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Construction Noise and Vibration Impact Statement (CNVIS)

Project Number:	0392956	**Date:**	18 April 2017
Project Name:	Sydney Yard Access Bridge (SYAB)	**Subject:**	Noise Modelling and Assessment of SYAB Works
Client:	Laing O'Rourke Australia Construction Pty Ltd	**Reference:**	0392956RP01_F01 - SYAB CNVIS.docx
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Status:	FINAL	**Version:**	F02

1. OVERVIEW

This document has been prepared by Environmental Resources Management Australia Pty Ltd (ERM) on behalf of Laing O'Rourke Australia Construction Pty Ltd (LOR). It presents the methodology, findings and recommendations of the noise and vibration assessment completed for construction aspects of the Sydney Yard Access Bridge (SYAB) as part of the Sydney Metro City and Southwest project (Sydney Metro). The SYAB project and associated construction works are located on Regent Street in Chippendale, near the Sydney Central Business District (CBD) in New South Wales (NSW).

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro Northwest (previously known as the North West Rail Link) and Sydney Metro City and Southwest. A core component of Sydney Metro includes the Chatswood to Sydenham project. This involves construction and operation of an underground rail line, about 15.5 kilometres long, and new stations between Chatswood and Sydenham.

The SYAB is part of enabling works for Sydney Metro. It is a new permanent road bridge that will provide a connection from Regent Street into the Sydney Yard. In particular, the SYAB will extend from Regent Street over the Mortuary Station line and intercity tracks into the Sydney Yard.

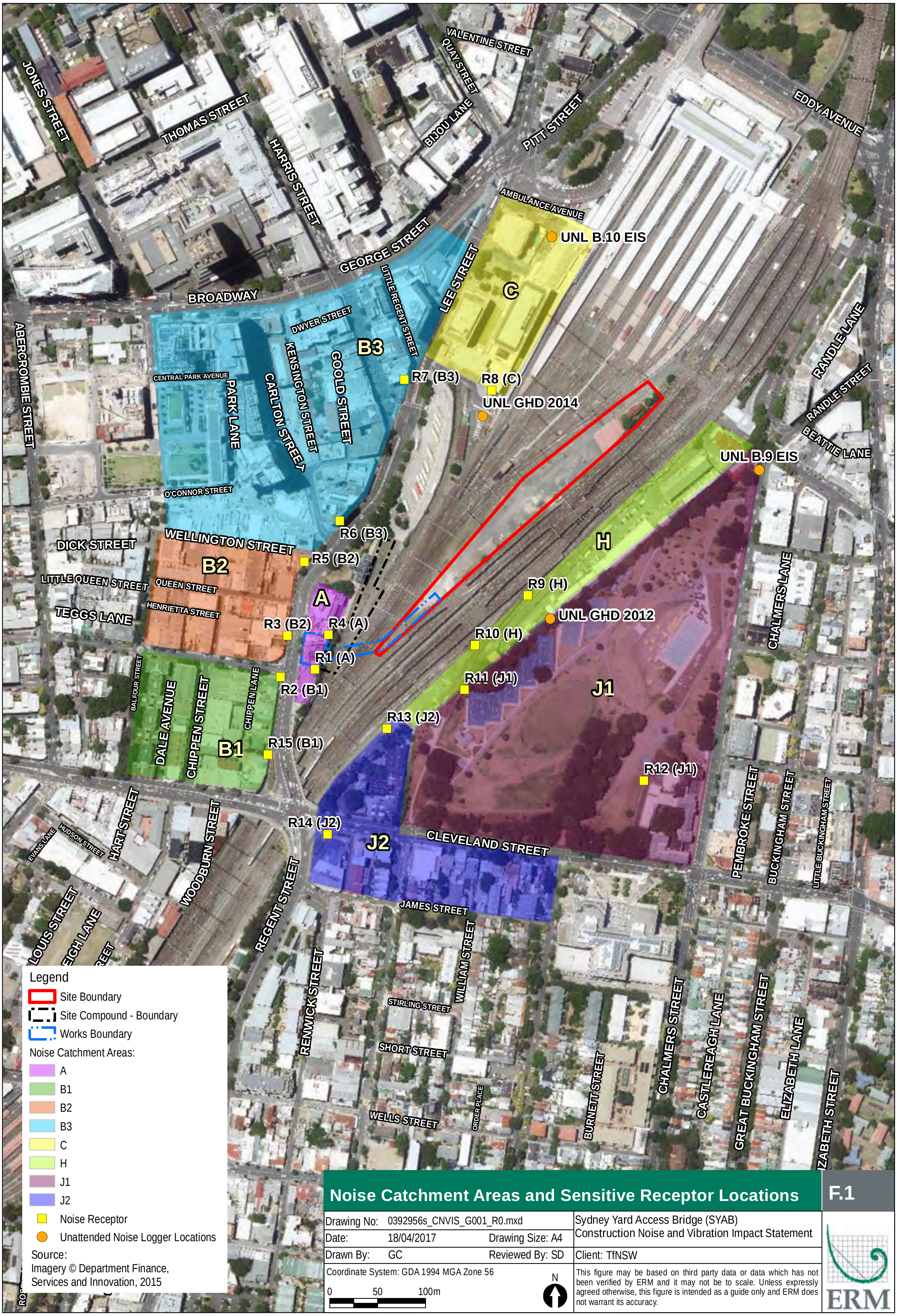
a. BACKGROUND

Nuisance, or an unacceptable level of noise and vibration amenity, may arise from construction activities associated with new or existing developments. These potential issues are recognised in the various approval documents requiring the preparation of this CNVIS and the mitigation and management of potential impacts during SYAB works.

This CNVIS (conducted and documented with regard to the relevant policy, guidelines and standards presented in the reference section of this report) addresses these potential issues and applies directly to the SYAB construction phase of Sydney Metro. This CNVIS applies to all activities, tasks, products and services on the site over which it has control or influence. Blasting (a feature of the broader Sydney Metro project) is not required for SYAB works and is therefore not addressed in this CNVIS.

The SYAB works will include demolition, earthworks and construction of all permanent new infrastructure and modifications to existing infrastructure. The SYAB scope and potential noise and vibration issues associated with the works are outlined further in the overall Construction Environment Management Plan (CEMP) and the Construction Noise and Vibration Management Plan (CNVMP) already developed for the project.

The SYAB site is located in the rail corridor near the Sydney Yard just beyond a rail access gate at Regent Street, Sydney in NSW. The location of the site is illustrated below in **Figure 1**.



JONES STREET
THOMAS STREET
HARRIS STREET
VALENTINE STREET
QUAY STREET
BIJOU LANE
PITT STREET
EDDY AVENUE
AMBULANCE AVENUE
UNL B.10 EIS
GEORGE STREET
BROADWAY
LITTLE REGENT STREET
LEE STREET
C
DWYER STREET
B3
ABERCROMBIE STREET
CENTRAL PARK AVENUE
PARK LANE
CARLTON STREET
KENSINGTON STREET
GOOLD STREET
R7 (B3)
R8 (C)
UNL GHD 2014
RANDLE LANE
RANDLE STREET
BEATTIE LANE
UNL B.9 EIS
O'CONNOR STREET
R6 (B3)
WELLINGTON STREET
DICK STREET
B2
R5 (B2)
H
LITTLE QUEEN STREET
QUEEN STREET
A
R9 (H)
HENRIETTA STREET
TEGGS LANE
R3 (B2)
R4 (A)
UNL GHD 2012
CHALMERS LANE
R10 (H)
R1 (A)
R11 (J1)
J1
R2 (B1)
BALFOUR STREET
CHIPPEN LANE
DALE AVENUE
CHIPPEN STREET
R13 (J2)
B1
R15 (B1)
R12 (J1)
HART STREET
R14 (J2)
J2
CLEVELAND STREET
PEMBROKE STREET
BUCKINGHAM STREET
LITTLE BUCKINGHAM STREET
EVANS LANE
HUDSON STREET
WOODBURN STREET
REGENT STREET
JAMES STREET
LOUIS STREET
RENWICK STREET
WILLIAM STREET
STIRLING STREET
SHORT STREET
ORDER PLACE
WELLS STREET
BURNETT STREET
CHALMERS STREET
CASTLEREAGH LANE
GREAT BUCKINGHAM STREET
ELIZABETH LANE
ZABETH STREET
Legend
Site Boundary
Site Compound - Boundary
Works Boundary
Noise Catchment Areas:
A
B1
B2
B3
C
H
J1
J2
Noise Receptor
Unattended Noise Logger Locations
Source:
Imagery © Department Finance, Services and Innovation, 2015
Noise Catchment Areas and Sensitive Receptor Locations
F.1
Drawing No: 0392956s_CNVIS_G001_R0.mxd
Date: 18/04/2017
Drawing Size: A4
Drawn By: GC
Reviewed By: SD
Coordinate System: GDA 1994 MGA Zone 56
0 50 100m
N
Sydney Yard Access Bridge (SYAB)
Construction Noise and Vibration Impact Statement
Client: TfNSW
This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
ERM

2. EXISTING ENVIRONMENT

A key element in assessing environmental noise impacts is an understanding of the existing ambient and background noise levels in the vicinity of the closest and/or potentially most affected receptors situated in proximity to a site. This section provides a summary of the existing noise conditions as relevant to SYAB works.

a. NOISE CATCHMENT AREAS

ERM has identified 'Noise Catchment Areas' (NCA) for eight discrete areas surrounding SYAB works. These NCA were established to approximate areas of land that:

- may experience similar existing noise levels;
- may experience similar noise levels to receptor locations where values are predicted via modelling; and
- to inform the extent of any notification area boundary that may be required.

These NCA are an important feature of the assessment as it is not feasible or useful to predict noise levels at every building or dwelling within the potential area of influence of SYAB works.

These NCAs were adapted from those presented in the Sydney Metro, *Chatswood to Sydenham Environmental Impact Statement (EIS) – Chapter 10: Construction Noise and Vibration*, dated May 2016. These NCA were shown in **Figure 1** and are described below in **Table 2.1**.

