the CCSI

1. Day refers to 7am to 6pm Monday to Friday and 8am to 6pm Saturday, Sunday and Public Holidays; Evening refers to Monday to Sunday 6:00pm to 10:00pm; Night refers to Monday to Friday 10:00pm to 7:00am and Saturdays, Sundays and public holidays 10:00pm to 8:00am.
2. These are identified by the applicable Local Environmental Plan land zoning of the receiver.
3. Sydney Metro City & South West Construction Noise and Vibration Strategy (Sydney Metro 2016)
4. Criteria as described in SSI 7400 Condition E38
5. A 5 dB penalty shall be applied if rock breaking or any other annoying activity likely to result in ground-borne noise or a perceptible level of vibration is planned

4.1.2 Sensitive receiver NMLs and respite for high noise impact works (CSSI-7400 Conditions E37 and E38)

Day-time works need to be assessed against the requirements of CSSI-7400 Conditions E37 and E38. Consultation will be undertaken with receivers predicted to experience internal noise levels greater than $L_{Aeq(15minute)}$ 60 dB(A), between 7am and 8pm, to determine appropriate hours of respite in accordance with CSSI-7400 Conditions E37 and E38. Receivers have been identified using the following process:

- An NML equivalent to an internal noise level of $L_{Aeq(15minute)}$ 60 dB(A) was established for all identified receivers:
  - For residential receivers, the equivalent external NML is based on a 10 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows open)
  - For non-residential receivers with light weight glazing, the equivalent external NML is based on a 20 dB(A) minimum (conservative) difference between external and internal noise levels (assuming windows closed)
  - Where additional information is available (e.g. if residential or non-residential properties have been acoustically treated), alternative outdoor to indoor noise difference will be determined to establish the equivalent external noise threshold.
- Receivers where noise is predicted to be above the equivalent external NML are identified as requiring consultation (APPENDIX D.2).

The adopted difference between external and internal noise levels is identified in APPENDIX D.

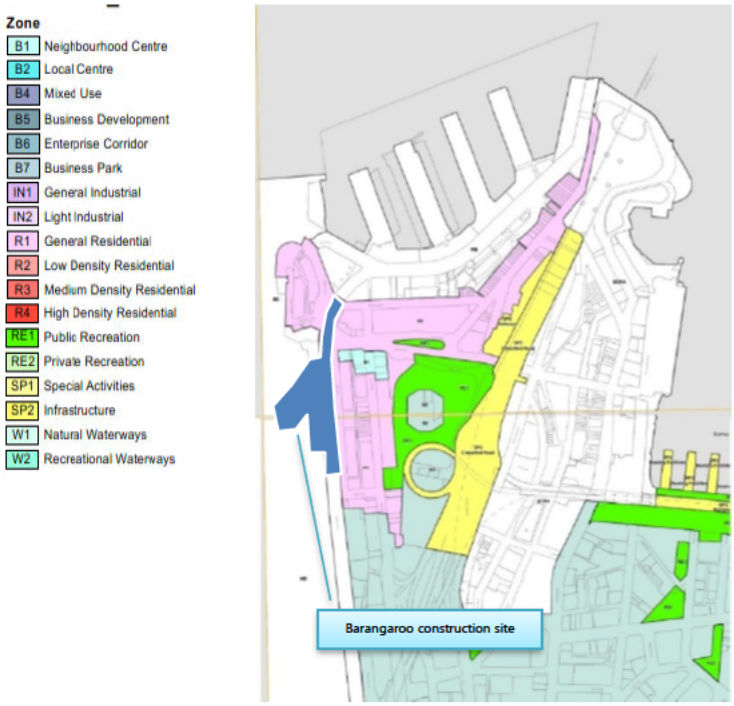
4.1.3 Residential receiver NMLs – 8pm to 7am (CSSI-7400 Conditions E41 and E42)

CSSI-7400 Conditions E41 and E42 require that residential receivers within non-residential zones or residential zones (respectively) are not above the internal noise levels identified in Table 4-1. In accordance with CSSI-7400 Conditions E41 and E42, if construction works are particularly annoying (as described in *ICNG NMLs* above) or include ground-borne noise or a perceptible level of vibration at the affected receiver, a 5 dB(A) penalty should be added to the predicted construction noise level.

Where the above internal noise levels cannot be achieved, additional mitigation in accordance with the *Sydney Metro City and South West Noise and Vibration Strategy* (SMCSNVS) [8] is to be offered.

Addendum A of the SMCSNVS notes that the applicable Local Environmental Plan land zoning of the receiver be used to identify if residential receivers are located within residential or non-residential zones. Figure 4.1 is an extract from Sydney Local Environmental Plan 2012 land zoning maps LZN_013 and LZN_014 (accessed 30/10/17). As shown in Figure 4.1, the nearest residential receivers are in a residential zone (R1 General Residential).

Figure 4.1: Extract from Sydney Local Environmental Plan 2012 Land Zoning Map - compilation of Sheet LZN_013 and Sheet LZN_014



For this assessment, all residential receivers are assumed to be in residential zones (CoA E42), with a corresponding internal noise threshold level of $L_{Aeq(15minute)}$ 45 dB(A) between 8pm and 7am. Based on a minimum (conservative) external to internal noise difference of 10 dB(A) (assuming windows open), an equivalent external noise threshold of $L_{Aeq(15minute)}$ 55 dB(A) is applicable between 8pm and 7am for all receivers, expect for few receivers where previous measurements and site inspections confirmed the existing façade loss (APPENDIX D). Where these external equivalent levels are above the external noise threshold, additional mitigation may be required in accordance with the SMCSNVS.

The assessment presented in Section 5 has assessed all receivers against the approach outlined in the SMCSNVS [8] and the CNVMP [1] which achieves the requirements of CSSI-7400 Conditions E41 and E42, and is consistent with the ICNG [4] and the EIS [3].

4.1.4 Sleep disturbance

Consistent with Section 4.5.5 of the NVMP, to assess the likelihood of sleep disturbance, an initial screening level of L_{Amax} <$L_{A90,15min}$ + 15 is used. In situations, where this results in an internal screening levels of less than 45 dB(A) (internal), a minimum internal screening level of 45 dB(A) is set. Note that this is equivalent to an external maximum noise level of 55 dB(A) with windows open or 65 dB(A) with closed windows, based on an outside-to-inside noise reduction of respectively 10 dB(A) and 20 dB(A).

Where there are noise events found to exceed the initial screening level, further analysis is made to identify:

- The likely number of events that might occur during the night assessment period
- Whether events exceed an 'awakening reaction' level of 55dBA L_{Amax} (internal) that equates to an external NML of L_{Amax} 75 dB(A) (assuming closed windows).

The ICNG recommends that where construction works are planned to extend over more than two consecutive nights, maximum noise levels and the extent and frequency that maximum noise levels exceed the RBL should be analysed.

4.1.5 National Standard for exposure to noise

In accordance with PPA Condition E43, BESIX Watpac will be managed to ensure that noise generated by construction will not be above the National Standard for exposure to noise in the occupational environment of an eight-hour equivalent continuous A-weighted sound pressure level ($L_{Aeq,8h}$,) of 85 dB(A) for any employee working at a location near a Barangaroo Sydney Metro worksite. Representative noise measurements will be undertaken in close proximity to the nearby worksites to determine the L_{Aeq8h} that workers from adjacent worksites may be experienced due to works associated with Sydney Metro Barangaroo site.

4.1.6 Construction related road traffic noise objectives

On the roads immediately adjacent to construction sites, the community may associate heavy vehicle movements with the site. Construction traffic movements on public roads will aim to limit any increase in existing road traffic noise levels to no more than 2 dB(A). All feasible and reasonable noise mitigation and management measures will be implemented.

4.2 Construction vibration goals

As reported in Section 4.8 of the CNVMP [1], construction vibration goals have been determined using:

- Human comfort – disturbance to building occupants: vibration in which the occupants or users of the building are inconvenienced or possibly disturbed.
- Effects on building contents – vibration where the building contents may be affected.
- Effects on building structures – vibration in which the integrity of the building or structure itself may be prejudiced.

4.2.1 Disturbance to buildings occupants

The vibration dose values recommended in the guideline ‘Assessing Vibration; a technical guideline’ are presented in Table 4-2.

Table 4-2: Vibration Dose Values for intermittent vibration

Place and Time	Preferred Vibration Dose Value (VDV) in $m/s^{1.75}$	Maximum Vibration Dose Value (VDV) in $m/s^{1.75}$
Critical areas[1] (day or night)	0.1	0.2
Residential buildings 16 hr day	0.2	0.4
Residential buildings 8 hr night	0.13	0.26
Offices, schools, educational institutions and places of worship (day or night)	0.4	0.8
Workshops (day or night)	0.8	1.6

Notes:
1) 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.

To assess the potential for vibration impact on human comfort, an initial screening test will be done based on peak velocity units, as this metric is also used for the cosmetic damage vibration assessment. This screening test is a conservative approach since it is based on the continuous vibration velocity criteria (i.e. vibration that continues uninterrupted for a defined assessment period) whilst construction works are mostly intermittent. The screening test (Table 4-3) will be based on maximum peak values for surface construction works, which are intermittent in nature. This approach has been adopted so that the screening test is not unduly stringent.

If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (i.e. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

Table 4-3: Construction vibration disturbance – initial screening test.

Place and Time	Preferred peak velocity, mm/s (>8Hz)	Maximum peak velocity, mm/s (>8Hz)
Critical areas (day or night)	0.14	0.28
Residential buildings 16 hr day	0.28	0.56
Residential buildings 8 hr night	0.20	0.40
Offices, schools, educational institutions and places of worship (day or night)	0.56	1.10
Workshops (day or night)	1.10	2.20

4.2.2 Structural damage to buildings

Potential structural damage of buildings caused by 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 (1993) as required by Project Planning Approval Condition E28. 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.

