

Sydney Metro City and Southwest – Sydney Yard Access Bridge Construction Noise and Vibration Management Plan (CNVMP)

Document

Title	Construction Noise and Vibration Management Plan (CNVMP)
Client	Sydney Metro City and Southwest
Document Reference No.	SYAB-LOR-CNVMP_FINAL_V0.7.docx
Laing O'Rourke Contract No.	K26

Author

CNVMP Author Details	Qualifications and Experience
<p>Steven De Luzuriaga ERM Level 15, 309 Kent Street Sydney NSW 2000 T: +61 2 8584 8888 (switchboard) E: steven.deluzuriaga@erm.com W: www.erm.com</p>	<p>Graduate Certificate of Architectural Science (Audio and Acoustics), University of Sydney. Bachelor of Environmental Science, Southern Cross University, Lismore Member Australian Acoustical Society (MAAS).</p> <p>Steven has four years of professional experience specialising in noise and vibration environmental impact assessment, assessment and management.</p>
<p>Nathan Lynch ERM Level 15, 309 Kent Street Sydney NSW 2000 T: +61 2 8584 8888 (switchboard) E: nathan.lynch@erm.com W: www.erm.com</p>	<p>Master of Design Science. (Audio & Acoustics) University of Sydney, Australia, 2007. Member Australian Acoustical Society (MAAS).</p> <p>Nathan has over nine years of professional experience specialising in noise, overpressure and vibration environmental impact assessment, assessment and management.</p>

Revisions

Date	Version	Description	Prepared by	Approved by	Signature
Various	0.0 to 5	Drafts for review	ERM	LOR	
09/06/17	6	Approved by DPE	C McCallum	Huw Griffith	
05/07/17	7	Update for publishing	C McCallum	Huw Griffith	
01/03/18	8	Periodic Review	C McCallum	Huw Griffith	

Management reviews

Review date	Details	Reviewed by
01/03/18	Periodic review	Chris McCallum

Controlled:

YES

Copy no.:

Uncontrolled:

NO

Sydney Metro City and Southwest – Sydney Yard Access Bridge
Construction Noise and Vibration Management Plan (CNVMP)

CNVMP

Terms and definitions

The following general terms, abbreviations and definitions are used in this plan.

Terms	Explanation
A1055	Standards Australia AS1055–1997™ – Description and Measurement of Environmental Noise
AMM	Additional Mitigation Measures
AMMM	Additional Mitigation Measures Matrix
AS2436	Standards Australia AS 2436–2010™ – Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites.
AS61672 or AS1259	Standards Australia AS IEC 61672.1–2004™ – Electro Acoustics - Sound Level Meters Specifications Monitoring or Standards Australia AS1259.2-1990™ – Acoustics – Sound Level Meters – Integrating/Averaging as appropriate to the device.
BS 6472	British Standard (BS 6472–1992) – Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz) dated 1992;
BS 7385	British Standard BS7385: Part 2-1993 - Evaluation and Measurement for Vibration in Buildings — Part 2 – Guide to Damage Levels from Ground-borne Vibration, dated 1993.
CBD	Sydney Central Business District
CNVS	Construction Noise and Vibration Strategy
CNS	NSW Government – Transport for NSW (TfNSW) Construction Noise Strategy (CNS), April 2013.
CNVIS	Construction Noise and Vibration Impact Statement
CNVMP	Construction Noise and Vibration Management Plan
CoA	Conditions of Approval
DIN4150:3	German Institute for Standardisation – DIN 4150 (1999-02) Part 3 – Structural Vibration - Effects of Vibration on Structures.
CSSI	Critical State Significant Infrastructure
DPE	Department of Planning and Environment
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	NSW Environment Protection Authority
ER	Environmental Representative
ERAP	Environmental Risk Action Plan
ERM	Environmental Resources Management Australia Pty Ltd
HNAML	Highly Noise Affected Management Level
ICNG	NSW Department of Environment and Climate Change – NSW Interim Construction Noise Guideline, July 2009.
IEC60942	Standards Australia AS/IEC 60942:2004/IEC 60942:2003 – Australian Standard™ – Electroacoustic – Sound Calibrators.
INP	NSW Environment Protection Authority – NSW Environmental Noise Management – Industrial Noise Policy, January 2000 and relevant application notes.
Laing O’Rourke	Laing O’Rourke Australia Construction Pty Limited
LGA	Local Government Area