Table 2.1 – Noise Catchment Areas (NCA)

Noise Catchment Area (NCA)	Description	Distance (m) SYAB Construction Site
A	Residential and Commercial receptors to the west of the site, east of Regent Street.	20
B1	Residential and Commercial receptors to the south west of the site, west of Regent Street.	50
B2	Residential and Commercial receptors to the west of the site, west of Regent Street.	50
B3	Residential and Commercial receptors to the north west of the site, west of Regent Street.	130
C	Commercial receptors to the north of the site, east of Regent Street.	220
H	Commercial and Industrial receptors to the east of the site, west of Prince Alfred Park.	60
J1	Prince Alfred Park, to the east of the site.	80
J2	Place of worship and residential receptors, to the south of the site.	85

1. NCA adapted from those presented in the overall project Environmental Impact Statement (EIS).

b. POTENTIALLY SENSITIVE RECEPTORS

ERM has identified the following sensitive receptors to be the closest and/or potentially most affected locations situated within the potential area of influence of SYAB works, as presented in **Table 2.2**. These locations were established based on review of aerial photography, land use zoning and cadastre data and the results of preliminary noise modelling, where receptor positions were optimised to ensure representative worst-case levels were being predicted. These locations do not represent all receptors located in the vicinity of SYAB but have been selected for the purposes of this noise and vibration impact assessment; they are considered to be representative of locations that will potentially experience the highest impacts associated with SYAB works, and will be the most affected during construction.

In addition to these locations the vibration assessment has considered potential impacts (cosmetic and structural damage) at the nearby **Mortuary Station**, a heritage structure situated north of the site at a distance of approximately 65 metres. The location is assessed for vibration only as it is unoccupied, no longer in active use and therefore not considered a sensitive receptor for noise.

The NCA and all sensitive receptor locations are identified in the **Figure 1**.

Table 2.2 – Sensitive Receptor Locations

ID	Description	GPS Co-ordinates (Zone 56H)	
		Easting	Northing
R1 (A)	Service Station (Commercial)	333717	6248847
R2 (B1)	Lord Gladstone Hotel (Commercial)	333678	6248832
R3 (B2)	Mixed Use (Residential)	333685	6248876
R4 (A)	Residential Apartments – locally listed heritage building (Former Co-Masonic Temple)	333732	6248877
R5 (B2)	Mixed Use (Residential)	333706	6248953
R6 (B3)	Residential Apartments	333739	6248998
R7 (B3)	Residential Apartments	333813	6249147
R8 (C)	Commercial Buildings south west of Central Station	333876	6249138
R9 (H)	Industrial Buildings to the east of SYAB works, along the rail corridor	333946	6248909
R10 (H)	Commercial Building to the east of SYAB works, along the rail corridor	333886	6248859
R11 (J1)	Active recreational area to the east of SYAB works (Tennis Courts)	333868	6248815
R12 (J1)	Educational Buildings (Cleveland St High School)	334062	6248724
R13 (J2)	Place of Worship / Education (Greek Orthodox / St Andrews Theological College)	333802	6248764
R14 (J2)	Residential Apartments	333735	6248667
R15 (B1)	Residential Apartments	333666	6248751

1. All GPS coordinates are in UTM, Zone 56H

c. Background Noise Levels

Existing conditions have been quantified primarily from data in the EIS however supplementary data has been obtained from other reports provided by LOR, these are:

- Degnan Constructions Pty Ltd - **Sydney to Burwood Compressor House Detailed Design Operational Noise Assessment**, prepared by GHD Pty Ltd, dated November 2012 (GHD 2012); and
- TfNSW – Power supply Upgrade Program – **Lee Street Substation Noise and Vibration Assessment** prepared by GHD Pty Ltd, dated February 2014 (GHD 2014)

Rating Background Levels (RBL) at sensitive receptor locations considered representative of each of the eight NCA were established via measurement in the EIS in accordance with the INP. The RBLs (adapted from those presented in the EIS and adapted based on additional information provided by LOR in the GHD 2012 and GHD 2014 reports) are presented in **Table 2.3** below for the day, evening and night-time periods. For data obtained from the EIS, the lowest recorded value for any location was adopted to establish a conservative set of daytime, evening and night time period RBL. There is no requirement or benefit for measuring existing vibration levels as they are typically (in the absence of any significant vibration generating source) imperceptible. GHD 2012 provided baseline noise data measured in Prince Alfred Park (representative of NCA H and J1). GHD 2014 provided baseline noise data measured at 30 Lee St, Haymarket NSW (representative of NCA B3 and C). Unattended noise monitoring locations are presented in **Figure 1**.

Due to the built environment of the area surrounding SYAB works and the noise reduction expected from the shielding provided by the first row of buildings to the second row of buildings and receptors, reduced impacts are anticipated for these additional locations and in the broader community

Table 2.3 – Rating Background Noise Levels (RBL)

Noise Catchment Area (NCA)	Rating Background Levels (RBL) in dBA		
	Daytime (7am to 6pm)	Evening (6pm to 10pm)	Night-time (10pm to 7am)
A[1]	51	50	45
B1[1]	51	50	45
B2[1]	51	50	45
B3[2]	54	52	46
C[2]	54	52	46
H[2]	48	48	45
J1[2]	48	48	45
J2[1]	51	50	45

Source: EIS, GHD

1. Data adapted from EIS (lowest recorded levels from daytime, evening and night time periods adopted); and
2. Data obtained from GHD 2012 or GHD 2014.

3. METHODOLOGY, INPUTS AND ASSUMPTIONS

The methodology, inputs and assumptions that have informed SYAB works noise modelling and assessment are outlined below:

- Brüel and Kjær's Predictor 7810 (Version 11.1) noise modelling software package was utilised to calculate noise levels using the International Organisation for Standardisation (ISO) 9613-2:1996 (ISO9613:2) - *Acoustics - Attenuation of Sound during Propagation Outdoors - Part 2: General Method of Calculation* noise propagation algorithms (international method for general purpose, 1/1 octaves). For sound calculated using ISO9613:2, the indicated accuracy is ±3dBA at source to receiver distances of up to 1000 metres (m) and unknown at distances above 1000m.

- The Predictor software package allows 3D elevation data to be combined with ground regions, water, foliage, significant building structures etc. and receptor locations, to create a detailed and accurate representation of the site and surrounding area. The noise model allowed for the quantification of noise levels from multiple sources, based on sound power or pressure levels emitted from each source. The model computed the noise propagation in the assessment area of influence to specifically quantify A-weighted decibels, $L_{Aeq,\ 15minute}$ dBA at identified receptors. All predicted noise levels in this document are expressed as the $L_{eq,\ 15\ minute}$ parameter in dBA.

- Sound Power Level (L_W, dBA) data incorporated into the project-specific noise model was obtained from the following documents 1) NSW Government – Sydney Metro Construction Noise and Vibration Strategy (CNVS), dated August 2017, 2) Standards Australia AS 2436–2010™ (AS2436) – *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites* and 3) NSW Government – Transport for NSW (TfNSW) *Construction Noise Strategy* (7TP-ST-157/2.0 or CNS), dated April 2013.

- Sound Power Level (L_W) is a measure of the total power radiated by a source. The Sound Power of a source is a fundamental property of the source and is independent of the surrounding environment. This differs from a Sound Pressure Level (L_P) which is the level of sound pressure as measured at a distance by a standard sound level meter with a microphone. L_P is the received sound (e.g. $L_{Aeq,\ 15minute}$) as opposed to L_W which is the sound 'intensity' at the source.

- 3D elevation data and cadastre (spatial data) was obtained from the NSW Government - Land and Property Information (LPI). Buildings near the project were included in the noise model also based on spatial data obtained from LPI; they were modelled as building regions for applicable areas surrounding the project. The exception being the first row of buildings around the site, these were included in the noise model (as buildings) based on the spatial data obtained from LPI.

- NCA locations identified in the Sydney Metro EIS, 2016 were utilised to establish receptor locations. These locations were modified, or additional locations included in some cases to ensure the most affected points were assessed. The NCA and receptor locations adopted for this CNVIS are presented in **Figure 1**.

- Noise levels were calculated at 1.5 metres (m) above ground level for all receptors, in accordance with the ICNG. It is noted that ambient, background and project noise levels may be higher at receptor heights above 1.5 m.

- In all cases noise has been assessed at the most-affected point at or within the residential property boundary or, if that is more than 30 m from the residence, at the most-affected point within 30 m of the residence.

- Calm conditions only were modelled. Meteorological conditions for prevailing winds were not included in the model however a D class temperature inversion was adopted (representing a stable condition). The model included a temperature of 15°C and humidity of 60%, representative of typical Sydney conditions. A ground factor of 0.6 was adopted for the modelling area (0.0 is hard, 1.0 is soft).

- To accurately represent general construction emissions; capturing the size, layout and number of noise generating plant / equipment, ERM has utilised a combination of area sources and point sources to predict L_{Aeq} noise levels. A separate area source was placed in the model for each phase of works to accurately represent the distribution of noise across the site during each work phase, while point sources were used to identify positions of known plant / equipment.

- The general noise emission sources such as trucks and vibratory rollers were included in the noise model as “area sources”. An area source is a horizontal area with point sources evenly distributed throughout its layout; in this case the SYAB work phase areas. The point specific noise emission sources such as piling rig and tower crane were included in the noise model as point sources. Point sources are a single multi-directional emission sources with an L_W value (as well as other features) assigned to each.

- The noise assessment scenarios are summarised in **Section 3a** with the full noise modelling data set provided in **Annex A** of this document. All L_W, dBA values considered the applicable NSW Environment Protection Authority – NSW Environmental *Noise Management – Industrial Noise Policy* (INP), January 2000 modifying factors (penalties) prior to modelling. The values provided in **Annex A** represent the overall level following this consideration.

a. ASSESSMENT SCENARIOS

A summary of the ten assessment scenarios that were considered is provided below in **Table 3.1**.

The sound power level (L_W) data identified for individual plant / equipment is presented as relevant to the noise assessment, as well as the quantity of equipment and potential for out-of-hours works (OOHW) to be required.

For vibration, only the activity and/or equipment with potential to generate vibration (demolition and vibratory compaction) were considered as is described in **Section 5** of this document.