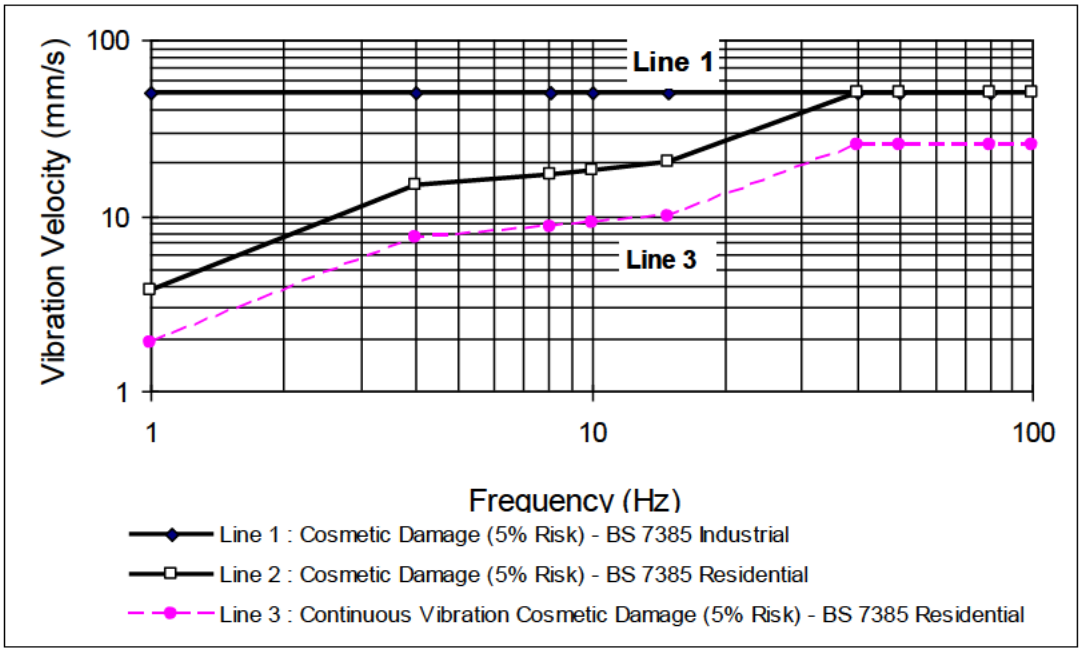
Table 4-4 sets out the recommended limits from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential, commercial and industrial buildings. This is shown graphically in Figure 4.2.

Table 4-4: Transient vibration guide values - minimal risk of cosmetic damage (BS 7385) - peak component particle velocity

Line	Type of structure	Frequency range 4 to 15 Hz	Frequency range 15 to 40 Hz	Frequency range 40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4Hz, increasing to 20 mm/s at 15Hz	20 mm/s at 15Hz, increasing to 50 mm/s at 40Hz	50 mm/s

BS7385 states that the guide values in Table 4-4 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4-4 may need to be reduced by up to 50%, as shown by Line 3 of Figure 4.2 for residential buildings.

Figure 4.2: Graph of Transient Peak Component Particle Velocity Vibration Guide Values for Cosmetic Damage



4.2.3 General vibration screening criterion

The British Standard states that the guide values in Table 4-4 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings. Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4-4 may need to be reduced by up to 50%. This is especially applicable at the lower frequencies where lower guide values apply.

On this basis, consistent a conservative vibration screening criteria per receiver type is given below:

- Reinforced or framed structures (Line 1): **25.0 mm/s**
- Unreinforced or light framed structures (Line 2): **7.5 mm/s**

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable vibration level. The analysis would take into consideration the transient vibration guide values for minimal risk of cosmetic damage set out in Figure 4.2.

4.2.4 Heritage structures/buildings

The British Standard BS7385 states that *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

In accordance with Project Planning Approval Condition E31, the advice of a heritage specialist on methods and locations for installing equipment used for vibration, movement and noise monitoring of heritage-listed structures will be sought.

Unless otherwise advised, a conservative vibration damage screening level (peak component particle velocity) for heritage buildings/structures can be set to 2.5mm/s (the more stringent criterion in the German Standard DIN 4150-2016 Structural Vibration Part 3: Effects of Vibration on Structures). This screening level will allow potentially impacted heritage structures to be identified. If a heritage structure is predicted to be exposed to vibration levels above the conservative vibration screening level of 2.5mm/s, further investigation would be undertaken to determine whether the structure is structurally unsound. Where a heritage building is deemed to be sensitive to vibration impacts, the more stringent DIN 4150-2016 Group 3 guideline values can be applied. Otherwise, structural damage vibration limits based on BS 7385 (Section 4.2.3) can be applied.

4.2.5 Sensitive scientific and medical equipment

No sensitive scientific or medical equipment are known to be located near the assessed works. If they are identified, relevant vibration criteria should be established for each item in line with Section 4.8.5 of the NVMP [1], and any corresponding management or mitigation measures determined.

4.2.6 Utilities and other vibration sensitive structures

Where utilities or other vibration sensitive structures are identified, relevant vibration criteria will be established for each item per Section 4.8.6 of the CNVMP [1], and any corresponding management or mitigation measures determined.

5 Construction noise assessment

5.1 Noise prediction methodology

Modelling and assessment of airborne noise impacts from activities associated with the construction works were determined by modelling the noise sources, receiver locations, topographical features, and possible noise mitigation measures using a Cadna-A computer noise model developed for this project. The model calculates the contribution of each noise source at identified sensitive receiver locations and allows for the prediction of the total noise from a site for the various stages of the construction works.

The noise prediction models take into account:

- Location of noise sources and sensitive receiver locations.
- Height of sources and receivers referenced to one metre digital ground contours for the site area and surrounding area.
- Sound Power Levels (L_w) of plant and equipment likely to be used during the various construction activities (see Table C1 in APPENDIX C). Table C1 also identifies the plant and equipment that will operate during each assessment period and the likely timing of each activity/aspect.
- Separation distances between sources and receivers.
- Ground type between sources and receivers.
- Attenuation from barriers (natural and purpose built).

Key details regarding the construction site layout, the likely plant and equipment (including truck movements), and hours of operation were informed by the Design and Construction Teams. This information is presented in APPENDIX C and formed the basis for all modelling assumptions used in this assessment.

5.2 Detailed design outcomes

The key noise mitigation measures that have been included in the noise modelling results presented in this CNVIS are:

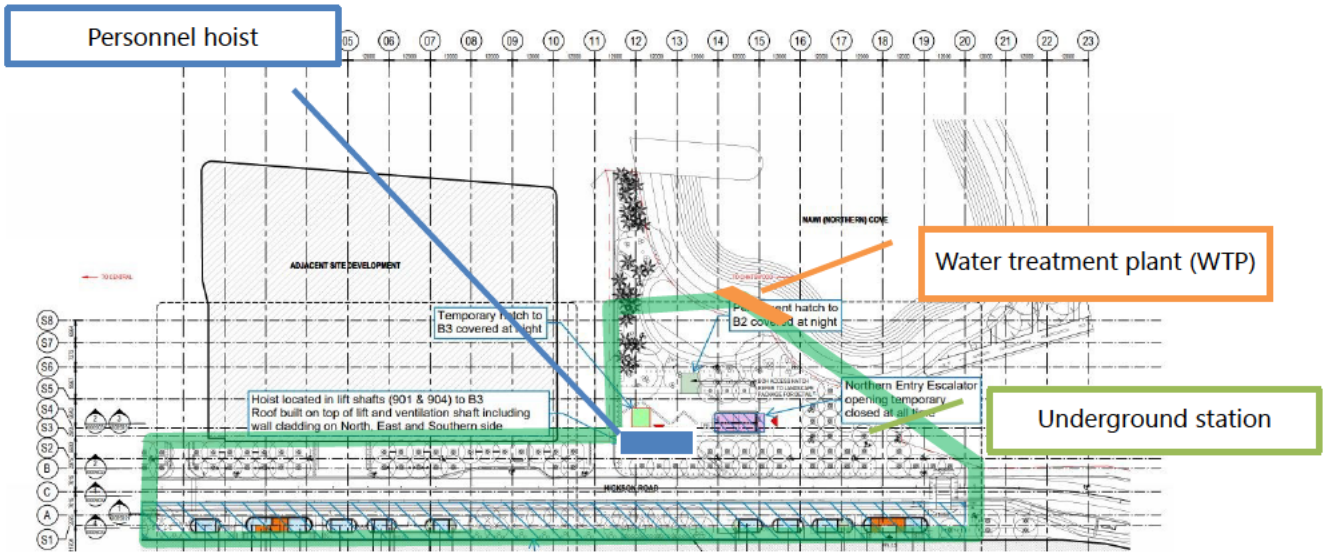
- acoustic shed (on Hickson Road) for materials delivery;
- acoustic attenuators for the intake ventilation fan located in the Hickson Road shed;
- acoustic treatment of shed louvres to further reduce noise during underground tunnel and station fit-out works;
- full enclosure of the station box with a concrete roof;

The above recommendations are all existing measures which have previously been implemented for past construction works. All hoardings and acoustic sheds developed for the TSE works will remain on site and will not be altered from the existing configuration until the end of the project.

In addition, BESIX Watpac will include the following mitigation measures:

- acoustic attenuators for the exhaust fans located within the underground station;
- removable enclosure to close B2 and B3 access hatches in the "shark fin" area at night (Figure 5.1);
- temporary enclosure to close the northern entry escalator opening in the "shark fin" area at all times;
- personnel hoist: noise aware practices such as avoiding slamming the doors open/close and consideration of door pads which could provide soft cushioning to slow down the door as it closes (preventing a slam) where practicable.
- Water treatment plant: further investigation to identify reasonable and feasible mitigation measures to minimise noise
- partial enclosure on the lift shafts (901 and 904) in the "shark fin" area to reduce noise levels at residential receivers to the north, east and south.

Figure 5.1: Access hatches and openings to be totally or partially enclosed



More detailed mitigations measures are presented in APPENDIX C Table C2, Table C3 and Table C4.

5.3 Predicted noise levels

Predicted L_{Aeq} noise levels from the worksite are assessed against the NMLs and summarised in the following sections, with colour coding to denote the highest level of exceedance of the NML. Detailed results for each receiver are given in APPENDIX D.

The noise predictions presented in this CNVIS represent a realistic worst-case scenario when construction occurs at work locations close to residences and other sensitive receivers. At each receiver, noise levels will vary during the construction period based on the position of equipment within the worksite, the distance to the receiver, the construction activities being undertaken and the noise levels of particular plant items and equipment. Actual noise levels will often be less than the predicted levels presented in this CNVIS.

The construction activity included in this CNVIS is summarised in Table 5-1.