Terms	Explanation
LOR	Laing O'Rourke Australia Construction Pty Limited
Minister, the	NSW Minister for Planning
NCA	Noise Catchment Area
NML	Noise Management Level
NSW Vibration Guideline, the	NSW Department of Environment and Conservation – NSW Environmental Noise Management – Assessing Vibration: a Technical Guideline (the NSW Vibration Guideline), February 2006.
NVIA	Noise and Vibration Impact Assessment
OEH	Office of Environment and Heritage
OOHW	Out of Hours Works
PEM	Project Environment Manager
POEO Act	Protection of the Environment Operations Act 1997
RNP	NSW Department of Environment, Climate Change and Water – NSW Road Noise Policy, March 2011.
SSI	State Significant Infrastructure
TfNSW	Transport for New South Wales
the Project	Sydney Yard Access Bridge Construction Project

The following technical terms, abbreviations and definitions are used in this plan. A glossary of relevant acoustical concepts and terminology is provided in *Appendix A*.

Terms	Explanation
Decibel, dB	The unit used to describe sound levels and noise exposure. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure
dBA	The unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear
LAeq	Equivalent Continuous Sound Level
LAeq, 15minute	Equivalent Continuous Sound Level, over a period of 15 minutes
LA90	Background Noise Level
RBL	Rating Background Level
LW or SWL	Sound Power Level
LP or SPL	Sound Pressure Level
PPV	Peak Particle Velocity (in mm/s)
VDV	Vibration Dose Value (in $m/s^{1.75}$)
mm/s	Millimetres per second
m/s	Metres per second

Contents

1. Introduction	7
1.1 Purpose and Application.....	7
1.2 Background and Scope	7
1.2.1 Sydney Yard Access Bridge Project Overview	9
1.2.2 Project scope of works	9
1.2.3 Environmental Planning Approval	10
1.2.4 Project-Specific Environmental Management System	11
1.3 Objectives and Targets.....	11
1.4 Consultation	11
2. Legal and Other Requirements	11
2.1 Legislation	11
2.2 Policy and Guidelines	12
2.3 Structure of this Plan.....	12
3. Existing Environment and Noise/Vibration Guidelines.....	14
3.1 Existing Environment	14
3.2 Background Noise Levels.....	14
3.3 Noise and Vibration Guidelines	17
3.3.1 Residential Receptors (Noise)	17
3.3.2 Non-Residential Receptors (Noise)	18
4. Work Hours and Management Levels	20
4.1 Hours of Work.....	20
4.1.1 Works Outside of the Approved Standard Hours	20
4.1.2 Emergency Construction.....	21
4.2 Noise Management Levels.....	21
4.2.1 General Construction Noise.....	21
4.2.2 Construction Road Traffic Noise.....	23
4.3 Vibration Management Levels.....	23
4.3.1 Human Comfort (or Annoyance).....	23
4.3.2 Building Damage (Structural/Cosmetic Damage)	25
5. Aspects, Impacts & Risks	28
5.1 Construction Methodology.....	28
5.2 Predicted Construction Impacts	30
5.2.1 Potential Noise Impacts	30
5.2.2 Potential Vibration Impacts	33
6. Mitigation and Management Measures	36
6.1 Standard Mitigation Measures.....	36
6.1.1 Construction Observed to Exceed Management Levels.....	47
6.1.2 Ground Vibration – Safe Working Distances.....	47
6.1.3 Managing Potential Impacts to Heritage Structures	48
6.2 Additional Mitigation Measures	49
7. Training	52