Table 3.1 – Assessment Scenarios

ID	Period	Equipment	Sound Power Level / Item (LW in LAeq, 15 minute)	Equipment Quantity	Potential OOHW Required
SCN01	Demolition of Terrace Buildings	35t Excavator Bogie Bobcat	123 107 104	2 4 1	N
SCN02	Site Investigation and Setup	Vac Truck Cranes 6t Excavator Road sweeper	107 105 95 107	1 1 1 1	Y
SCN03	Removal of part of Up Shunting Neck	Loader 8t Excavator + tamping head 10t Roller Bogie Semitrailer Rail saw	111 100 114 107 107 117	1 1 1 2 1 1	Y
SCN04	Piling of Bridge Abutments and Piers	Piling Rig 8t Excavator Bogie Tipper Concrete Pump Concrete Agitator 50t All Terrain Semitrailer	111 100 107 109 112 117 107	1 1 1 1 1 1 1	Y
SCN05	Abutments and Piers - Precast	Tower Crane (Favco) Cherry Picker	110 102	1 2	Y
SCN06	Abutments and Piers – Cast in Situ	Concrete Pump Concrete Agitator	109 112	1 1	Y
SCN07	Construction of Deck Spans	Tower Crane (Favco) Cherry Picker Jinkers Rattle gun	110 102 107 116	1 2 3 1	Y
SCN08	Construction of Reinforced Earth Wall	10t Roller City crane 8t Excavator Bogie	114 105 100 107	1 1 1 2	N
SCN09	Construction of Deck	Concrete Pump Concrete Agitator	109 112	1 1	N
SCN10	Regent St Services	5t Excavator Road saw Bogie 2.5t Roller Concrete Agitator	95 117 107 108 112	1 1 1 1 1	Y

Source: LOR

4. MANAGEMENT LEVELS AND CRITERIA

a. NOISE MANGEMENT LEVELS

Based on the ICNG and CNVS methodology and outlined in the CNVMP the following construction Noise Management Levels (NMLs) for residential receptors in each NCA will apply to SYAB works as presented in **Table 4.1**. Predicted noise levels are compared to these "criteria" values in **Section 5** to identify any activities that exceed the applicable management levels and to identify the extent of potential noise impacts.

For other sensitive receptors (i.e. not residential) the internal/external criteria value translated from the ICNG may be adopted as relevant and if other receptors are identified. External NMLs for other sensitive receptors applicable to this assessment have also been included in **Table 4.1** below.

It is a requirement under **CoA – E37, E38, E41** and **E42** that LOR must identify and consult with all receptors likely to experience internal noise levels greater than $L_{eq\ 15\ minute}$ 60 dBA, regenerated (ground-borne) noise or a perceptible level of vibration, with the objective of determining appropriate hours of respite. These activities should be scheduled to occur between the hours of 7am and 8pm, as far as practical. These receptors should be offered additional mitigation in accordance with the Additional Mitigation Measures Matrix (AMMM) outlined in **Table 4.6**, **Table 4.7** and **Table 4.8**.

Table 4.1 – Background Noise and Management Levels

Noise Catchment Area (NCA) / Receptor type	Acceptable LAeq, 15 minute Noise Level			
	Standard Construction Hours RBL + 10 in dBA[1]	Outside Standard Construction Hours RBL + 5 in dBA		
		Daytime[2]	Evening[3]	Night[4]
A	61	56	55	50
B1	61	56	55	50
B2	61	56	55	50
B3	64	59	57	51
C	64	59	57	51
H	58	53	53	50
J1	58	53	53	50
J2	61	56	55	50
Commercial	70	70	70	70
Industrial	75	75	75	75
Recreational (Active)	65	65	65	65
Place of Worship	55	55	55	55
Educational	55	55	55	55

Source: EIS, GHD

3. Standard (daytime): 7:00am to 6:00pm Mondays to Fridays, inclusive and 8:00am to 1:00pm Saturdays;
4. Outside standard (daytime): 1:00pm to 6:00pm Saturdays, and 8:00am to 6:00pm on Sundays or public holidays;
5. Outside standard (evening): 6:00pm to 10pm Monday to Sunday, inclusive; and
6. Outside standard (night time): 10:00pm to 7:00am Monday to Friday and 10:00pm to 8:00am on Saturdays, Sundays and public holidays.

Highly Noise Affected Management Level

In accordance with the ICNG, the Highly Noise Affected Management Level (HNAML) of **75 dBA** will apply to residential (dwelling) receptors during standard construction hours and during the daytime period only. The HNAML does not apply outside the recommended standard hours and does not apply to other sensitive receptors.

Sleep Disturbance

'Sleep disturbance screening thresholds' have been developed as per the guidance in the INP and CNVS. These screening levels (refer **Table 4.2**) will only apply during the night time period. These screening levels will generally apply at residential (dwelling) receptors with other sensitive receptors considered where applicable e.g. at other receptors where habitable sleeping spaces are identified.

Table 4.2 – Sleep disturbance screening levels

Noise Catchment Area (NCA)	Sleep Disturbance Screening Level ($L_{A1,1minute}$ / L_{Amax})[1]
A	60
B1	60
B2	60
B3	61
J2	60

Source: EIS

1. These sleep disturbance screening levels only apply during the night time defined by the INP as the period from 10:00pm to 07:00am (Monday to Saturday) and 10:00pm to 08:00am (Sundays and Public Holidays).

b. VIBRATION MANAGEMENT LEVELS

Based on the CNVS methodology and outlined in the CNVMP, impacts from vibration will be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (structural/cosmetic damage). The following construction vibration management levels / criteria will apply to SYAB works as presented below.

Human Comfort

The NSW Vibration Guideline and the CNVS provides guidance for assessing human exposure to vibration. These documents are based on British Standard (BS 6472–1992) – *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* dated 1992. The vibration dose values recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in **Table 4.3**. The NSW Vibration Guideline also presents PPV, mm/s values for the assessment and management of human comfort vibration issues however VDV, $m/s^{1.75}$ is the focus of this CNVIS. VDV is adopted here as it considers the duration or works and characteristic frequency of measured vibration events. The NSW Vibration Guideline values (PPV, mm/s) are also of value and may be incorporated into the CNVMP if considered appropriate.

Table 4.3 – (Human Comfort) Vibration Dose Value Ranges which Might Result in Various Probabilities of Adverse Comment within Residential Buildings

Place and Time	Low Probability of Adverse Comment ($m/s^{1.75}$)	Adverse Comment Possible ($m/s^{1.75}$)	Adverse Comment Probable ($m/s^{1.75}$)
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Source: CNVS

1. For offices and workshops, multiplying factors of 2 and 4 respectively would be applied to the above vibration dose value ranges for a 16 hr day.

Building Damage (Structural/Cosmetic Damage)

To achieve the requirements of the CNVS, British Standard BS7385: Part 2-1993 (BS 7385) - *Evaluation and Measurement for Vibration in Buildings — Part 2 – Guide to Damage Levels from Ground-borne Vibration*, dated 1993 is presented in **Table 4.4** and will be considered during works where applicable. BS 7385 provides safe limit guideline values, below which vibration is considered insufficient to cause structural or cosmetic damage to buildings.

Table 4.4 – Building Damage (BS 7385)

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

Source: BS 7385, *CNVS*

For most construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, a conservative vibration damage screening level per receptor type is given below:

- Reinforced or framed structures: **25.0 mm/s**
- Unreinforced or light framed structures: **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 safe vibration level.

Heritage Structures

If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage criteria of **2.5 mm/s** peak component particle velocity from the German Institute for Standardisation – *DIN 4150 (1999-02) Part 3 (DIN4150:3) – Structural Vibration - Effects of Vibration on Structures, dated 1999* would be considered. The applicable German Standard DIN 4150:3 management levels are tabulated in **Table 4.5**.

Table 4.5 – Building Damage (DIN4150:3)

Line	Type of Structure	Guideline Values for Velocity (PPV in mm/s)		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under either of the other classifications and of great intrinsic value	3	3 to 8	8 to 10

Source: DIN4150:3, CNVS

1. At frequencies above 100 Hz, the values given in this column may be used as minimum values; and
2. The 50 Hz values may be applied to assess vibration at the horizontal plane of the highest building floor at all frequencies.
3. As per the CNVS, Heritage criteria are provided. It is noted that line one and line two do not apply to this project. These criteria are only to be applied if a heritage building or structure is found to be structurally unsound.

C. THRESHOLDS FOR ADDITIONAL MITIGATION MEASURES

The project-specific mitigation measures are outlined in the already prepared CNVMP and have been defined based on the activities proposed and potential impacts. "Standard" mitigation (and practices) applicable to SYAB works are described in Section 7 of the CNVS and the actions set out must be implemented on all Sydney Metro construction projects.

Where the predicted "mitigated" construction noise levels are above the ICNG noise management levels, the Additional Mitigation Measures Matrix (AMMM) identified in Section 8 of the CNVS is to be implemented. The approach, guided by the AMMM, is primarily aimed at pro-active engagement with affected sensitive receptors rather than additional noise reducing mitigation.

The types of additional mitigation measures are listed in **Table 4.6** and described in Appendix C of the CNVS.

Table 4.6 – Additional Mitigation Measures

Measure	Abbreviation
Alternative accommodation	AA
Monitoring	M
Individual briefings	IB
Letter box drops	LB
Project specific respite offer	RO
Phone calls	PC
Specific notifications	SN

Source: CNVS

The project-specific AMMM for construction (airborne) noise are identified in **Table 4.7**. Any noise level exceedances of the AMMM thresholds are highlighted in red, blue, olive green or purple (as shown in **Table 4.7**) as is applicable to the findings of this assessment. The project-specific AMMM for ground-borne vibration are identified in **Table 4.8**. Those applicable to ground-borne noise are excluded from this CNVIS as any impacts are unlikely to occur.

Table 4.7 – Additional Mitigation Measures Matrix (AMMM) – Construction (Airborne) Noise

Period	Time of Day	0 to 10 dBA Noticeable	10 to 20 dBA Clearly Audible	20 to 30 dBA Moderately Intrusive	>30 dBA Highly Intrusive
Standard	Mon-Fri (7am - 6pm) Saturdays (8am - 1pm) Sundays/Public Holidays (No Works)	-	-	M, LB	M, LB
OOHW Period 1	Mon-Fri (6pm - 10pm) Saturdays (7am-8am) and (1pm- 10pm) Sundays/Public Holidays (8am-6pm)	-	LB	M, LB	M, IB, LB, PC, RO, SN
OOHW Period 2	Mon-Fri (10pm - 7am) Saturdays (10pm - 8am) Sundays/Public Holidays (6pm - 7am)	-	M, LB	M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN

Source: CNVS

Table 4.8 – Additional Mitigation Measures Matrix (AMMM) – Ground-borne Vibration

Time Period		Mitigation Measures Predicted Vibration Levels Exceed Maximum Levels
Standard	Mon-Fri (7am-6pm)	M, LB, RO
	Sat (8am-1pm)	
	Sun/Pub Hol (Nil)	
OOHW Period 1	Mon-Fri (6pm-10pm)	M, IB, LB, PC, RO, SN
	Sat (7am-8am and 1pm-10pm)	
	Sun/Pub Hol (8am-6pm)	
OOHW Period 2	Mon-Fri (10pm-7am)	AA, M, IB, LB, PC, RO, SN
	Sat (10pm-8am)	
	Sun/Pub Hol (6pm-7am)	

Source: CNVS

5. IMPACT ASSESSMENT

a. POTENTIAL NOISE IMPACTS

Based on the methodology, inputs and assumptions described above, $L_{Aeq, 15minute}$ noise levels have been predicted. All noise levels have been rounded to the nearest whole integer. The resultant noise levels and comparison to the daytime and night time NML are presented in **Table 5.1** to **Table 5.10**. Values that exceed the NML are highlighted in **bold** typeset. Values that exceed the HNAML (fixed at 75 dBA for residential receptors) are highlighted in **bold and underlined** typeset.