Table 5-1: Summary of construction activities

Work Activity (APPENDIX C)	Work area	Scenario reference code (APPENDIX C)
Underground station fit-out works	See APPENDIX B	USFW

5.3.1 ICNG NMLs

5.3.1.1 ICNG Standard construction hours

Table 5-2 presents the predicted worst case construction noise levels for each of the construction work zones identified in Table 5-1 at the most noise affected receivers. The results are presented in terms of level above the ICNG standard daytime NMLs.

For **Standard Hours** construction noise impacts are presented as follows:

- ◆ Complies with NML
- ○ < 10dB(A) above NML - construction noise clearly audible
- ◆ > 10dB(A) above NML - construction noise moderately intrusive
- □ > 75dB(A) - highly noise affected (for residential receivers)

Table 5-2: Summary of construction noise impacts – standard construction hours

NCA	Standard construction hours D(S)
	Construction scenario (see APPENDIX C)
	USFW
BN_01	●
BN_02	●
BN_03	○
BN_04	●
BN_05	●
BN_06	●
OSR	●

Notes: Day D(S): 7am to 6pm Monday to Friday and 8am to 1pm on Saturdays

During the standard construction hours, construction noise levels are predicted to comply with the corresponding NMLs for nearby residential receivers except for one residential receiver (18-18A High Street, Millers Point in NCA BN_03) where the predicted levels are 1 dB above the NML. Noise levels for nearby other sensitive receivers are predicted to comply with the corresponding NMLs.

5.3.1.2 ICNG OOHW

Table 5-3 presents the predicted worst-case construction noise levels for each of the construction work zones identified in Table 5-1 at the most noise affected receivers in each NCA. The results are presented in terms of level above the ICNG NMLs for the OOHW period.

- ● Below NML
- ○ < 5dB(A) above NML - construction noise noticeable
- ◆ 5 to 15dB(A) above NML - construction noise clearly audible
- ■ > 15 to 25dB(A) above NML - construction noise moderately intrusive
- □ >25dB(A) above NML - construction noise highly intrusive

Table 5-3: Summary of construction noise impacts – OOHW periods

NCA	OOHW Periods		
	Construction scenario - USFW (see APPENDIX C)		
	OOHW D(O)	Evening	Night
BN_01	●	●	●
BN_02	●	●	●
BN_03	●	●	○
BN_04	●	●	●
BN_05	●	●	●
BN_06	●	●	●
OSR	●	●	●

Notes: Night N: 10pm to 7am Monday to Friday, 10pm to 8am on Saturdays and 6pm to 8am on Sunday or Public Holidays

During the OOHW daytime and evening periods, noise levels are predicted to comply with the corresponding NMLs for nearby residential and other sensitive receivers.

During the OOHW night-time period, a maximum of 2dB exceedance above the corresponding NML at the most affected residences in NCA BN_03 have been predicted.

Other sensitive receivers have been predicted to comply with the corresponding NMLs for the specified OOHW periods.

Mitigation and management measures are discussed in Section 5.4 of this report.

5.3.2 CSSI-7400 Conditions E37/E38

Table 5-4 presents the predicted worst-case construction noise levels for each of the construction stages identified in Table 5-1 at the most affected residential receiver in each NCA and other sensitive receivers (OSR). The results are compared with the internal NMLs in CSSI-7400 Conditions E37 and E38. Where the measured or predicted noise levels are above the equivalent external NML, consultation will be undertaken with affected receivers to determine appropriate hours of respite in accordance with CSSI-7400 Conditions E37 and E38. The impacts presented are as follows:

- ◆ Noise levels predicted to be below internal NMLs in CSSI-7400 Conditions E37 and E38
- ☐ Noise levels predicted to be above internal NMLs in CSSI-7400 Conditions E37 and E38

Table 5-4: Summary of construction noise impacts for the Day and E1 period – CSSI-7400 Conditions E37/ E38

NCA	Standard construction hours D(S) and Evening E1 period (7am to 8pm)
	Construction scenario (see APPENDIX C)
	USFW
BN_01	●
BN_02	●
BN_03	●
BN_04	●
BN_05	●
BN_06	●
OSR	●

Notes: D(S): 7am to 6pm Monday to Friday and 8am to 6pm Saturday, Sunday and Public Holidays
E1: Evening period from 6pm to 8pm

Based on the results presented in Table 5-4, noise levels are predicted to comply with CSSI-7400 E37 and E38 during the underground station fit-out works at all receivers. Therefore, consultation and respite periods are not required for the proposed station works.

5.3.3 CSSI-7400 Conditions E41/E42

Table 5-5 summarises the predicted noise impacts for each construction stage in each NCA compared with the internal NMLs in CSSI-7400 Conditions E41 and E42. Where predicted levels are above the E41/42 NMLs at residential receivers, additional mitigation measures will be implemented in accordance with the documented procedure in Addendum A of the SMCNVS.

The impacts presented are as follow:

- ◆ Noise levels predicted to be below internal NMLs in CSSI-7400 Conditions E41 and E42
- ☐ Noise levels predicted to be above internal NMLs in CSSI-7400 Conditions E41 and E42

Table 5-5: Summary of construction noise impacts for the E2 and Night period – CSSI-7400 Conditions E41/42 (residential only)

NCA	Evening E2 period and Night-time period (8pm to 7am)
	Construction scenario (see APPENDIX C)
	USFW
BN_01	●
BN_02	●
BN_03	●
BN_04	●
BN_05	●
BN_06	●

Notes: E2: Late evening period from 8pm to 10pm
N: Night-time period from 10pm to 7am Sunday to Thursday and 10pm to 8am Friday, Saturday and Public Holidays

From Table 5-5 above, noise levels during the Evening E2 and night-time period are predicted to comply with CSSI-7400 E41 and E42 during the underground station fit-out works for all nearby residential receivers.

5.3.4 Sleep disturbance

Although maximum noise levels associated with the operation of the personnel hoist may be above the screening levels, they are well below the sleep disturbance 'awakening reaction' internal NML of 55 dB(A) $L_{A,max}$. Nonetheless, these activities will be managed by introducing noise aware practices such as avoiding slamming the doors open/close and consideration of door pads which could provide soft cushioning to slow down the door as it closes (preventing a slam) where practicable.

Toolbox talks will be used to advise all personnel of the need to follow quiet work practices during OOHW periods and of the need to respect the residential receivers surrounding the work site. Other management measures are outlined in Section 5.4 to aid in providing additional noise reduction benefits where predicted levels are above the objective.

5.4 Noise mitigation and management

5.4.1 Consultation with affected receivers (CSSI-7400 Condition E33)

CSSI-7400 Condition E33 requires consultation with affected receivers to assist in determining site-specific mitigation measures to be included in this CNVIS.

BESIX Watpac has engaged with the contractor previously working on Sydney Metro City and Southwest Project at Barangaroo worksite (JHCPBG JV) to provide a register of the consultation outcomes. Nevertheless, BESIX Watpac will continue to consult with potentially affected sensitive receivers, both prior to and following commencement of construction to inform the identification of mitigation measures for the Barangaroo site.

These measures may include:

- minimising high noise impact works during night-time hours;
- limiting night-time works in individual locations to no more than two consecutive nights, three nights a week and ten nights a month whenever practicable;
- scheduling high noise impact works around sensitive periods where feasible and reasonable;
- providing respite from high-impact noisy works during the childcare centre's requested respite periods.
- reorganising the program of works, where possible, to work in with KU Lance Child Care Centre's needs.

5.4.2 Site noise control measures

Table 5-6 shows the noise control measures recommended to reduce potential noise impacts.

Table 5-6: Site noise control measures

Control type	Control measure	Typical use
At-source control measures	Noise control kits	Plant that is brought to site for works should meet the sound power limits identified in Table C1. Where plant are above limits then the plant may require installation of 'noise control kits' to comply with the noise limits in Table C1. Such 'noise control kits' comprise: • high performance 'residential-grade' exhaust mufflers, • additional engine cowling / enclosure lined inside with sound absorbent industrial-grade foam, and • air intake and discharge silencers / louvres. The need to fit 'noise control kits' onto the identified plant, will be confirmed once each plant item is tested prior to its regular use on site, in accordance with Section 8 of the NVMP.
	Limit equipment in use	Only the equipment necessary during each stage of the works will be used.
	Timing of equipment in use	Where practicable, activities and plant will be limited as outlined in Table C1 (APPENDIX C).

Control type	Control measure	Typical use
	Limit activity duration	Any equipment not in use for extended periods shall be switched off. For example, heavy vehicles should switch engines off when not in use.
	Use and siting of plant	Avoid/ limit simultaneous operation of noisy plant and equipment within discernible range of a sensitive receiver. Direct noise-emitting plant away from sensitive receivers where practicable. Locate fixed location plant items as far from sensitive receivers as practicable.
	Equipment selection	Use quieter and less noise/ vibration emitting construction methods where feasible and reasonable.
	Truck movements	Where practicable, avoid the use of park air brakes at night. Air brake silencers are to be correctly installed and fully operational for any heavy vehicles (as per CNVMP). Minimise unnecessary acceleration on site.
	Non-tonal alarms	Alternative alarms, such as 'quackers' will be installed on all vehicles & mobile plant regularly used on site and on all vehicles & mobile plant required for OOHW.
Noise management measures	Site inductions & Toolbox Talks	All employees, contractors and subcontractors will receive a Project induction. The environmental component may be covered in toolboxes and should include: • location of nearest sensitive receivers • relevant project specific and standard noise and vibration mitigation measures; • permitted hours of work; • OOHW Procedure and Form • construction employee parking areas.
	Community consultation	Inform community of construction activity and potential impacts.
	Respite periods	Noise levels are required to be less than $L_{Aeq(15\ minute)}$ 60 dB(A) for at least 6.5 hours between 7am and 8pm, of which at least 3.25 hours must be below $L_{Aeq(15\ minute)}$ 55 dB(A). Noise equal to or above $L_{Aeq(15\ minute)}$ 60 dB(A) is allowed for the remaining 6.5 hours between 7am and 8pm.
	Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
	Noise monitoring	Noise monitoring is to be carried out as detailed in Section 5.4.4
	Dive services building OOHW	For deliveries during OOHW periods, unloading to occur away from the northern extent of the site where possible. Unloading deliveries adjacent to the dive services building to occur where no alternatives are available.