8. Noise and Vibration Monitoring Program	53
8.1 Baseline data	53
8.2 General Monitoring Requirements	54
8.2.1 Noise Measurement Requirements	54
8.2.2 Vibration Measurement Requirements	54
8.2.3 Noise Monitoring in the Community	55
8.2.4 Vibration Monitoring in the Community	56
8.2.5 Actions Following Monitoring in the Community	59
8.2.6 Maximum Noise Levels for Plant and Equipment	59
8.2.7 Noise and Vibration Reporting	60
9. Enquiries, Complaints and Incident Management	61
10. CNVMP Administration	61
10.1 Pre-construction Compliance Requirements and Hold Points	61
10.2 Roles and Responsibilities	62
10.3 CNVMP Review	65
11. References	66
Appendix A – Acoustics: Glossary of Terms and Definitions	67
Appendix B – Sydney Metro Out of Hours Works Application Form	72
Appendix C – Compliance Matrix	73
Appendix D – Consultation	74

1. Introduction

1.1 Purpose and Application

The Sydney Yard Access Bridge (SYAB) Construction Noise and Vibration Management Plan (CNVMP or this Plan) describes how Laing O'Rourke Australia Construction Pty Ltd (LOR) and its sub-contractors will ensure all risks associated with noise and vibration issues are considered and managed effectively during the construction stage of the SYAB, as part of the Sydney Metro City and Southwest project.

This plan has been developed to address the following:

- Critical State Significant Infrastructure Conditions of Approval (SSI 15_7400);
- Sydney Metro Construction Environmental Management Framework;
- Sydney Metro Construction Noise and Vibration Strategy;
- SYAB Construction Noise and Vibration Impacts Statement (CNVIS); and
- All applicable guidelines and standards specific to noise and vibration management during construction.

A summary table demonstrating CNVMP compliance against the requirements of the relevant Project Approval for the works is attached in Appendix C. The CNVMP is supported by, and forms a sub-plan to, the SYAB Construction Environmental Management Plan (CEMP).

1.2 Background and Scope

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 CNVMP and the mitigation and management of potential impacts during SYAB works.

This plan addresses these potential issues and applies directly to the SYAB construction phase of the Sydney Metro City and Southwest project (hereafter referred to as the Project). This plan applies to all activities, tasks, products and services on the site over which it has control or influence.

The overall LOR CEMP has been developed for the construction phase of the Project, in compliance with the Client's requirements and LOR environmental management system. As a sub-plan this CNVMP has been developed to specifically address potential noise and vibration impacts. Blasting (a feature of the broader Sydney Metro City and Southwest project) is not required for the Project and is therefore not addressed in this CNVMP.