Where the predicted construction noise levels are above the NML, the AMMM identified in Section 8 of the CNVS and **Section 4c** of this CNVIS should be implemented.

Predicted values at select receptors exceed the project-specific NML. The level by which they exceed the NML varies depending on the assessment scenario, the receptor proximity to the activity and the time of day. A comparison of the predicted construction noise levels to the existing background noise levels (L_{A90}, period) is therefore required (for any receptor where the NML is exceeded) to establish the necessary mitigation AMMM requirements. This comparison is provided in **Table 5.1 to Table 5.10** below.

Any noise level exceedance of the AMMM thresholds (refer **Table 4.7**) is highlighted in red, blue, olive green or purple to illustrate the extent and level of AMMM required.

During construction works, actual noise levels will vary depending on the number of items of equipment, their exact location within the site, their usage and how many items of equipment operate concurrently at any one time. A receptor will therefore experience a range of noise levels.

Construction noise level predictions have been conducted to identify results for representative **worst-case scenarios**, as the predicted values consider the cumulative emission (and potential impact) of all equipment sources working concurrently, and in the case of point source emissions the location was modelled closest to the nearest residential receptor.

It is not possible, or warranted to reflect potential impacts, to model every plausible activity, task or usage for each noise generating source and location, hence the conservative approach adopted here has been applied to ensure that representative worst-case noise predictions were conducted. Furthermore, a combination of point sources and area sources were utilised where possible to reflect the potential distribution of noise across the project area, and the potential emissions from activities undertaken at various locations within and around the site.

The AMMM has not been applied to commercial or other sensitive receptors (i.e. educational / places of worship) outside the standard hours of construction (**Table 5.1 to Table 5.10**) as these receptors are not envisaged to be in use during these periods.

Table 5.1 – Resultant Noise Level Assessment: Scenario 1 (Demolition of Terrace Buildings)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq, 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq, 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq, 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**91**	21	21	21	21	40	40	41	46
R2 (B1)	R2 (B1) - Hotel	**81**	11	11	11	11	30	30	31	36
R3 (B2)	R3 (B2) - Residential	**86**	25	30	31	36	35	35	36	41
R4 (A)	R4 (A) - Residential	**91**	30	35	36	41	40	40	41	46
R5 (B2)	R5 (B2) - Residential	**65**	4	9	10	15	14	14	15	20
R6 (B3)	R6 (B3) - Residential	**57**	-7	-2	0	6	-	-	-	11
R7 (B3)	R7 (B3) - Residential	**52**	-12	-7	-5	1	-	-	-	6
R8 (C)	R8 (C) - Commercial	56	-14	-14	-14	-14	-	-	-	-
R9 (H)	R9 (H) - Industrial	65	-10	-10	-10	-10	-	-	-	-
R10 (H)	R10 (H) - Commercial	69	-1	-1	-1	-1	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	**70**	5	5	5	5	22	22	22	25
R12 (J1)	R12 (J1) - Educational	**62**	7	7	-	-	14	14	-	-
R13 (J2)	R13 (J2) - Church	**73**	18	18	-	-	22	22	-	-
R14 (J2)	R14 (J2) - Residential	**68**	7	12	13	18	17	17	18	23
R15 (B1)	R15 (B1) - Residential	**73**	12	17	18	23	22	22	23	28

1. Works outside the approved SYAB standard construction hours are not envisaged for this scenario.

Table 5.2 – Resultant Noise Level Assessment: Scenario 2 (Site Investigation and Setup)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq, 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq, 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq, 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	66	-4	-4	-4	-4	-	-	-	-
R2 (B1)	R2 (B1) - Hotel	59	-11	-11	-11	-11	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**58**	-3	2	3	8	-	7	8	13
R4 (A)	R4 (A) - Residential	**71**	10	15	16	21	20	20	21	26
R5 (B2)	R5 (B2) - Residential	**56**	-5	0	1	6	-	-	6	11
R6 (B3)	R6 (B3) - Residential	**57**	-7	-2	0	6	-	-	-	11
R7 (B3)	R7 (B3) - Residential	50	-14	-9	-7	-1	-	-	-	-
R8 (C)	R8 (C) - Commercial	52	-18	-18	-18	-18	-	-	-	-
R9 (H)	R9 (H) - Industrial	56	-19	-19	-19	-19	-	-	-	-
R10 (H)	R10 (H) - Commercial	59	-11	-11	-11	-11	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	56	-9	-9	-9	-9	-	-	-	-
R12 (J1)	R12 (J1) - Educational	47	-8	-8	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**56**	1	1	-	-	5	5	-	-
R14 (J2)	R14 (J2) - Residential	48	-13	-8	-7	-2	-	-	-	-
R15 (B1)	R15 (B1) - Residential	**52**	-9	-4	-3	2	-	-	-	7

1. Works outside the approved SYAB standard construction hours are not envisaged for this scenario.

Table 5.3 – Resultant Noise Level Assessment: Scenario 3 (Removal of part of Up Shunting Neck)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq,\ 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq,\ 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq,\ 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**72**	2	2	2	2	21	21	22	27
R2 (B1)	R2 (B1) - Hotel	67	-3	-3	-3	-3	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**69**	8	13	14	19	18	18	19	24
R4 (A)	R4 (A) - Residential	**<u>76</u>**	15	20	21	26	25	25	26	31
R5 (B2)	R5 (B2) - Residential	47	-14	-9	-8	-3	-	-	-	-
R6 (B3)	R6 (B3) - Residential	**61**	-3	2	4	10	-	7	9	15
R7 (B3)	R7 (B3) - Residential	46	-18	-13	-11	-5	-	-	-	-
R8 (C)	R8 (C) - Commercial	54	-16	-16	-16	-16	-	-	-	-
R9 (H)	R9 (H) - Industrial	56	-19	-19	-19	-19	-	-	-	-
R10 (H)	R10 (H) - Commercial	60	-10	-10	-10	-10	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	60	-5	-5	-5	-5	-	-	-	-
R12 (J1)	R12 (J1) - Educational	50	-5	-5	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**63**	8	8	-	-	12	12	-	-
R14 (J2)	R14 (J2) - Residential	**56**	-5	0	1	6	-	-	6	11
R15 (B1)	R15 (B1) - Residential	**61**	0	5	6	11	-	10	11	16

1. Works outside the approved SYAB standard construction hours may be required for this scenario.

Table 5.4 – Resultant Noise Level Assessment: Scenario 4 (Piling of Bridge Abutments and Piers)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq, 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq, 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq, 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**76**	6	6	6	6	25	25	26	31
R2 (B1)	R2 (B1) - Hotel	67	-3	-3	-3	-3	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**69**	8	13	14	19	18	18	19	24
R4 (A)	R4 (A) - Residential	**74**	13	18	19	24	23	23	24	29
R5 (B2)	R5 (B2) - Residential	**56**	-5	0	1	6	-	-	6	11
R6 (B3)	R6 (B3) - Residential	**55**	-9	-4	-2	4	-	-	-	9
R7 (B3)	R7 (B3) - Residential	50	-14	-9	-7	-1	-	-	-	-
R8 (C)	R8 (C) - Commercial	53	-17	-17	-17	-17	-	-	-	-
R9 (H)	R9 (H) - Industrial	57	-18	-18	-18	-18	-	-	-	-
R10 (H)	R10 (H) - Commercial	61	-9	-9	-9	-9	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	60	-5	-5	-5	-5	-	-	-	-
R12 (J1)	R12 (J1) - Educational	50	-5	-5	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**61**	6	6	-	-	10	10	-	-
R14 (J2)	R14 (J2) - Residential	**54**	-7	-2	-1	4	-	-	-	9
R15 (B1)	R15 (B1) - Residential	**57**	-4	1	2	7	-	6	7	12

1. Works outside the approved SYAB standard construction hours may be required for this scenario.

Table 5.5 – Resultant Noise Level Assessment: Scenario 5 (Abutments and Piers – Precast)

Receptor ID	Receptor Description	Predicted Noise Levels: LAeq, 15minute	Comparison to NML (predicted – NML): LAeq, 15minute				If exceedance of NML - Comparison to RBL (predicted – RBL): LAeq, 15minute			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	70	0	0	0	0	-	-	-	-
R2 (B1)	R2 (B1) - Hotel	63	-7	-7	-7	-7	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**69**	8	13	14	19	18	18	19	24
R4 (A)	R4 (A) - Residential	**86**	25	30	31	36	35	35	36	41
R5 (B2)	R5 (B2) - Residential	**51**	-10	-5	-4	1	-	-	-	6
R6 (B3)	R6 (B3) - Residential	46	-18	-13	-11	-5	-	-	-	-
R7 (B3)	R7 (B3) - Residential	44	-20	-15	-13	-7	-	-	-	-
R8 (C)	R8 (C) - Commercial	47	-23	-23	-23	-23	-	-	-	-
R9 (H)	R9 (H) - Industrial	51	-24	-24	-24	-24	-	-	-	-
R10 (H)	R10 (H) - Commercial	55	-15	-15	-15	-15	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	56	-9	-9	-9	-9	-	-	-	-
R12 (J1)	R12 (J1) - Educational	47	-8	-8	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**58**	3	3	-	-	7	7	-	-
R14 (J2)	R14 (J2) - Residential	**52**	-9	-4	-3	2	-	-	-	7
R15 (B1)	R15 (B1) - Residential	**52**	-9	-4	-3	2	-	-	-	7