5.4.3 Additional noise mitigation measures

In circumstances where, after application of all reasonable and feasible mitigation measures, the $L_{Aeq(15minute)}$ airborne construction noise levels are still predicted to exceed the NMLs, additional airborne noise management measures can be applied to further limit the risk of annoyance from construction noise (Figure 5.2). This requirement is supplemental to the basic requirements in the ICNG. These measures are consistent with the approach outlined in the Sydney Metro City and Southwest Construction Noise and Vibration Strategy (SMCSNVS) [8].

Figure 5.2: Additional airborne noise mitigation measures

Time Period		Mitigation Measures			
		Predicted LAeq(15minute) Noise Level Above Background (RBL)			
		0 to 10 dB	10 to 20 dB	20 to 30 dB	> 30 dB
Standard	Mon-Fri (7.00 am - 6.00 pm)	-	-	M, LB,	M, LB
	Sat (8.00 am - 1.00 pm)				
	Sun/Pub Hol (Nil)				
OOHW 1	Mon-Fri (6.00 pm - 10.00 pm)	-	LB	M, LB	M, IB, LB, PC, RO,SN
	Sat (1.00 pm - 10.00 pm)				
	Sun/Pub Hol (8.00 am - 6.00 pm)				
OOHW 2	Mon-Fri (10.00 pm - 7.00 am)	-	M, LB,	M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	Sat (10.00 pm - 8.00 am)				
	Sun/Pub Hol (6.00 pm - 7.00 am)				

Notes: LB = Letter box drops
M = Monitoring
PC = Phone Call and email
SN = Specific notifications
IB = Individual Briefing
RO = Project specific respite offer
AA* = Alternative accommodation

Where OOHW occur in the evening/night shoulder period (10:00pm to 12:00am) or the night/morning shoulder period (5:00am to 7:00am) apply additional airborne mitigation measures from the OOHW Period 2, excluding AA.

*AA applies where a construction activity impacts receivers over 2 or more consecutive nights.

There are no additional mitigation measures in APPENDIX D.4 for the proposed works as predicted levels are less than 5 dB(A) above the evening and night-time NMLs (see detailed predictions in APPENDIX D.1).

5.4.4 Noise monitoring

Attended noise monitoring will be undertaken to verify that construction activities are consistent with the noise modelling scenarios and that noise levels resulting from construction works are not higher than the levels predicted in this CNVIS or relevant NMLs. Attended monitoring on private property is subject to obtaining the property owner/occupier's consent (where required).

Attended noise monitoring will be undertaken during works at one of the representative receivers identified in the table below in the NCAs most impacted by the works. Nominated attended measurement locations have been selected with the best opportunity to validate the predicted noise levels.

Table 5-7: Nominated verification monitoring locations

NCA	Nominated receiver address	Monitoring location at 1 m from
BN_03	18-18A High Street, Millers Point	Western facade

Note: Monitoring on private property is subject to owner consent and where relevant, occupier consent

If verification monitoring shows that the external noise levels from the construction works are above the predicted levels, investigation will be undertaken to understand the cause of the exceedance and relevant reasonable and feasible mitigation measures will be implemented.

Periodic assessment of plant noise levels will also be undertaken in accordance with the NVMP to confirm the plant noise levels are within the recommended levels in APPENDIX C Table C1.

Real-time noise monitoring in accordance with PPA Condition C11 is proposed for this site and will commence prior to the start of the demolition works (see *Civil CNVIS*). The real-time noise monitor will be installed at the site office on Hickson Road by trained personnel, familiar with the relevant standards and assessment procedures which are outlined in Appendix E of the NVMP.

5.4.5 Complaints handling

Complaints will be recorded and managed as detailed in the Community Communications Strategy and Business Management Plan.

Sydney Metro operate a 24-hour construction complaints line (1800 171 386). Enquiries/ complaints may also be received through the Sydney Metro project email (sydneymetro@transport.nsw.gov.au).

6 Construction vibration impacts

From the plant and equipment listed in APPENDIX C, there are no vibration intensive plant or equipment proposed for the underground station fit-out works. As a result, the risk of cosmetic damage and human annoyance caused by vibration is negligible and has not been addressed further in this CNVIS.

7 Ground-borne noise assessment

There are no vibration intensive plant or equipment proposed for the underground station fit-out works. As a result, the risk of annoyance due to ground-borne noise is negligible and has not been addressed further in this CNVIS.

8 Traffic noise assessment

8.1 Traffic sources

A maximum of 6 concrete/delivery trucks per hour may be required during day and night-time periods for the civil and underground station fit-out works. Details of projected heavy vehicle movements associated with the construction works were provided by BESIX Watpax and described in APPENDIX C Table C1. Light vehicle movements are expected to be up to 300 movements during the day and 72 movements at night.

Traffic counts for Hickson Road over the week of 9 December 2017 to 15 December 2017 were provided by JHCPBG and used to predict the relative increase in road traffic noise levels from the project. Those traffic volumes are detailed in Table 8-1.

Table 8-1: Traffic noise modelling data - existing road network

Site	Road	Road category (RNP)	15-hour day period (7am-10pm)				9-hour night period (10pm-7am)			
			Existing		Project		Existing		Project	
			TOTAL	HV	TOTAL	HV	TOTAL	HV	TOTAL	HV
Barangaroo	Hickson Road	Arterial	9768	634	480	180	1614	157	180	108

8.2 Predicted construction traffic noise

The potential impact of construction road traffic noise to nearby residential receivers has been estimated using the United Kingdom Department of Environment's 'Calculation of Road Traffic Noise' (1988) method. The method uses the average 1-hour traffic volume for the 'assessment period' (i.e. day or night) to predict the $L_{10,\ 1hour}$ noise levels. A correction of -3dB(A) is applied to obtain the $L_{eq,\ 1\ hour}$ noise levels which equate to the L_{Aeq} noise levels for the 'assessment period'.

For this assessment, the model has taken into account:

- traffic volume and heavy vehicle forecasts;
- posted vehicle speed;
- road gradient;
- ground reference levels of the road and receivers;
- separation distances of the road to receivers;
- ground type between the road and receivers; and
- angles of view of the road from the receiver's position.

For assessment purposes, closest residential receivers are along High Street.

Table 8-2 below summarises the predicted construction traffic noise levels during day and night periods.

Table 8-2: Predicted traffic noise levels (with/ without construction)

Site	Road	Predicted noise level, dB(A)					
		Day period (7am to 10pm)			Night period (10pm to 7am)		
		Noise descriptor	No construction	With construction	Noise descriptor	No construction	With construction
Barangaroo	Hickson Road	$L_{Aeq(15h)}$	52.1	52.8	$L_{Aeq(9h)}$	47.8	49.6

Note: Bold text indicates more than 2dB(A) increase in traffic noise levels resulting from construction traffic.

The predicted road traffic noise levels indicate a less than 2dB(A) increase in overall day $L_{Aeq(15h)}$ and night $L_{Aeq(9h)}$ noise and so construction traffic is predicted to have minimal impact on nearby road network used to access/exit the site.

8.3 Traffic noise mitigation and management

No mitigation or management measures are required when construction vehicles are on public roads, provided hourly traffic movements associated with construction are consistent with the assumptions outlined above.

9 Cumulative impacts

The impacts addressed in this assessment have not considered the civil works which are assessed in a separate CNVIS (*Civil CNVIS*). The impacts predicted in the *Civil CNVIS* are considerably higher than those presented in this CNVIS as they are associated with high noise impact works on surface. As a result, any increase in noise from the underground station fit-out works would not be significant, therefore the cumulative worst-case impacts from all Sydney Metro Barangaroo Station works are assessed in the *Civil CNVIS*.

BESIX Watpac are aware of other ongoing, potentially concurrent construction activities within the vicinity of the Barangaroo site. These works, summarised in Table 9-1, are mainly undertaken during standard construction hours and they may have the potential to increase cumulative noise impacts on receivers up to 1-2dB(A). These works have been considered but it has been determined that, due to the nature of the other unrelated construction works and the minor increase in cumulative impacts, no additional physical mitigation measures are deemed reasonable. Nevertheless, BESIX Watpac will continue consulting with proponents of other nearby construction works and take all reasonable steps to coordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receivers.

Table 9-1: Other construction works close to Barangaroo worksite

Construction company	Project	Timing of activities	Hours of works	Works location	Activity types	General plant types
Lendlease	One Sydney Harbour	September 2020 to 2025	Standard construction hours only	100 Barangaroo Ave, Barangaroo	Building construction	Cranes, concrete and delivery trucks, power tools, forklift, EWP
CPB UGL	Sydney Metro Linewide	November 2020 to 2023	Day and night	Hickson Road acoustic shed, cross over cavern and underground station	Delivery and tunnel fitout	Cranes, delivery trucks, power tools
John Holland	Waterloo ISD	September 2021 to September 2022	Day and night	Adjacent to Zone 9	Laydown area	Forklift and franna crane

10 Conclusion

Construction noise and vibration associated with the underground station fit-out works for the construction of the Sydney Metro Barangaroo Station project have been identified and described in this report. The noise sensitive receivers surrounding the works areas and the relevant construction noise objectives have been identified and discussed to allow the assessment of potential construction noise and vibration impacts.

Construction noise

The expected construction noise levels have been predicted and presented in Section 5.3 and APPENDIX D.

During the standard construction hours, construction noise levels are predicted to comply with the corresponding NMLs for nearby residential receivers except for one residential receiver where the predicted levels are 1 dB above the NML. Noise levels for nearby other sensitive receivers are predicted to comply with the corresponding NMLs.

During the OOHW daytime and evening period, noise levels are predicted to comply with the corresponding NMLs for nearby residential and other sensitive receivers. During the OOHW night-time period, a maximum of 2dB exceedance above the corresponding NML at the most affected residences in NCA BN_03 have been predicted.

Predicted levels are expected to be below CSSI-7400 E37, E38, E41 and E42 noise goals at all receivers.

All relevant mitigation measures are presented in Section 5.4 to reduce potential noise impact.

Construction traffic

The predicted road traffic noise levels associated with the proposed underground station fit-out works indicate a less than 2dB(A) increase in overall day $L_{Aeq(15h)}$ and night $L_{Aeq(9h)}$ noise. As a result, construction traffic is predicted to have minimal impact on nearby road network used to access/exit the site.

Ground-borne noise and vibration

There are no vibration intensive plant or equipment proposed for the underground station fit-out works. As a result, the risk of vibration and ground-borne noise impacts is negligible.