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

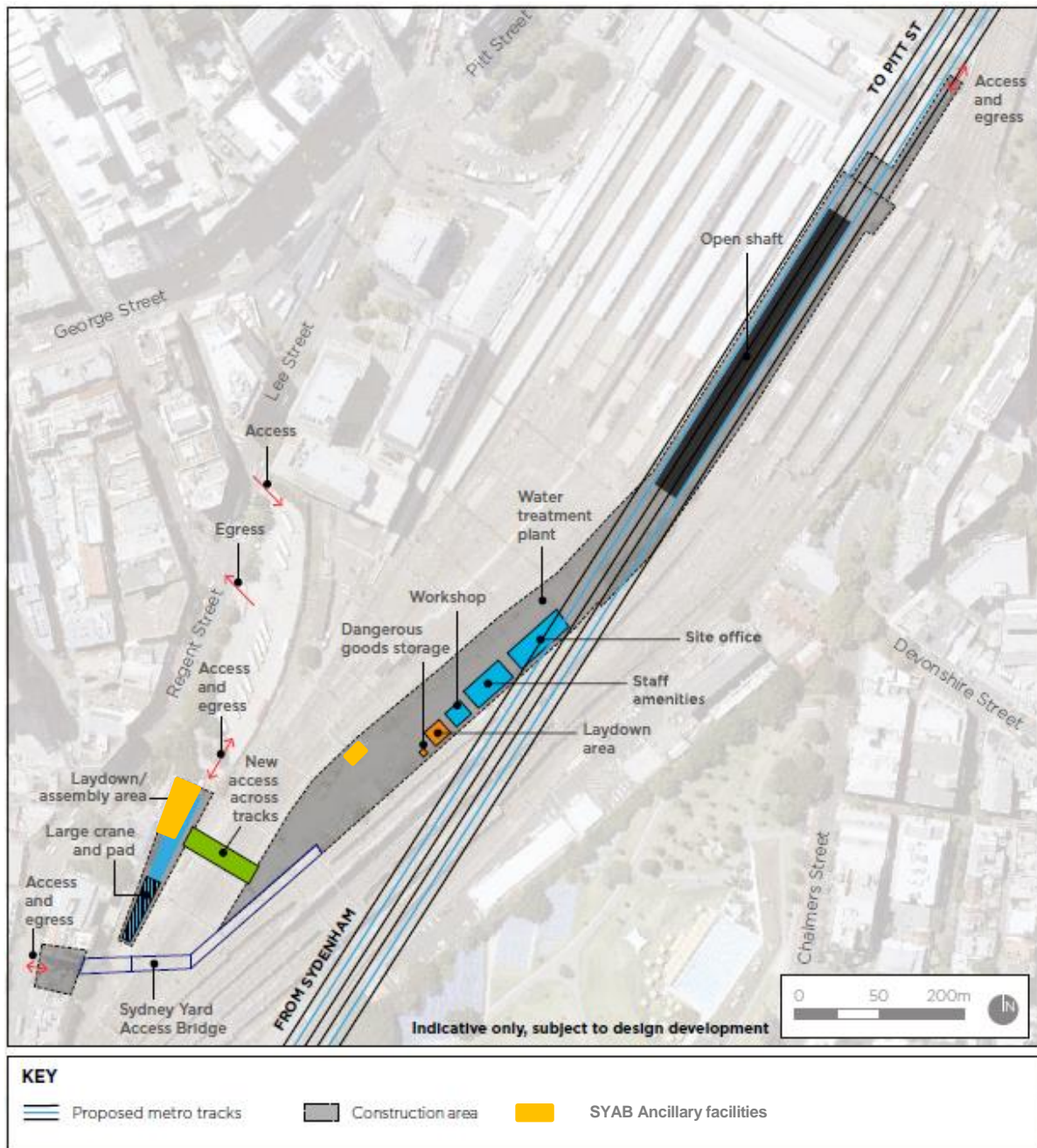


Figure 1: Sydney Yard Access Bridge and Central Station construction sites (TNSW Sydney Metro C2S EIS 2016)

1.2.1 Sydney Yard Access Bridge Project Overview

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 & Southwest.

A core component of the proposed Sydney Metro City & Southwest project includes the Chatswood to Sydenham project. This would involve construction and operation of an underground rail line, about 15.5 kilometres long, and new stations between Chatswood and Sydenham.

The SYAB 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.

The users of the SYAB will include:

- the contractors responsible for the construction of the Sydney Metro City & Southwest works at Central Station;
- the contractors responsible for other construction activities at Central Station;
- the operator and maintainer of Sydney Metro; and
- Sydney Trains and NSW Trains for the purpose of maintenance activities and periodic major projects in and around Sydney Yard.

SYAB will be owned by Transport for New South Wales (TfNSW) and, following completion of the Sydney Metro City & Southwest construction works, will be operated and maintained by Sydney Trains or the Sydney Metro operator and will provide an improved access which is grade separated into the Sydney Yard for Sydney Trains and Sydney Metro operations by:

- avoiding track crossings, usually restricted to Sydney Trains possessions, for the majority of vehicles and loads that need access to the Sydney Yard;
- providing a service access point for vehicles to Central Station away from the public entrances;
- supporting emergency vehicles access to Central Station; and
- improving safety by avoiding construction or maintenance traffic crossing the high traffic pedestrian area at the Eddy Avenue entrance and at the proposed Sydney Light Rail crossing.