1. Works outside the approved SYAB standard construction hours may be required for this scenario.

Table 5.6 – Resultant Noise Level Assessment: Scenario 6 (Abutments and Piers – Cast in Situ)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq, 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq, 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq, 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**74**	4	4	4	4	23	23	24	29
R2 (B1)	R2 (B1) - Hotel	67	-3	-3	-3	-3	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**69**	8	13	14	19	18	18	19	24
R4 (A)	R4 (A) - Residential	**76**	15	20	21	26	25	25	26	31
R5 (B2)	R5 (B2) - Residential	44	-17	-12	-11	-6	-	-	-	-
R6 (B3)	R6 (B3) - Residential	**60**	-4	1	3	9	-	6	8	14
R7 (B3)	R7 (B3) - Residential	42	-22	-17	-15	-9	-	-	-	-
R8 (C)	R8 (C) - Commercial	53	-17	-17	-17	-17	-	-	-	-
R9 (H)	R9 (H) - Industrial	55	-20	-20	-20	-20	-	-	-	-
R10 (H)	R10 (H) - Commercial	59	-11	-11	-11	-11	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	59	-6	-6	-6	-6	-	-	-	-
R12 (J1)	R12 (J1) - Educational	50	-5	-5	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**62**	7	7	-	-	11	11	-	-
R14 (J2)	R14 (J2) - Residential	**55**	-6	-1	0	5	-	-	-	10
R15 (B1)	R15 (B1) - Residential	**62**	1	6	7	12	11	11	12	17

1. Works outside the approved SYAB standard construction hours may be required for this scenario.

Table 5.7 – Resultant Noise Level Assessment: Scenario 7 (Construction of Deck Spans)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq,\ 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq,\ 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq,\ 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**73**	3	3	3	3	22	22	23	28
R2 (B1)	R2 (B1) - Hotel	66	-4	-4	-4	-4	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**70**	9	14	15	20	19	19	20	25
R4 (A)	R4 (A) - Residential	**<u>86</u>**	25	30	31	36	35	35	36	41
R5 (B2)	R5 (B2) - Residential	**58**	-3	2	3	8	-	7	8	13
R6 (B3)	R6 (B3) - Residential	**57**	-7	-2	0	6	-	-	-	11
R7 (B3)	R7 (B3) - Residential	52	-12	-7	-5	1	-	-	-	6
R8 (C)	R8 (C) - Commercial	55	-15	-15	-15	-15	-	-	-	-
R9 (H)	R9 (H) - Industrial	59	-16	-16	-16	-16	-	-	-	-
R10 (H)	R10 (H) - Commercial	63	-7	-7	-7	-7	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	62	-3	-3	-3	-3	-	-	-	-
R12 (J1)	R12 (J1) - Educational	52	-3	-3	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**63**	8	8	-	-	12	12	-	-
R14 (J2)	R14 (J2) - Residential	**55**	-6	-1	0	5	-	-	-	10
R15 (B1)	R15 (B1) - Residential	**59**	-2	3	4	9	-	8	9	14

1. Works outside the approved SYAB standard construction hours may be required for this scenario.

Table 5.8 – Resultant Noise Level Assessment: Scenario 8 (Construction of Reinforced Earth Walls)

Receptor ID	Receptor Description	Predicted Noise Levels: $L_{Aeq, 15minute}$	Comparison to NML (predicted – NML): $L_{Aeq, 15minute}$				If exceedance of NML - Comparison to RBL (predicted – RBL): $L_{Aeq, 15minute}$			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	70	0	0	0	0	-	-	-	-
R2 (B1)	R2 (B1) - Hotel	63	-7	-7	-7	-7	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**64**	3	8	9	14	13	13	14	19
R4 (A)	R4 (A) - Residential	**71**	10	15	16	21	20	20	21	26
R5 (B2)	R5 (B2) - Residential	**57**	-4	1	2	7	-	6	7	12
R6 (B3)	R6 (B3) - Residential	**56**	-8	-3	-1	5	-	-	-	10
R7 (B3)	R7 (B3) - Residential	51	-13	-8	-6	0	-	-	-	-
R8 (C)	R8 (C) - Commercial	54	-16	-16	-16	-16	-	-	-	-
R9 (H)	R9 (H) - Industrial	57	-18	-18	-18	-18	-	-	-	-
R10 (H)	R10 (H) - Commercial	62	-8	-8	-8	-8	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	60	-5	-5	-5	-5	-	-	-	-
R12 (J1)	R12 (J1) - Educational	50	-5	-5	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**61**	6	6	-	-	10	10	-	-
R14 (J2)	R14 (J2) - Residential	**53**	-8	-3	-2	3	-	-	-	8
R15 (B1)	R15 (B1) - Residential	**58**	-3	2	3	8	-	7	8	13

1. Works outside the approved SYAB standard construction hours are not envisaged for this scenario.

Table 5.9 – Resultant Noise Level Assessment: Scenario 9 (Construction of Deck)

Receptor ID	Receptor Description	Predicted Noise Levels: LAeq, 15minute	Comparison to NML (predicted – NML): LAeq, 15minute				If exceedance of NML - Comparison to RBL (predicted – RBL): LAeq, 15minute			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**71**	1	1	1	1	20	20	21	26
R2 (B1)	R2 (B1) - Hotel	65	-5	-5	-5	-5	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**66**	5	10	11	16	15	15	16	21
R4 (A)	R4 (A) - Residential	**73**	12	17	18	23	22	22	23	28
R5 (B2)	R5 (B2) - Residential	42	-19	-14	-13	-8	-	-	-	-
R6 (B3)	R6 (B3) - Residential	**58**	-6	-1	1	7	-	-	6	12
R7 (B3)	R7 (B3) - Residential	39	-25	-20	-18	-12	-	-	-	-
R8 (C)	R8 (C) - Commercial	51	-19	-19	-19	-19	-	-	-	-
R9 (H)	R9 (H) - Industrial	52	-23	-23	-23	-23	-	-	-	-
R10 (H)	R10 (H) - Commercial	56	-14	-14	-14	-14	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	56	-9	-9	-9	-9	-	-	-	-
R12 (J1)	R12 (J1) - Educational	47	-8	-8	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**60**	5	5	-	-	9	9	-	-
R14 (J2)	R14 (J2) - Residential	**53**	-8	-3	-2	3	-	-	-	8
R15 (B1)	R15 (B1) - Residential	**59**	-2	3	4	9	-	8	9	14

1. Works outside the approved SYAB standard construction hours are not envisaged for this scenario.

Table 5.10 – Resultant Noise Level Assessment: Scenario 10 (Regents St Services)

Receptor ID	Receptor Description	Predicted Noise Levels: LAeq, 15minute	Comparison to NML (predicted – NML): LAeq, 15minute				If exceedance of NML - Comparison to RBL (predicted – RBL): LAeq, 15minute			
			Day Standard Hours	Day non-Standard Hours	Evening	Night time	Day Standard Hours	Day non-Standard Hours	Evening	Night time
R1 (A)	R1 (A) - Service Station	**77**	7	7	7	7	26	26	27	32
R2 (B1)	R2 (B1) - Hotel	68	-2	-2	-2	-2	-	-	-	-
R3 (B2)	R3 (B2) - Residential	**73**	12	17	18	23	22	22	23	28
R4 (A)	R4 (A) - Residential	**77**	16	21	22	27	26	26	27	32
R5 (B2)	R5 (B2) - Residential	**52**	-9	-4	-3	2	-	-	-	7
R6 (B3)	R6 (B3) - Residential	44	-20	-15	-13	-7	-	-	-	-
R7 (B3)	R7 (B3) - Residential	39	-25	-20	-18	-12	-	-	-	-
R8 (C)	R8 (C) - Commercial	42	-28	-28	-28	-28	-	-	-	-
R9 (H)	R9 (H) - Industrial	52	-23	-23	-23	-23	-	-	-	-
R10 (H)	R10 (H) - Commercial	56	-14	-14	-14	-14	-	-	-	-
R11 (J1)	R11 (J1) - Recreational	57	-8	-8	-8	-8	-	-	-	-
R12 (J1)	R12 (J1) - Educational	48	-7	-7	-	-	-	-	-	-
R13 (J2)	R13 (J2) - Church	**60**	5	5	-	-	9	9	-	-
R14 (J2)	R14 (J2) - Residential	**55**	-6	-1	0	5	-	-	-	10
R15 (B1)	R15 (B1) - Residential	**60**	-1	4	5	10	-	9	10	15

1. Works outside the approved SYAB standard construction hours may be required for this scenario.

Summary of Findings

The resultant noise levels are summarised below:

- The highest predicted noise levels range between 70 and 91 dBA for activities potentially associated with all scenarios. These noise levels are predicted at the receptors located in the first row of buildings with direct line of sight to SYAB works.
- The daytime NML applicable at residential (occupied dwellings) receptors for works within the recommended standard hours for construction is exceeded by up to 30 dBA at the most affected location R4 (A) in SCN01.
- The magnitude and extent that predicted noise levels exceed the daytime NML applicable at commercial and other sensitive receptors for works within the recommended standard hours for construction are broadly similar to that identified for residential receptors and exceed the NML at non-residential receptors by between approximately 1 and 21 dBA.
- The extent that noise levels are predicted to exceed the NML at residential receptors, for works outside the recommended hours for construction, varies depending on the assessment scenario and period i.e. daytime, evening, night time periods. Predicted noise levels exceed the NML to a larger extent during the evening and night time (when compared to the daytime) as the NML are more stringent during those periods. The highest exceedances are predicted for the night time, when the most stringent NML apply.
- For commercial and other sensitive receptors the extent that noise levels are predicted to exceed the NML is the same for each period, as the NML are fixed values for all times of the day and days of the week.
- It is noted that the HNAML (75 dBA) applicable at residential (dwelling) receptors during the daytime is exceeded for at least one receptor in the first row of buildings in assessment scenarios SCN01, SCN03, SCN05, SCN06 and SCN07.
- It is possible to estimate internal noise levels based on the predicted values presented above for each scenario by deducting 10 dBA from these external values to represent windows being partially open and by deducting 20 dBA to represent windows being closed. This method results in estimated noise levels between 70 dBA and approximately 80 dBA (internal) for SCN01 and between 60 dBA and approximately 75 dBA (internal) for the other scenarios (SCN02 to SCN10) assessed, at the most affected receptors.
- Comparing the estimated internal noise levels to the **CoA – E37** and **E38** requirements (i.e. internal noise levels should not exceed $L_{eq,\ 15\ minute}$, 60 dBA) identifies that noise levels will generally be in compliance for the broader community but levels are likely to exceed the **CoA – E37** and **E38** threshold at the first row of buildings around the site. This trend is likely to occur during most scenarios but is most significant for SCN01 where the highest levels are predicted. SCN01 will be conducted during the approved standard construction hours however works outside the approved standard construction hours may be required for SCN03, SCN04, SCN05, SCN06, SCN07 and SCN10.
- SCN01 is expected to generate highly intrusive noise levels (as per the AMMM) at R1 (A), R2 (B1), R3 (B2) and R4 (A) for works within the recommended standard hours of construction.
- SCN05 and SCN07 are expected to generate highly intrusive noise levels (as per the AMMM) at R4 (A) for works within the recommended standard hours of construction.