References

[1] BARANGAROO METRO STATION – Noise and Vibration Management Plan (TM031-01F01 Barangaroo Metro Station NVMP)

[2] Barangaroo Metro Station, Construction Noise and Vibration Impact Statement: Civil works, reference: TM031-02F01 CIVIL CNVIS.

[3] SLR Consulting Australia Pty Ltd 2016 Sydney Metro Chatswood to Sydenham - Technical Paper 2: Noise and Vibration Report Number 610.14718R1 – 28 April 2016

[4] Department of Environment and Climate Change 2009 NSW Interim Construction Noise Guideline (ICNG),

[5] Department of Environment Conservation NSW 2006 Assessing Vibration; a technical guideline

[6] British Standard 7385 Part 2 1993, Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration

[7] British Standard BS 6472-2008, Evaluation of human exposure to vibration in buildings (1-80Hz)

[8] Transport for NSW Sydney Metro City & Southwest Construction Noise Strategy (ref: 610.14213-R3) 08 August 2016

[9] Transport for NSW Construction Noise Strategy (ref: 7TP-ST-157/2.0) April 2012

[10] Transport for NSW Sydney Metro Construction Environmental Management Framework August 2016

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.

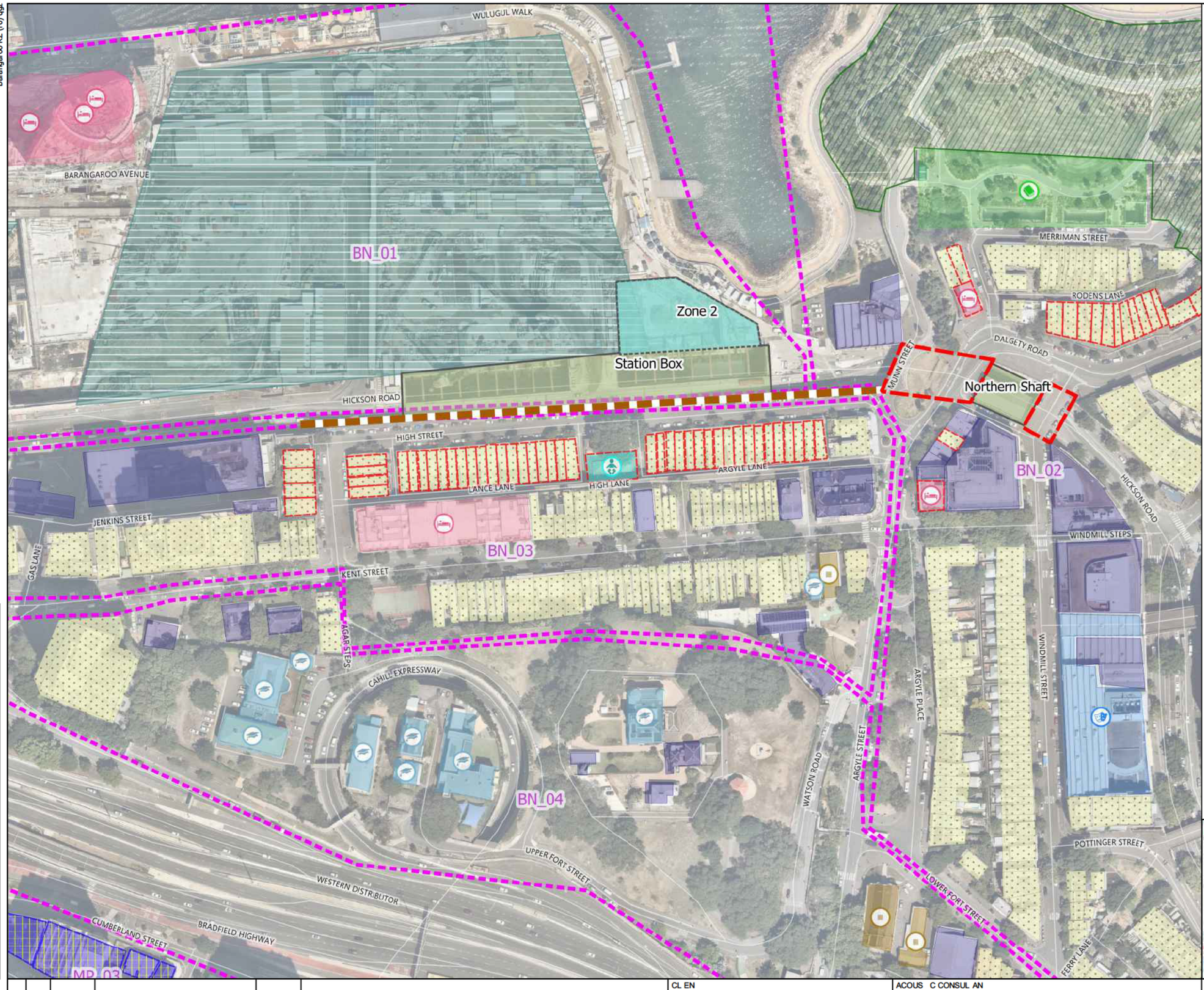
Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights 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 Nearest sensitive receivers and noise management levels

Figure B1 –Construction work areas, NCAs and land use

Land Use file revision_date r40_31/08/21
Plot Date 31/08/21 14 24 Layout TM031_02CNV SS Vibration screening for cosmetic damage (r0)
G S File R \AssocSydPro ects\TM001 TM050\TM031 mt Barangaroo Metro Station\5 Calcs\00 GENERAL\01 G S\QG S TM031 Barangaroo RZ (r0).qgz

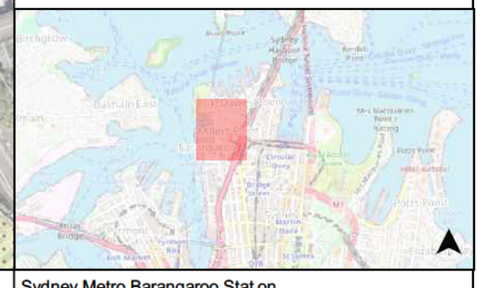


LEGEND

Noise sensitive receivers

- Residential
- Mixed use
- Commercial
- Industrial
- otel/Motel/ ostel
- Medical facility
- Place of Worship
- Community centre
- Recording studio
- Library/Museum
- Flight simulator
- Childcare
- Educational
- heatre/Auditorium
- Cinema
- Laboratory
- Recreational - Passive
- Recreational - Active
- Other
- eritage

- NCA
- Heritage Wa
- Project Work Zone
- Station Box and Northern Shaft



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Sydney Metro Barangaroo Stat on
Underground Stat on F t out Works

Land Use, NCAs
Work Zones: Zone 2, Stat on Box and Northern Shaft

Sheet 1 o 1

Table B1: Noise Sensitive Receivers and Construction Noise Management Levels **BARANGAROO**

			Existing Noise Levels, dB(A)						Residential NMLs based on ICNG (to guide notifications and feasible and reasonable mitigation measures)						Residential External Noise Management Levels (NMLs) LAeq(15 min)		Sleep Disturbance		Comments
NCA	Receiver Type	Reference RBL	RBL Day	RBL Evening	RBL Night	LAeq_D	LAeq_E	LAeq_N	D(S)	D(O)	E1 / E2	NS	N	MS	D(S)/D(O)/E1 (7am tp 8pm)[1]	E2/N (8pm to 7am)[1]	Screening[2]	Max[2]	
BN_01	Residential tower under construction	EIA B.12	50	45	40	61	64	51	60	55	50	47.5	45	50	70-80	55-65	55	65	
BN_02	Residential buildings north of Argyle St and Bettington St	EIA B.12	50	45	40	61	64	51	60	55	50	47.5	45	50	70-80	55-65	55	65	
BN_03	Residential buildings east of High St and south of Kent St	EIA B.12	50	45	40	61	64	51	60	55	50	47.5	45	50	70-80	55-65	55	65	
BN_04	Mixed residential and commerical west of Harbour Bridge	EIS B.13	62	62	52	66	65	63	72	67	67	62	57	62	70-80	55-65	67	65	
BN_05	Mixed residential and commerical at Jones Bay and Pyrmont Bay	EIS B.28	51	46	41	56	52	47	61	56	51	48.5	46	51	70-80	55-65	56	65	
BN_06	Residential buildings in Balmain East	EIS B.29	49	49	41	55	55	49	59	54	54	50	46	50	70-80	55-65	56	65	
Other sensitive receivers																			
Studio building (music recording studio)									45	45	45	45	45	45					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Studio building (film or television studio)									50	50	50	50	50	50					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Cinema space, theatre, auditorium									55	55	55	55	55	55					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Hotel (Sleeping areas: Hotels near major roads)									60	60	60	60	60	60					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Classrooms at schools and other educational institutions									55	55	55	55	55	55					Source: ICNG, assuming a conservative façade loss of 10 dB(A)
Chilcare centre (internal play and sleeping areas)									50	50	50	50	50	50					Source: AAAC - guideline for Child Care Centre Acoustic Assessment, assuming a conservative façade loss of 10 dB(A)
Hospital wards and operating theatres									65	65	65	65	65	65					Source: ICNG, assuming a conservative façade loss of 20 dB(A)
Places of worship									55	55	55	55	55	55					Source: ICNG, assuming a conservative façade loss of 10 dB(A)
Library (reading areas)									65	65	65	65	65	65					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Hotel (bars and lounges)									70	70	70	70	70	70					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Community centres – Municipal Buildings									60	60	60	60	60	60					Source: AS2107 maximum , assuming a conservative façade loss of 10 dB(A)
Restaurant, bar (Bars and lounges/ Restaurant)									70	70	70	70	70	70					Source: AS2107 maximum , assuming a conservative façade loss of 20 dB(A)
Café/ Restaurant/ Bar (outdoors)									60	60	60	60	60	60					Source: AS2107 maximum1
Passive recreation areas (e.g. area used for reading, meditation)									60	60	60	60	60	60					Source: ICNG
Active recreation areas (e g. sports fields)									65	65	65	65	65	65					Source: ICNG
Commercial premises (including offices and retail outlets)									70	70	70	70	70	70					Source: ICNG
Industrial premises									75	75	75	75	75	75					Source: ICNG

Notes
1 - Range in the external equivalent NMLs depends on the specific building façade loss and is based on PPA Conditions E37 and E41/E42
2 - Levels are estimated assuming an open windows (i.e. 10dBA façade loss)
D(S) standard construction hours from 7 am to 6 pm Monday to Friday, from 8 am to 6 pm Saturday, Sunday and Public holidays
D(O) out-of-hours day period from 1 pm to 6 pm Saturday, from 8 am to 6 pm Sunday and Public holidays - OOHW P1
E1 early evening period from 6 pm to 8 pm Monday to Sunday - OOHW P1
E2 late evening period from 8 pm to 10 pm Monday to Sunday - OOHW P1
NS night shoulder period from 10pm to 12am Monday to Sunday - OOHW P1
N night-time period from 12am pm to 5 am Monday to Friday, from 12am to 6 am Saturday, Sunday and Public holidays - OOHW P2
MS morning shoulder period from 5 am to 7 am Monday to Friday, from 6 am to 8 am Saturday, Sunday and Public holidays - OOHW P1

APPENDIX C Construction timetable/ activities/ management

Table C1: Construction timetable/ activities/ equipment **BARANGAROO**

Activity	Aspect	Indicative timing/ Duration	Scenario reference code	Work area	Plant/ Equipment	Plant/ Equipment (as provided by client)	Number of plant/equipment items (operating on site)			2 Sound Power Level (Lw re: 1pW) in Noise Model, dB(A)			5 High noise plant	6 Vibration intensive plant	Notes
							Day 7am - 6pm	Evening 6pm - 10pm	Night 10pm - 7am	L_{Aeq}	Penalty	L_{Amax}			
Underground station fit-out works	-Deliveries to Northern shaft -Platform fitout works - Fomrwork and reinforcemente fixing of - Fix cable trays and p pes - Electrical serv ces plant rooms	September 2021 to May 2023	USFW	Zone 2	Handtool - power	Power hand tools	3	-	-	108	-	118	-	-	
					Road truck (deliveries to site)	Delivery trucks	4 p h.	-	-	106	-	111	-	-	
					Mobile crane (20t-250t)	Mobile crane	2	-	-	104	-	108	-	-	
					Telehander / Franna crane (20t)	Franna Crane	2	-	-	98	-	102	-	-	
					Concrete Agitator	Concrete trucks	4 p h.	-	-	108	-	111	-	-	
					Concrete vibrator	Concrete vibrators	2	-	-	97	-	100	-	-	
					Concrete Agitator	Concrete agitator	2	-	-	108	-	111	-	-	
					Concrete pump	Concrete pumps	2	-	-	103	-	107	-	-	
				Station Box	Handtool - power	Power hand tools (including impact wrench and hammer drill)	3	2	1	108	-	118	-	-	Underground inside the station
					Forklift	14t forklift	2	2	1	99	-	103	-	-	Underground inside the station
					Telehander / Franna crane (20t)	Franna Crane	3	3	3	98	-	102	-	-	Underground inside the station
					Telehander / Franna crane (20t)	Telehandler	3	3	3	98	-	102	-	-	Underground inside the station
					Gantry Crane - electric	Gantry crane	1	1	1	96	-	100	-	-	Underground inside the station
					Personnel hoist	Personell hoist	1	1	1	86	-	100	-	-	On surface Level time corrected assuming two lifts per 15min period. See recommended mitigation measures in Table C2.
					WTP	Water treatment plant	1	1	1	92	-	96	-	-	On surface This is the noise budget for this plant to comply with relevant NMLs. Further investigation will be conducted to dentify reasonable and feasible mitigation measures to minimise noise aiming to ach eve the allocated noise budget.

Table C2: Construction Noise Management Schedule **BARANGAROO**

Items	Areas	Specific Mitigation/ Management Measure	Typical Details
1 Noise hoardings	Site boundary	Noise hoardings to be partially retained and constructed as early as practicable. This measure will only reduce the noise levels for pedestrian walking along the Barangaroo promenade	see Table C3 for details
2 Permanent and temporary hatches	B2	to be closed outside standard construction hours with an acoustic panel	see Table C4, Table C4a for acoustic panel requirements
	B3	to be closed outside standard construction hours with an acoustic panel	see Table C4, Table C4a for acoustic panel requirements
	Northern entry escalator	to be closed day and night	see Table C4, Table C4a for acoustic panel requirements
	Lift and ventilation shafts (901 & 904)	to be left open for ventilation, however, partial enclosure including roof, south, east and north walls	see Table C4, Table C4a for partial enclosure requirements
3 Concrete pours	Hatches B2 and B3	No concrete pours outside standard construction hours	
4 Delivery	Hickson Road Shed	Minimise requirement for deliveries OOH. All deliveries to the Hickson Road Shed.	
5 Eastern pods along Hickson Road		Consideration for partial closure or fan attenuation/silencers depending on type of fans and locations	
6 Ventilation fans	Within the underground station	Acoustic treatments may be required for the ventilation fan inside the underground station subject to type and number of fans and final location.	
7 Personnel hoist	on surface	It is recommended that noise from opening/closing doors be minimised where reasonable and feasible. This could comprise noise aware practices such as avoiding slamming the doors open/close and consideration of door pads which could provide soft cushioning to slow down the door as it closes (preventing a slam) where practicable.	
8 Water treatment plant	on surface	Further investigation will be conducted to identify reasonable and feasible mitigation measures to minimise noise aiming to achieve the allocated noise budget. Mitigation measures may include partial or full enclosure with noise blankets for pumps and other components	

Figure C2: Locations of permanent and temporary hatches

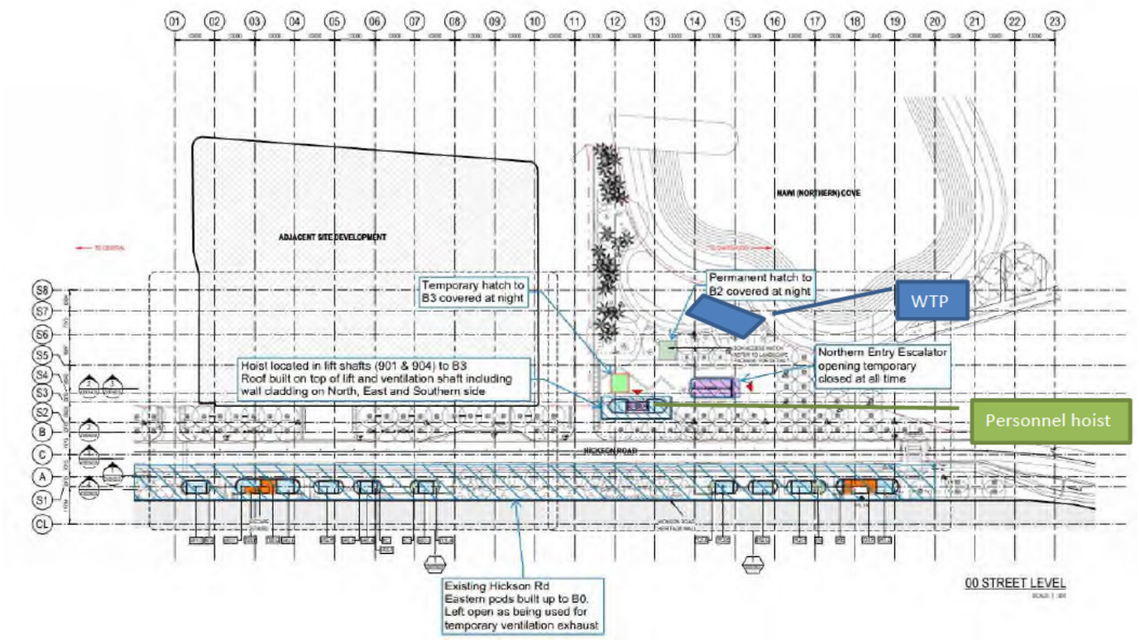

Table C3: Noise Wall / Hoarding Design Specifications **BARANGAROO**

Noise wall reference	Location	Noise wall/ hoarding height	Proposed Construction	Acoustic Rating of Construction*
NW01	Site boundary	2 m	17 mm plywood hoarding	Rw 24

Notes:

Noise barrier performance: Low - Rw 10-15; Medium - Rw 15-20; Medium-High - Rw 20-25; High - Rw 25; Very High - Rw 30

* estimated by calculations and/or reference to other similar barrier type data

GENERAL

- The specified 'required rating' must be achieved by the product selected.
- By way of explanation, the Sound Insulation Rating Rw is a measure of the noise reduction property of the assembly, a higher rating implying a higher sound reduction performance.
- Note that the Rw rating of systems measured as built on site (R'w Field Test) may be up to 5 points lower than the laboratory result.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- 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.

Table C4: Noise Shed / Enclosure Design Specifications **BARANGAROO**

Area to be Mitigated	Construction component	Reference ID	Indicative element construction
Hatches B2, B3 and Northern entry escalator	Roof	F043	2 x 25mm plywood
Lift and ventilation shafts (901 & 904)	Walls	F043	2 x 25mm plywood
	Roof	F043	2 x 25mm plywood
	Acoustic lining	-	Acoustic lining with roofing blanket on inner skin facing inside enclosure with perforated foil for walls and roof
	Doors	-	No doors on the norhern, southern and eastern walls
	Openings (ventilation/ access)	-	Any necessary ventilation openings should face away from neighbours and also fitted with acoustic louvres / attenuators or doors to achieve requirements.

Notes:

1 The final level of noise reduction required from an acoustic shed / enclosure is dependent on a number of factors, however one important factor is whether or not there are noisy plant on site which cannot be acoustically treated and operate outside the acoustic shed / enclosure Depending on the number and noise emissions of such plant, it may be necessary to apply greater acoustic treatment to the acoustic shed / enclosure in order to keep its noise contributions down so that the total noise emissions from site meet the set environmental noise limits at neighbouring receptors

LEGEND * estimated by calculations and/or reference to other similar wall type data The client is advised not to commit to materials which have not been tested in an approved laboratory or for which an opinion only is available Testing materials is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project No responsibility is taken for use of or reliance upon untested materials, estimates or opinions

GENERAL

- The underside of the roof and (where possible) internal walls should be lined with acoustic insulation to reduce the build-up of sound inside the shed
- The specified performances must be achieved by the product selected
- The sealing of all gaps is critical in a sound rated construction Use only sealer approved by the acoustic consultant
- Check design of all junction details with acoustic consultant prior to construction
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed
- The information provided in this table is subject to modification and review without notice
- 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
- Only the buildings elements noted in Table C4 and Table C4a have been assessed It is assumed that all other items will not impact the acoustic properties, or can be sufficiently acoustically treated

BARANGAROO

Table C4a: Specification for acoustic elements of noise sheds/ acoustic

Reference	Sound transmission loss per octave spectrum dB							Indicative shed element construction
ID	63	125	250	500	1000	2000	4000	
F043	21	24	29	31	26	33	42	2 x 25mm plywood

LEGEND * estimated by calculations and/or reference to other similar wall type data. The client is advised not to commit to materials which have not been tested in an approved laboratory or for which an opinion only is available. Testing materials is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions.