- Predicted noise levels exceed the existing background noise level to a larger extent during the evening and night time period (when compared to the daytime) as the existing background noise levels are lower during those periods.
- For works within the recommended standard hours for construction, letterbox drops and noise monitoring will be required at the most affected locations during select construction activities associated with SYAB works.
- For works outside the recommended standard hours for construction, letterbox drops, noise monitoring and a range of other additional mitigation measures from the AMMM will be required at the most affected locations during select construction activities associated with SYAB works.

Discussion: The predicted noise levels identified above are typical of construction works and activities undertaken in the vicinity of and in close proximity to residential, commercial and other sensitive land use precincts.

Although a number of exceedances are identified, these are associated with predicted 15 minute noise values calculated via modelling for the purposes of the assessment, in accordance with the ICNG and the CNVS. These values do not represent a constant noise emission that would be experienced by the community on a daily basis throughout the SYAB schedule. The predicted noise levels will only be experienced for limited periods of time when works are occurring; they will not be experienced over whole daytime, evening or night time periods. Any impacts associated with these works will be temporary and do not represent a permanent impact on the community and surrounding environment.

Some noise from construction sites is inevitable, such that the ICNG focuses on minimising construction noise impacts, rather than only on achieving numeric noise levels. These results and noted exceedances identify that best-practice construction noise management and control techniques will be required to reduce noise levels as far as practicable. To minimise impacts additional noise control, mitigation and management measures may also be warranted. These will need to be implemented in conjunction with community and stakeholder consultation and notification processes.

As per **CoA – E37, E38, E41 and E42** LOR must consult with all receptors likely to experience internal noise levels greater than $L_{eq\ 15\ minute}$ 60 dBA, regenerated (ground-borne) noise or a perceptible level of vibration, with the objective of determining appropriate hours of respite. These receptors must be offered additional mitigation in accordance with AMMM outlined in **Table 4.6**, **Table 4.7** and **Table 4.8**. In accordance with **CoA – E37** these works should be scheduled to occur between 7am and 8pm. **CoA - E38** requires that noise levels be less than $L_{eq\ 15\ minute}$ 60 dBA for at least 6.5 hours between 7am and 8pm, of which at least 3.25 hours must be below $L_{eq\ 15\ minute}$ 55 dBA, noise equal to or above $L_{eq\ 15\ minutes}$ 60 dBA is allowed for the remaining 6.5 hours between 7am and 8pm.

Sydney Metro have developed their own best-practice techniques for managing construction noise and vibration, and implementing feasible and reasonable mitigation measures. The mitigation and management measures provided by Sydney Metro and documented in Section 7 of the CNVS are consistent with the intent and recommendations of the ICNG for managing construction noise, and implementing feasible and reasonable mitigation measures. These management measures are outlined for the SYAB in Section 6 of the CNVMP.

Works outside the Recommended Standard Hours

Based on the noise levels predicted to exceed criteria identified in **Table 5.1 to Table 5.10** it is also considered likely that the sleep disturbance screening criteria will be exceeded at the nearest and most sensitive residential receptor **R4 (A)** during OOHW.

With due regard to the AMMM, the extent of additional mitigation required will increase for out-of-hours work (refer **Table 5.1 to Table 5.10**) compared to that assessed for works within the standard hours. More mitigation is necessary in accordance with the CNVS for works undertaken outside the recommended standard hours for construction.

This feature is a well-accepted element of good industry practice construction noise management; high noise generating activities should be avoided in the evening, at night and on the weekends as receptors are generally more sensitive during those periods.

In accordance with the requirements of the ICNG and the CNVS suitable recommendations, which can be practically implemented on site, are provided in the CNVMP. Construction noise levels will be reduced and impacts minimised with the successful implementation of these recommendations. Impacts may not be reduced to negligible levels for all receptors during all construction activities; however the recommendations are designed to ensure that any residual impacts are minimised as far as is practically achievable.

Construction Road Traffic

Construction road traffic (noise and vibration) impacts from SYAB works are not anticipated (i.e. from additional vehicles on the public road network). It is assumed that the noise generated from heavy vehicles due to the size of the construction works and type of works will have minimal impact to developments along their routes. The project will not generate a significant increase in vehicles when compared to that of the existing vehicle flows and mixes on the surrounding road network.

Ground-borne Construction Noise

Ground-borne construction noise impacts from SYAB works are not anticipated as vibration generating source/s with the potential to generate perceptible ground-borne noise, does not form part of the overall construction design. Ground-borne construction noise is usually present on tunnelling projects when significant tunnel boring equipment is operated underground.

b. POTENTIAL VIBRATION IMPACTS

To assess potential vibration impacts a combined approach of research and predictive methods was adopted.

The research involved two parts, the first being to identify measured vibration levels (based on data presented in publically available reports) for similar activities required on SYAB; and the second making reference to the applicable safe work distances published in the TfNSW CNS. The most useful and accessible report utilised for this research aspect was the *WestConnex Enabling Works (Airport East) - Construction Noise and Vibration Impact Statement*, prepared for Roads and Maritime Services (RMS) by Wilkinson Murray, Version B - dated November 2014 (WM 2014). This document presented results from vibration monitoring trials of various plant operating, as previously undertaken by Wilkinson Murray (refer Table 8-1 of the WM 2014 report).

The predictive method adopted the Table E.1 empirical predictors for ground-borne vibration arising from mechanized construction works as presented in British Standard – BS5228-2:2009+A1:2014 (BS5228) – *Code of Practice for Noise and Vibration Control on Construction and Open Sites* – Part 2: Vibration.

BS 5228 presents methods to estimate vibration due to vibratory compaction, such as that of the SYAB vibratory roller usage. A conservative method has been applied based on the specified calculative inputs and distance offsets to estimate potential vibratory roller levels, PPV in mm/s.

For the SYAB demolition activity (requiring an excavator fitted with hydraulic hammer) BS 5228 does not present a specific calculative method however a method is provided for percussive piling. This percussive piling (piles at refusal) calculative method was adopted to estimate levels and is considered a reasonable approach as the vibration generating is broadly similar and enables demolition levels to be approximated in the absence of a specific calculative method. A conservative method has again been applied based on the specified calculative inputs and distance offsets to estimate potential demolition levels, PPV in mm/s.

A comparison of the BS 5228 predicted values e.g. at 5 metres and 10 metres, aligned closely with the measured values presented in the WM 2014 report for Large Vibratory Roller (20t) and Heavy Hydraulic Hammer (1500kg hammer on 30t excavator).

Vibration Dose Values (VDV in m/s^2) have then been estimated for a conceptual scenario based on a typical range of vibration levels and component frequencies. A total duration of four hours of vibration intensive works was adopted with varying levels of vibration being received during that time.

All calculative inputs are summarised in **Figure 5.1**, **Figure 5.2**, **Equation 5.1** and **Table 5.11**.

In all cases the comparison of predicted values to criteria is focused on the closest and/or potentially most affected vibration receptors being **R4 (A) – Former Co-Masonic Temple** (cosmetic/structural damage and human annoyance) situated north and directly adjacent to the site at a distance of ≥3 metres and the **Mortuary Station**, (cosmetic/structural damage only, heritage structure) again situated north of the site but at a distance of approximately 65 metres.

All predicted values are estimates only and may vary depending on geotechnical features and intervening structures, amongst other things. In ERM's experience these predicted values are typically conservative but offer a useful guide for the purpose of assessing impacts, evaluating mitigation and management measures and defining monitoring requirements.

Operation	Prediction question	Scaling factors (and probability of predicted value being exceeded)	Parameter range
Vibratory compaction (steady state)	$v_{res} = k_s\sqrt{n_d}\left[\frac{A}{x+L_d}\right]^{1.5}$	$k_s = 75$ (50%) $k_s = 143$ (33.3%) $k_s = 276$ (5%)	$1 \leqslant n_d \leqslant 2$ $0.4 \leqslant A \leqslant 1.72$ mm $2 \leqslant x \leqslant 110$ m

Figure 5.1 – Vibratory Compaction Method

Operation	Prediction question	Scaling factors (and probability of predicted value being exceeded)	Parameter range
Percussive piling	$v_{res} \leqslant k_p\left[\frac{\sqrt{W}}{r^{1.3}}\right]$	For piles at refusal: $k_p = 5$ For piles not at refusal: $1 \leqslant k_p \leqslant 3$, depending on soil type (Table E.2)	$1 \leqslant L \leqslant 27$ m $1 \leqslant x \leqslant 111$ m (where $r^2 = L^2 + x^2$) $1.5 \leqslant W \leqslant 85$ kJ

Figure 5.2 – Demolition Method (Adapted From Percussive Piling)

To calculate VDV the following formula (refer Section 2.4.1 of the guideline) is used.

Equation 5.1 – Vibration Dose Values (VDV) Estimate

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, a (t) is the frequency-weighted RMS of acceleration in m/s^2 and T is the total period of the day (in seconds) during which vibration may occur.

Table 5.11 – Calculative Inputs

Activity	Type	Parameter	Input
Vibratory Roller	PPV	mm/s	Scaling factor, ks = 143, Number of Drums, nd = 1, Amplitude of Drum, A = 1.1 and Drum Width, Ld of 2.
Demolition			Piles at Refusal Factor, kp = 5, Energy, W = 85
Vibratory Roller	VDV	$m/s^{1.75}$	10 minutes at 14 mm/s, 20 minutes at 8.4 mm/s, 30 minutes at 3 mm/s and three hours at 0.5 mm/s. All events at 20 Hz.
Demolition			10 minutes at 11.1 mm/s, 20 minutes at 5.7 mm/s, 30 minutes at 1.5 mm/s and three hours at 0.5 mm/s. All events at 40 Hz.