APPENDIX D Detailed predicted noise levels

D.1 Predicted noise levels

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
BN_01	23 BARANGAROO AVENUE BARANGAROO	60	44	50	34	45	-
BN_02	24 MUNN STREET BARANGAROO	60	55	50	45	45	42
BN_02	40-48 MERRIMAN STREET MILLERS POINT	60	49	50	39	45	37
BN_02	38 MERRIMAN STREET MILLERS POINT	60	39	50	-	45	-
BN_02	36 MERRIMAN STREET MILLERS POINT	60	38	50	-	45	-
BN_02	32 MERRIMAN STREET MILLERS POINT	60	37	50	-	45	-
BN_02	30 MERRIMAN STREET MILLERS POINT	60	36	50	-	45	-
BN_02	28 MERRIMAN STREET MILLERS POINT	60	36	50	-	45	-
BN_02	26 MERRIMAN STREET MILLERS POINT	60	35	50	-	45	-
BN_02	24 MERRIMAN STREET MILLERS POINT	60	35	50	-	45	-
BN_02	22 MERRIMAN STREET MILLERS POINT	60	34	50	-	45	-
BN_02	2-18 DALGETY ROAD BARANGAROO	60	37	50	-	45	-
BN_02	68 BETTINGTON STREET MILLERS POINT	60	37	50	-	45	-
BN_02	66 BETTINGTON STREET MILLERS POINT	60	44	50	-	45	-
BN_02	27-27A DALGETY ROAD MILLERS POINT	60	45	50	-	45	-
BN_02	25-25A DALGETY ROAD MILLERS POINT	60	43	50	-	45	-
BN_02	34 MERRIMAN STREET MILLERS POINT	60	37	50	-	45	-
BN_02	18-20 MUNN STREET MILLERS POINT	60	53	50	43	45	41
BN_02	6 TOWNS PLACE MILLERS POINT	60	39	50	-	45	-
BN_02	8 Argyle Place, Millers Point	60	52	50	41	45	38
BN_02	1-5 Towns Place, Millers Point NSW 2000	60	48	50	35	45	-
BN_03	38 HICKSON ROAD MILLERS POINT	60	48	50	37	45	-
BN_03	127-153 KENT STREET MILLERS POINT	60	50	50	39	45	34
BN_03	187 KENT STREET MILLERS POINT	60	47	50	36	45	-
BN_03	161 KENT STREET MILLERS POINT	60	48	50	36	45	-
BN_03	155-157 KENT STREET MILLERS POINT	60	47	50	36	45	-
BN_03	7-7A HIGH STREET MILLERS POINT	60	38	50	-	45	-
BN_03	115 KENT STREET MILLERS POINT	60	40	50	-	45	-
BN_03	117 KENT STREET MILLERS POINT	60	38	50	-	45	-
BN_03	119 KENT STREET MILLERS POINT	60	36	50	-	45	-
BN_03	121 KENT STREET MILLERS POINT	60	37	50	-	45	-
BN_03	80-80A HIGH STREET MILLERS POINT	60	53	50	42	45	37
BN_03	2-2A HIGH STREET MILLERS POINT	60	56	50	46	45	43
BN_03	2 HIGH STREET MILLERS POINT	60	56	50	45	45	42
BN_03	10-12 KENT STREET MILLERS POINT	60	37	50	-	45	-
BN_03	18 KENT STREET MILLERS POINT	60	35	50	-	45	-
BN_03	20 KENT STREET MILLERS POINT	60	37	50	-	45	-

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
BN_03	22 KENT STREET MILLERS POINT	60	39	50	-	45	-
BN_03	24-26 KENT STREET MILLERS POINT	60	37	50	-	45	-
BN_03	28 KENT STREET MILLERS POINT	60	38	50	-	45	-
BN_03	30A-30B KENT STREET MILLERS POINT	60	36	50	-	45	-
BN_03	32 KENT STREET MILLERS POINT	60	37	50	-	45	-
BN_03	34 KENT STREET MILLERS POINT	60	35	50	-	45	-
BN_03	36 KENT STREET MILLERS POINT	60	36	50	-	45	-
BN_03	38 KENT STREET MILLERS POINT	60	34	50	-	45	-
BN_03	40 KENT STREET MILLERS POINT	60	45	50	-	45	-
BN_03	42 KENT STREET MILLERS POINT	60	47	50	-	45	-
BN_03	44 KENT STREET MILLERS POINT	60	39	50	-	45	-
BN_03	46 KENT STREET MILLERS POINT	60	34	50	-	45	-
BN_03	48 KENT STREET MILLERS POINT	60	34	50	-	45	-
BN_03	50 KENT STREET MILLERS POINT	60	35	50	-	45	-
BN_03	52 KENT STREET MILLERS POINT	60	35	50	-	45	-
BN_03	56 KENT STREET MILLERS POINT	60	34	50	-	45	-
BN_03	58 KENT STREET MILLERS POINT	60	34	50	-	45	-
BN_03	85-87 KENT STREET MILLERS POINT	60	57	50	43	45	41
BN_03	81 KENT STREET MILLERS POINT	60	57	50	44	45	42
BN_03	79 KENT STREET MILLERS POINT	60	54	50	44	45	42
BN_03	77 KENT STREET MILLERS POINT	60	55	50	44	45	42
BN_03	75 KENT STREET MILLERS POINT	60	57	50	44	45	42
BN_03	73 KENT STREET MILLERS POINT	60	56	50	42	45	41
BN_03	71 KENT STREET MILLERS POINT	60	56	50	42	45	40
BN_03	59 KENT STREET MILLERS POINT	60	55	50	41	45	39
BN_03	61 KENT STREET MILLERS POINT	60	56	50	42	45	40
BN_03	63 KENT STREET MILLERS POINT	60	58	50	43	45	42
BN_03	37 KENT STREET MILLERS POINT	60	48	50	36	45	-
BN_03	39 KENT STREET MILLERS POINT	60	49	50	37	45	34
BN_03	41 KENT STREET MILLERS POINT	60	49	50	37	45	34
BN_03	43 KENT STREET MILLERS POINT	60	48	50	36	45	-
BN_03	45 KENT STREET MILLERS POINT	60	45	50	37	45	34
BN_03	47 KENT STREET MILLERS POINT	60	46	50	37	45	35
BN_03	49 KENT STREET MILLERS POINT	60	50	50	37	45	34
BN_03	51 KENT STREET MILLERS POINT	60	52	50	38	45	36
BN_03	53 KENT STREET MILLERS POINT	60	53	50	39	45	37
BN_03	55 KENT STREET MILLERS POINT	60	54	50	41	45	39
BN_03	38-38A HIGH STREET MILLERS POINT	60	59	50	44	45	40
BN_03	40-40A HIGH STREET MILLERS POINT	60	59	50	45	45	41
BN_03	42-42A HIGH STREET MILLERS POINT	60	57	50	43	45	39
BN_03	44-44A HIGH STREET MILLERS POINT	60	58	50	45	45	41

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
BN_03	46-46A HIGH STREET MILLERS POINT	60	58	50	46	45	41
BN_03	48-48A HIGH STREET MILLERS POINT	60	56	50	44	45	39
BN_03	50-50A HIGH STREET MILLERS POINT	60	57	50	45	45	41
BN_03	52-52A HIGH STREET MILLERS POINT	60	56	50	46	45	41
BN_03	54-54A HIGH STREET MILLERS POINT	60	55	50	46	45	40
BN_03	56-56A HIGH STREET MILLERS POINT	60	56	50	45	45	40
BN_03	58-58A HIGH STREET MILLERS POINT	60	54	50	45	45	40
BN_03	60-60A HIGH STREET MILLERS POINT	60	56	50	45	45	39
BN_03	62-62A HIGH STREET MILLERS POINT	60	56	50	45	45	39
BN_03	64-64A HIGH STREET MILLERS POINT	60	55	50	44	45	39
BN_03	66-66A HIGH STREET MILLERS POINT	60	55	50	44	45	39
BN_03	68-68A HIGH STREET MILLERS POINT	60	55	50	44	45	38
BN_03	70-70A HIGH STREET MILLERS POINT	60	54	50	43	45	38
BN_03	72-72A HIGH STREET MILLERS POINT	60	52	50	42	45	36
BN_03	78-78A HIGH STREET MILLERS POINT	60	47	50	36	45	-
BN_03	76-76A HIGH STREET MILLERS POINT	60	48	50	37	45	-
BN_03	74-74A HIGH STREET MILLERS POINT	60	46	50	35	45	-
BN_03	4-4A HIGH STREET MILLERS POINT	60	57	50	46	45	43
BN_03	6-6A HIGH STREET MILLERS POINT	60	57	50	46	45	44
BN_03	8-8A HIGH STREET MILLERS POINT	60	59	50	48	45	46
BN_03	10-10A HIGH STREET MILLERS POINT	60	58	50	47	45	44
BN_03	12-12A HIGH STREET MILLERS POINT	60	60	50	49	45	46
BN_03	14-14A HIGH STREET MILLERS POINT	60	58	50	47	45	44
BN_03	16-16A HIGH STREET MILLERS POINT	60	58	50	47	45	45
BN_03	18-18A HIGH STREET MILLERS POINT	60	61	50	49	45	46
BN_03	20-20A HIGH STREET MILLERS POINT	60	59	50	48	45	45
BN_03	22-22A HIGH STREET MILLERS POINT	60	55	50	48	45	46
BN_03	24-24A HIGH STREET MILLERS POINT	60	58	50	50	45	47
BN_03	26-26A HIGH STREET MILLERS POINT	60	58	50	50	45	47
BN_03	28-28A HIGH STREET MILLERS POINT	60	58	50	47	45	45
BN_03	30-30A HIGH STREET MILLERS POINT	60	57	50	46	45	45
BN_03	32-32A HIGH STREET MILLERS POINT	60	57	50	46	45	45
BN_03	34-34A HIGH STREET MILLERS POINT	60	56	50	45	45	44
BN_03	36-36A HIGH STREET MILLERS POINT	60	58	50	47	45	46
BN_03	83 KENT STREET MILLERS POINT	60	45	50	-	45	-
BN_03	3-3A HIGH STREET MILLERS POINT	60	54	50	42	45	38
BN_03	5-5A HIGH STREET MILLERS POINT	60	51	50	39	45	35
BN_03	9-9A HIGH STREET MILLERS POINT	60	34	50	-	45	-
BN_04	114A KENT STREET MILLERS POINT	72	35	67	-	57	-
BN_04	9 AGAR STEPS MILLERS POINT	72	40	67	-	57	-
BN_05	48B PIRRAMA ROAD PYRMONT	61	35	51	-	46	-