Source: BS 5228, NSW Vibration Guideline

Resultant Levels

The resultant vibration levels are presented below, as follows:

- The research based values from the WM 2014 report are presented in **Table 5.12** with values highlighted via a heat-map (red for high values and blue for low values).
- Predicted PPV values for vibratory roller and demolition presented in **Table 5.13** and **Table 5.14**.
- Predicted VDV values for vibratory roller and demolition presented in **Table 5.15** and **Table 5.16**.
- The applicable safe work distance offset assessment based on the values from the TfNSW CNS is provided in **Table 6.17**.

Table 5.12 – Measured Vibration Levels at Distance (WM 2014)

	PPV Vibration Level (mm/s) at Distance					
Source	5m	10m	20m	30m	40m	50m
Large Vibratory Roller (20t)	7.00	4.50	3.00	2.30	2.00	1.70
Medium Vibratory Roller (10t)	-	3.60	2.00	1.50	1.00	-
Compactor (7t)	-	6.00	2.50	0.30	-	-
Heavy Hydraulic Hammer (1500kg hammer on 30t excavator)	4.50	2.50	0.50	0.20	0.12	<0.1
Light Hydraulic Hammer (300kg on 5t Excavator)	0.20	0.10	<0.1	-	-	-
Air Track Drill	4.50	1.50	0.60	-	0.10	<0.1
Small Rock drill (estimate)	-	0.50	0.20	0.10	<0.1	-
Down the Hole Hammer	0.90	0.20	<0.1	-	-	-
Ripping (measured in Sydney sandstone)	0.70	0.15	0.03	-	-	-
Impact Piling	11.00	3.50	1.00	0.50	0.20	<0.1
Vibratory Piling	10.00	5.00	-	0.50	0.20	-
Rock Sawing	1.20	0.50	0.30	-	-	-
Bored Piling	-	0.20	<0.1	-	-	-

Discussion: As is evident in the data presented in **Table 5.12** above vibration levels are below 15 mm/s at distances ≥ 5 metres. This data also identifies that vibration dissipates rapidly with distance. Based on the distance offset to **R4 (A) – Former Co-Masonic Temple** cosmetic/structural damage impacts for vibratory roller and demolition works are unlikely and highly unlikely at **Mortuary Station**. Impacts to the broader community are not anticipated, only the closest receptors may be affected.

Table 5.13 – Predicted PPV (mm/s) Vibration Levels (Vibratory Roller)

Distance, m	Predicted PPV, mm/s
1.0	30.0
2.0	19.5
3.0	14.0
4.0	10.6
5.0	8.4
6.0	6.9
7.0	5.8
8.0	4.9
9.0	4.3
10.0	3.8
11.0	3.3
12.0	3.0
13.0	2.7
14.0	2.4
15.0	2.2
16.0	2.0
17.0	1.9
18.0	1.7
19.0	1.6
20.0	1.5
21.0	1.4
22.0	1.3
23.0	1.2
24.0	1.2
25.0	1.1
50.0	0.4
75.0	0.2
100.0	0.2
200.0	0.1

Source: BS 5228

Discussion: Predicted values comply with the most stringent BS 7385 criteria (15 mm/s) at distances of 3 metres and beyond. Predicted values comply with the most stringent heritage structure criteria (2.5 to 3 mm/s) at distances of 14 metres and beyond. Based on this compliant levels of vibration are anticipated at the **R4 (A) – Former Co-Masonic Temple** and the **Mortuary Station** and cosmetic or structural damage impacts are unlikely to occur.

Table 5.14 – Predicted PPV (mm/s) Vibration Levels (Demolition)

Distance, m	Predicted PPV, mm/s
1.0	46.1
2.0	18.7
3.0	11.1
4.0	7.6
5.0	5.7
6.0	4.5
7.0	3.7
8.0	3.1
9.0	2.6
10.0	2.3
11.0	2.0
12.0	1.8
13.0	1.6
14.0	1.5
15.0	1.4
16.0	1.3
17.0	1.2
18.0	1.1
19.0	1.0
20.0	0.9
21.0	0.9
22.0	0.8
23.0	0.8
24.0	0.7
25.0	0.7
50.0	0.3
75.0	0.2
100.0	0.1
200.0	0.0

Source: BS 5228

Discussion: Predicted values comply with the most stringent BS 7385 criteria (15 mm/s) at distances of 3 metres and beyond. Predicted values comply with the most stringent heritage structure criteria (2.5 to 3 mm/s) at distances of 9 metres and beyond. Based on this compliant levels of vibration are anticipated at the **R4 (A) – Former Co-Masonic Temple** and the **Mortuary Station** and cosmetic or structural damage impacts are unlikely to occur.

Table 5.15 – Predicted VDV (m/s^2) Vibration Levels (Vibratory Roller)

Distance, m	Receptor	Predicted VDV, $mm/s^{1.75}$	Adverse Comment Probable ($m/s^{1.75}$)
3	R4 (A)	1.71	≤ 1.6

Source: NSW Vibration Guideline

Table 5.16 – Predicted VDV (m/s^2) Vibration Levels (Demolition)

Distance, m	Receptor	Predicted VDV, $mm/s^{1.75}$	Adverse Comment Probable ($m/s^{1.75}$)
3	R4 (A)	2.54	≤ 1.6

Source: NSW Vibration Guideline

Discussion: Predicted values exceed the VDV criteria defined in the CNVS for “Adverse Comment Probable” at distances of 3 metres i.e. at the **R4 (A) – Former Co-Masonic Temple**. The levels by which the predicted values exceed criteria for vibratory roller works are marginal (0.1) but greater for demolition works. This increased margin is associated with the component frequency adopted for the assessment of these works, which recognises that higher frequency vibration events are typically more annoying. As is evident in the data presented in **Table 5.13** and **Table 5.14** vibration dissipates rapidly with distance (e.g. between 5 and 10 metres vibration reduces by 3 to 5 mm/s) so impacts to the broader community are not anticipated, only the closest receptors will be affected.

Table 5.17 – Safe Work Distance Offset Vibration Assessment

Scenario ID	Work Phase Description	Vibration Generating Equipment / Plant Utilised	Applicable Safe work distance (Cosmetic)	Applicable Safe work distance (Human Comfort)	Vibration Assessment (nearest) distance (m)	Vibration Assessment (furthest) distance (m)	Works Required within applicable Safe work distances (Cosmetic)	Works Required within applicable Safe work distances (Human Comfort)	Potential OOHW Required?
SCN01	Demolition of Terrace Buildings	35t Excavator - Hydraulic hammer	22	73	3	30	Y (partial)	Y	N
SCN03	Removal of part of Up Shunting Neck	10t Roller	15	100	13	34	Y (partial)	Y	Y
SCN04	Piling of Bridge Abutments and Piers	Piling Rig	2	n/a	19	100	N	n/a	Y
SCN08	Construction of Reinforced Earth Wall	10t Roller	15	100	14	100	Y (partial)	Y	N
SCN10	Regent St Services	2.5t Roller	6	20	3	30	Y (partial)	Y	Y

Note: Partial means that the equipment will operate within the applicable safe work distances for some (but not all) of the works

Discussion: With respect to the construction plant identified in **Table 3.1**, the highest levels of vibration would be expected to occur due to the use of a vibratory roller and an excavator with hydraulic hammer.

The highest risk for vibration impacts based on the CNS safe work distances is associated with SCN01 demolition works. These works will be undertaken between 3 and 30 m from the nearest sensitive receptor utilising two excavators fitted with hydraulic hammers. Complying, with the recommended safe working distances for vibration intensive plant presented **Table 5.17** may not be possible in all cases.

This assessment has utilised the safe work distances for a range of vibration generating construction activities and equipment established with due regard to the CNS. The CNS safe work distances were derived from BS7385 as relevant to cosmetic damage to buildings. BS7385 is a frequency (Hz) dependant criteria (less stringent at higher frequencies) and as such, works and activities may be able to occur at distances closer than those nominated in **Table 5.17** without any cosmetic or structural damage impacts occurring. This is typical of construction and demolition works in close proximity to other buildings and highlights the need to monitor and establish compliant levels during the early stages of vibration significant activities.

Overall Vibration Discussion

Based on the combined approach to assessing potential vibration impacts it can be seen that complying with the recommended safe working distances for vibration intensive plant may not be possible in all cases, however the predicted values comply with the most stringent heritage structure criteria (2.5 to 3 mm/s) at distances of 9 metres for demolition and 14 metres for vibratory roller. Based on this, compliant levels of vibration are anticipated at the **R4 (A) – Former Co-Masonic Temple** and the **Mortuary Station** and cosmetic or structural damage impacts are unlikely to occur.

Regardless, best-practice construction vibration management and control techniques should be implemented to reduce vibration levels as far as practicable. To minimise impacts to human comfort, additional mitigation and management measures may also be warranted. These will need to be implemented in conjunction with community and stakeholder consultation and notification processes outlined in the AMMM for Ground-borne Vibration in **Section 4c**.

For works outside the recommended standard hours for construction, letterbox drops, monitoring and a range of other additional mitigation measures from the AMMM will be required at the most affected locations during select construction activities associated with SYAB works. To avoid misunderstanding monitoring may be required at any time of day and is not limited to works outside the recommended standard hours, refer the recommendations for monitoring in **Section 6**.

6. RECOMMENDATIONS

Based on the findings of the assessment described above it is recommended that:

- The noise and vibration mitigation and management measures presented in the already prepared CNVMP should be considered and implemented where feasible and reasonable. The key features of this already established set of measures includes: implementing community consultation measures, selecting plant and equipment based on the least noise/vibration emission levels where reasonable, planning worksites and activities to minimise noise and vibration, provision of noise barriers around each construction site where reasonable and undertaking noise and vibration monitoring during identified activities.

- Consultation with the closest receptors that are likely to experience internal noise levels of $L_{eq\ 15\ minute}$ 60 dBA in accordance with **CoA – E37** should occur with the objective of determining appropriate hours of respite. These are the following residential receptors R3 (B2), R4 (A) and R15 (B1), and other sensitive receptors: R1 (A), R2 (B1) and R13 (J2).

- Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals noise or vibration monitoring should be conducted at the affected receptor(s) or a nominated representative location (typically the nearest receptor where more than one receptor have been identified).
- Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to inform the relevant personnel when the noise or vibration goal has been exceeded so that additional management measures may be implemented.
- Monitoring for SYAB works should be implemented at the commencement of works and at regular intervals throughout the project (i.e. when new construction activities commence) to quantify the airborne noise, ground-borne noise and vibration levels associated with construction activities. Monitoring would also be required in the event of a complaint being received and should be conducted at the most affected receptor in accordance with Appendix A of the CNVS.
- Attended measurements should be the focus of all noise monitoring however unattended noise (and vibration) monitoring may be undertaken where specific circumstances warrant.
- Attended noise measurements are recommended at the potentially most affected receptor(s) from the commencement of construction activities to confirm that the noise levels in the adjacent community are consistent with the predictions the CNVIS as reproduced in this CNVMP. Other potentially affected receptors should also be considered as part of the monitoring regime depending on the phase of works. At this stage noise monitoring should be targeted to SCN01 with monitoring of other work phases and activities being considered on a case by case basis, as detailed in the CNVMP
- Vibration monitoring is recommended at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria, further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms should be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the calculated safe-working distances. At this stage vibration monitoring should be targeted to SCN01 with monitoring of other work phases and activities being considered on a case by case basis, as detailed in the CNVMP
- Where OOHW is approved and monitoring is determined to be required, attended noise measurements will be conducted at the most affected receptors following the general and community monitoring requirements specified in the CNVMP. Further guidance is provided in the OOHW Protocol included in the CNVMP. Sleep disturbance screening criteria should be assessed at the nearest and most sensitive residential receptor R4 (A) where noise monitoring is required during OOHW.
- All demolition works associated with SCN01 should be limited to the approved hours for construction, being:
  - 7.00 am to 6.00 pm Monday to Friday;
  - 8.00 am to 1.00 pm on Saturdays; and
  - No work on Sundays or Public Holidays.

Construction noise and vibration levels will be reduced and impacts minimised with the successful implementation of the recommendations provided above and in the SYAB CNVMP. Impacts may not be reduced to negligible levels for all receptors during all activities; however the recommendations presented here will ensure that any residual impacts are minimised as far as is practically achievable.

7. CONTACTS

ERM trusts that this assessment meets LOR requirements. Should you have any questions or queries regarding the findings presented in this document please do not hesitate to contact Nathan Lynch on (02) 8584 8888 or via email at nathan.lynch@erm.com.

For Environmental Resources Management Australia Pty Ltd

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REFERENCES

British Standard – BS5228-2:2009+A1:2014 (BS5228) – **Code of Practice for Noise and Vibration Control on Construction and Open Sites** – Part 2: Vibration;

British Standard (BS 6472–1992) – **Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)** dated 1992;

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TfNSW - Sydney Metro - **Chatswood to Sydenham Environmental Impact Statement (EIS) – Chapter 10: Construction Noise and Vibration**, dated May 2016;

TfNSW - Sydney Metro - **Chatswood to Sydenham Environmental Impact Statement (EIS) – Technical Paper 2 Noise and Vibration**, Prepared by SLR, dated April 2016; and

WestConnex Enabling Works (Airport East) - Construction Noise and Vibration Impact Statement, prepared for Roads and Maritime Services (RMS) by Wilkinson Murray, Version B - dated November 2014 (WM 2014).

Annex A

Sound Power Levels and Noise Modelling Data

ID	Work Phase	Plant Utilised	Individual Lw for equipment type											Area Source - Work Phase Data for Model										
			31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	Total, dB(A)	Emission Height	31.5Hz	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	LW Total, dB(A)	Emission Height
SCN01	Demolition of Terrace Buildings	35t Excavator x 2 (80%)	84.4	103.1	111.3	111.9	122.8	117.7	113.9	109.1	102.6	125	2.0	84.4	103.2	111.4	112.1	122.9	117.8	114.1	109.1	102.7	125	2.0
		Bogie x 4 (20%)	61.7	87.1	91.4	97.8	101.1	98.4	100.4	89.4	82.6	106	2.0											
		Bobcat (40%)	47.7	69.9	79.0	85.5	95.9	96.1	91.3	83.1	81.0	100	2.0											
SCN02	Site Investigation and setup	Vac Truck (80%)	68.8	85.3	86.0	86.4	91.6	105.2	95.2	89.6	80.6	106	2.0	70.9	86.7	90.8	93.6	99.5	106.0	98.4	100.7	90.5	109	2.0
		Cranes (80%)	66.4	77.5	87.1	89.3	97.0	97.0	92.9	100.3	89.9	104	2.0											
		6t Excavator (80%)	51.5	72.2	80.9	83.5	88.8	89.8	85.1	79.8	72.6	94	2.0											
		Road sweeper (10%)	52.7	78.1	82.4	88.8	92.1	89.4	91.4	80.4	73.6	97	2.0											
SCN03	Removal of part of Up Shunting Neck	Loader (40%)	54.7	76.9	86.0	92.5	102.9	103.1	98.3	90.1	88.0	107	2.0	65.8	86.8	102.4	104.5	107.4	108.7	106.7	97.8	92.4	114	1.8
		8t Excavator + tamping head (40%)	53.5	74.2	82.9	85.5	90.8	91.8	87.1	81.8	74.6	96	2.0											
		10t Roller (20%)	56.4	74.6	89.7	100.2	100.6	101.8	100.0	91.8	85.7	107	2.0											
		Bogie x 2 (20%)	58.7	84.1	88.4	94.8	98.1	95.4	97.4	86.4	79.6	103	2.0											
		Semitrailer (10%)	52.7	78.1	82.4	88.8	92.1	89.4	91.4	80.4	73.6	97	2.0											
		Railsaw (20%)	62.9	77.6	101.7	100.7	101.7	105.2	103.5	94.4	87.8	110	1.0											
SCN04	Piling of Bridge Abutments & Piers	**Piling Rig (70%)**	**64.0**	**78.7**	**100.5**	**101.8**	**102.9**	**106.5**	**104.9**	**95.8**	**89.0**	**111**	0.0	66.7	85.0	93.3	98.5	105.5	106.1	102.5	97.1	90.3	110	1.9
		8t Excavator (20%)	50.5	71.2	79.9	82.5	87.8	88.8	84.1	78.8	71.6	93	2.0											
		Bogie Tipper (10%)	52.7	78.1	82.4	88.8	92.1	89.4	91.4	80.4	73.6	97	2.0											
		Concrete Pump (20%)	61.5	77.5	85.7	87.2	94.0	99.4	94.6	87.9	81.4	102	1.5											
		Concrete Agi (20%)	64.5	80.5	88.7	90.2	97.0	102.4	97.6	90.9	84.4	105	2.0											
		50t All Terrain (10%)	37.8	62.8	87.8	95.8	103.9	100.8	97.8	94.8	87.8	107	2.0											
		Semitrailer (10%)	52.7	78.1	82.4	88.8	92.1	89.4	91.4	80.4	73.6	97	2.0											
SCN05	Abutments and Piers - Precast	**Tower Crane (Favco) (80%)**	**72.4**	**83.5**	**93.1**	**95.3**	**103.0**	**103.0**	**98.9**	**106.3**	**95.9**	**110**	2.0											
		Cherry Picker x 2 (80%)	**67.9**	**90.1**	**94.4**	**90.4**	**95.7**	**94.2**	**95.2**	**90.8**	**81.6**	**102**	2.0											
SCN06	Abutments and Piers – Cast in Situ	**Concrete Pump (80%)**	**68.5**	**84.5**	**92.7**	**94.2**	**101.0**	**106.4**	**101.6**	**94.9**	**88.4**	**109**	1.5											
		Concrete Agi (80%)	**81.1**	**89.1**	**97.2**	**99.6**	**104.9**	**107.6**	**106.1**	**100.3**	**95.0**	**112**	2.0											
SCN07	Deck Spans	**Tower Crane (Favco) (80%)**	72.4	83.5	93.1	95.3	103.0	103.0	98.9	106.3	95.9	**110**	2.0	74.9	93.9	102.1	104.1	106.2	107.3	106.8	100.0	92.1	113	1.8
		Cherry Picker x 2 (80%)	69.9	92.1	96.4	92.4	97.7	96.2	97.2	92.8	83.6	104	2.0											
		Jinkers x 3 (10%)	57.7	83.1	87.4	93.8	97.1	94.4	96.4	85.4	78.6	102	2.0											
		Rattlegun etc (40%)	73.1	87.9	100.6	103.3	104.8	106.7	105.8	98.9	91.2	112	1.5											
SCN08	RE Wall	10t Roller (50%)	60.4	78.6	93.7	104.2	104.6	105.8	104.0	95.8	89.7	111	2.0	65.3	88.2	96.2	105.2	106.7	106.8	105.7	97.0	90.7	112	2.0
		City crane (20%)	57.4	76.1	84.3	84.9	95.8	90.7	86.9	82.1	75.6	98	2.0											
		8t Excavator (40%)	53.5	74.2	82.9	85.5	90.8	91.8	87.1	81.8	74.6	96	2.0											
		Bogie x 2 (40%)	61.7	87.1	91.4	97.8	101.1	98.4	100.4	89.4	82.6	106	2.0											
SCN09	Deck	**Concrete Pump (70%)**	**68.5**	**84.5**	**92.7**	**94.2**	**101.0**	**106.4**	**101.6**	**94.9**	**88.4**	**109**	1.5											
		Concrete Agi (30%)	**81.1**	**89.1**	**97.2**	**99.6**	**104.9**	**107.6**	**106.1**	**100.3**	**95.0**	**112**	2.0											
SCN10	Regent St Services	5t Excavator (40%)	48.5	69.2	77.9	80.5	85.8	86.8	82.1	76.8	69.6	91	2.0	71.8	83.4	102.0	102.1	103.5	106.4	104.9	96.4	90.2	111	1.8
		Roadsaw (20%)	62.9	77.6	101.7	100.7	101.7	105.2	103.5	94.4	87.8	110	1.0											
		Bogie (10%)	52.7	78.1	82.4	88.8	92.1	89.4	91.4	80.4	73.6	97	2.0											
		2.5t Roller (20%)	50.4	68.6	83.7	94.2	94.6	95.8	94.0	85.8	79.7	101	2.0											
		Concrete Agi (10%)	71.1	79.1	87.2	89.6	94.9	97.6	96.1	90.3	85.0	102	2.0											

Note: Equipment highlighted in bold text has been incorportated into the model as a point source and is therefore excluded from the total Lw of area sources.

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