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
BN_05	3 DARLING ISLAND ROAD PYRMONT	61	36	51	-	46	-
BN_05	3A DARLING ISLAND ROAD PYRMONT	61	35	51	-	46	-
BN_05	8-14 WHARF CRESCENT PYRMONT	61	35	51	-	46	-
BN_06	25 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	25 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	23 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	21 EDWARD STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	3 LITTLE EDWARD STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	19 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	17 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	15 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	11A EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	11 EDWARD STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	9 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	7 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	2 LITTLE EDWARD STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	4 LITTLE EDWARD STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	6 LITTLE EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	8 LITTLE EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	10 LITTLE EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	12 LITTLE EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	7 LITTLE EDWARD STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	5 EDWARD STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	1A WILLIAM STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	1 WILLIAM STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	1B WILLIAM STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	15 WILLIAM STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	17 WILLIAM STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	19 WILLIAM STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	21 WILLIAM STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	23 WILLIAM STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	33 WILLIAM STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	35 WILLIAM STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	18 ST MARYS STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	16 ST MARYS STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	14 ST MARYS STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	12 ST MARYS STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	10 ST MARYS STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	6 ST MARYS STREET BALMAIN EAST	59	38	54	-	46	-
BN_06	4 ST MARYS STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	7 WESTON STREET BALMAIN EAST	59	37	54	-	46	-

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
BN_06	5 WESTON STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	2 PAUL STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	6 PAUL STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	8 PAUL STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	12 PAUL STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	14 PAUL STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	2 PEARSON STREET BALMAIN EAST	59	39	54	-	46	-
BN_06	16 PEARSON STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	26 PEARSON STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	1 PEARSON STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	3 PEARSON STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	5 PEARSON STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	7 PEARSON STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	9 PEARSON STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	11 PEARSON STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	16 PAUL STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	18 PAUL STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	20 PAUL STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	22-26 PAUL STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	12 JOHNSTON STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	2-8 WESTON STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	10 DARLING STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	1 PAUL STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	3 PAUL STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	5 PAUL STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	7 PAUL STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	9 PAUL STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	11 PAUL STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	13 PAUL STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	3 WESTON STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	1 WESTON STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	12 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	14 DARLING STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	16 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	22 DARLING STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	24 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	34 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	34 DARLING STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	36 DARLING STREET BALMAIN EAST	59	34	54	-	46	-
BN_06	21 DARLING STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	23 DARLING STREET BALMAIN EAST	59	37	54	-	46	-

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
BN_06	25 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	27A DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	29 DARLING STREET BALMAIN EAST	59	35	54	-	46	-
BN_06	31 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	33-33A DARLING STREET BALMAIN EAST	59	37	54	-	46	-
BN_06	35-37 DARLING STREET BALMAIN EAST	59	36	54	-	46	-
BN_06	1 JAMES LANE BALMAIN EAST	59	36	54	-	46	-
BN_06	3 JAMES LANE BALMAIN EAST	59	35	54	-	46	-
BN_06	5 JAMES LANE BALMAIN EAST	59	36	54	-	46	-
BN_06	11A LOOKES AVENUE BALMAIN EAST	59	36	54	-	46	-
BN_06	13 LOOKES AVENUE BALMAIN EAST	59	36	54	-	46	-
BN_06	15 LOOKES AVENUE BALMAIN EAST	59	36	54	-	46	-
BN_06	17 LOOKES AVENUE BALMAIN EAST	59	35	54	-	46	-
BN_06	8 LOOKES AVENUE BALMAIN EAST	59	35	54	-	46	-
BN_06	3 GALLIMORE AVENUE BALMAIN EAST	59	35	54	-	46	-
BN_06	3 GALLIMORE AVENUE BALMAIN EAST	59	34	54	-	46	-
BN_06	22 ST MARYS STREET BALMAIN EAST	59	39	54	-	46	-
OSR	Cutaway	65	52	65	42	65	40
OSR	36 HICKSON ROAD MILLERS POINT	70	44	70	-	70	-
OSR	30-34 HICKSON ROAD MILLERS POINT	70	52	70	41	70	37
OSR	89-105 KENT STREET MILLERS POINT	60	55	60	42	60	39
OSR	27 KENT STREET MILLERS POINT	70	45	70	-	70	-
OSR	14-16 KENT STREET MILLERS POINT	55	45	55	-	55	-
OSR	14-16 KENT STREET MILLERS POINT	55	35	55	-	55	-
OSR	120 KENT STREET MILLERS POINT	70	41	70	-	70	-
OSR	124 KENT STREET MILLERS POINT	70	43	70	-	70	-
OSR	65-69 KENT STREET MILLERS POINT	60	58	60	45	60	43
OSR	33-35 KENT STREET MILLERS POINT	70	49	70	37	70	34
OSR	37 HIGH STREET MILLERS POINT	55	51	55	38	55	35
OSR	35-37 BETTINGTON STREET MILLERS POINT	60	50	60	39	60	36
OSR	8 WINDMILL STREET MILLERS POINT	70	45	70	35	70	-
OSR	19 KENT STREET MILLERS POINT	60	44	60	-	60	-
OSR	6-12A ARGYLE PL, MILLERS POINTS	70	48	70	39	70	39
OSR	26 PIRRAMA ROAD PYRMONT	70	36	70	-	70	-
OSR	30-32 PIRRAMA ROAD PYRMONT	70	36	70	-	70	-
OSR	8 DARLING ISLAND ROAD PYRMONT	70	34	70	-	70	-
OSR	1 DARLING ISLAND ROAD PYRMONT	70	34	70	-	70	-
OSR	4 TOWNS PLACE BARANGAROO	70	35	70	-	70	-
OSR	23 HICKSON ROAD MILLERS POINT	70	45	70	-	70	-
OSR	100 BARANGAROO AVENUE BARANGAROO	70	46	70	35	70	-
OSR	200 BARANGAROO AVENUE BARANGAROO	70	39	70	-	70	-

Receiver		Predicted noise levels, dB(A)					
		Day (Standard)		Evening (OOHW)		Night (OOHW)	
NCA	Address	NML	USFW	NML	USFW	NML	USFW
OSR	51A-B HICKSON ROAD BARANGAROO	60	44	60	-	60	-
OSR	189-197 KENT STREET SYDNEY	60	45	60	34	60	-
OSR	60 hisckson road barangaroo	70	43	70	34	70	-
OSR	12 Argyle Place, Millers Point	70	50	70	39	70	38
OSR	6 Argyle Place, Millers Point	70	54	70	43	70	40
OSR	10 Argyle Place, Millers Point	70	54	70	42	70	39
OSR	1 KENT STRET / 14 ARGYLE PLACE MILLERS	70	53	70	42	70	40
OSR	1 Barangaroo Ave, Barangaroo NSW 2000	60	51	60	41	60	38

D.2 Consultation required under conditions E37/E38

Address	Required consultation E37
N/A	

D.3 Number of receivers above NMLs

NCA	Day (Standard)		Evening (OOHW)		Night (OOHW)	
	dB(A) above NML	Number of exceedances	dB(A) above NML	Number of exceedances	dB(A) above NML	Number of exceedances
BN_01	0 to 10		0 to 5		0 to 5	
	>10		5 to 15		5 to 15	
	75dBA or greater		15 to 25		15 to 25	
			>25		>25	
BN_02	0 to 10		0 to 5		0 to 5	
	>10		5 to 15		5 to 15	
	75dBA or greater		15 to 25		15 to 25	
			>25		>25	
BN_03	0 to 10	1	0 to 5		0 to 5	7
	>10		5 to 15		5 to 15	
	75dBA or greater		15 to 25		15 to 25	
			>25		>25	
BN_04	0 to 10		0 to 5		0 to 5	
	>10		5 to 15		5 to 15	
	75dBA or greater		15 to 25		15 to 25	
			>25		>25	
BN_05	0 to 10		0 to 5		0 to 5	
	>10		5 to 15		5 to 15	
	75dBA or greater		15 to 25		15 to 25	
			>25		>25	
BN_06	0 to 10		0 to 5		0 to 5	
	>10		5 to 15		5 to 15	
	75dBA or greater		15 to 25		15 to 25	
			>25		>25	
OSR	0 to 10		0 to 5		0 to 5	
	>10		5 to 15		5 to 15	
			15 to 25		15 to 25	
			>25		>25	

D.4 Additional mitigation measures

There are no additional mitigation measures as predicted levels are less than 5 dB(A) above the evening and night-time NMLs.

APPROVAL
CITY & SOUTHWEST ACOUSTICS ADVISOR

Review of:	Barangaroo Metro Station Construction Noise and Vibration Impact Statement: Underground station fit-out works	**Document reference:**	TM031-03F01 STATION CNVIS (r6)
Prepared by:	[redacted] Acoustics Advisor		Prepared by Renzo Tonin & Associates Pty Ltd
Date of issue:	20 December 2022		19 December 2022

As approved Acoustics Advisor for the Sydney Metro City & Southwest project, and as required under A27 (d) of the project approval conditions (SSI 15-7400), I have reviewed and provided comment on the Construction Noise and Vibration Impact Statement (CNVIS) for Barangaroo Metro Station, Underground station fit-out works (revision 6). This revision includes minor updates to plant and equipment list and removal of deliveries to the Hickson Road acoustic shed.

I am satisfied that the CNVIS is technically valid and includes appropriate noise and vibration mitigation and management. On this basis, I endorse the CNVIS referenced herein.

[redacted]

[redacted], City & Southwest Acoustics Advisor