1.2.2 Project scope of works

The SYAB works include earthworks and construction of all permanent new infrastructure and modifications to existing infrastructure, including the following key phases of work:

- Construction of the SYAB;
- Construction hinged approach slabs;
- An entrance road between the Approach Slab at the southern end of the SYAB and Regent Street (Regent Street Entrance Road);
- If required by the Contractor's design, a road between the Approach Slab at the northern end of the SYAB and Sydney Yard Landing Slab ("Yard Access Road");
- Construction of an on-ground slab in Sydney Yard immediately adjacent to the Yard Access Road
- Adjustments to infrastructure within, or adjacent to, the Site which is affected by the construction of the SYAB, Approach Slabs, Regent Street Entrance Road, the Yard Access Road and the hardstand area; and
- Urban features and landscaping works.

There are also a number of temporary works being conducted as part of the Project, which are discussed in detail throughout the CEMP.

1.2.2.1 Potential Noise Issues

The key acoustical issues potentially associated with SYAB works are noise and vibration emissions attributable to general construction plant, equipment and machinery in use (or activities undertaken) within the site area, during and outside the approved (**CoA – E36**) standard construction hours.

In addition, noise issues potentially associated with “high-noise impact activities and work”; during the approved specified construction hours are considered in this CNVMP. High-noise impact activities and work identifies where receptors are likely to experience elevated noise levels e.g. 80 to 95 dBA external or as per **CoA – E37** “internal noise levels greater than $L_{eq, 15 \text{ minute } 60 \text{ dBA}}$ inclusive of a 5 dB penalty, if rock breaking or any other annoying activity likely to result in regenerated (ground-borne) noise or a perceptible level of vibration”.

During works outside the approved standard construction hours noise issues potentially associated with SYAB works includes general emissions ($L_{Aeq, 15\text{minute}}$) but extends to include potential sleep disturbance emissions ($L_{A1, 1\text{minute}}$) attributable to construction plant, equipment and machinery in use (or activities undertaken) within the site area. Potential SYAB works and activities required outside the approved standard construction hours are considered in this CNVMP. These are the focus of the Sydney Metro OOHW Application Form (refer *Appendix B*) developed for the assessment, management and approval of these non-standard works and activities, if required.

The broader environmental assessment for the Sydney Metro City and Southwest project has identified generic impacts for typical works near Central Station. Subsequently, a site specific SYAB Construction Noise and Vibration Impact Statement (CNVIS) has been prepared for the project. This CNVIS has identified task specific impacts associated with general construction noise ($L_{Aeq, 15\text{minute}}$) and potential sleep disturbance ($L_{A1, 1\text{minute}}$) noise emissions. Further detail regarding the specific works, tasks and impacts assessed is provided in **Section 5** of this CNVMP. Consistent with the CoA and this CNVMP the CNVIS has identified that general construction (and sleep disturbance) noise emissions during and outside the approved standard hours should be the focus of SYAB environmental noise management. Based on the SYAB project construction methodology and design, these potential impacts are the key emissions with the potential to generate a nuisance, or an unacceptable level of noise amenity, or give rise to complaints.

Other potential noise issues associated with SYAB works include road traffic emissions ($L_{Aeq, 15\text{hour}}$ and $L_{Aeq, 15\text{hour}}$) attributable to SYAB vehicles on the existing public road network, and ground-borne noise. A quantitative assessment of construction road traffic noise and ground-borne construction noise identified that impacts are minimal if any at all, regardless these are considered in the CNVMP.

1.2.2.2 Potential Vibration Issues

The key vibration issues potentially associated with SYAB works are human comfort or structural and cosmetic damage vibration (VDV in $\text{m/s}^{1.75}$ or PPV in mm/s) attributable to general construction plant, equipment and machinery in use (or activities undertaken) within the site area.

Consistent with noise, a site specific CNVIS has been conducted for the SYAB project. It identified that general construction vibration (VDV in $\text{m/s}^{1.75}$ or PPV in mm/s) during and outside the approved standard construction hours should be the focus of this CNVMP. Only select activities or equipment within certain work phases have the potential to generate any significant vibration, these scenarios are identified in **Section 5** of this CNVMP.

Other potential vibration issues associated with SYAB works include road traffic vibration attributable to SYAB vehicles on the existing public road network. A quantitative assessment of construction road traffic vibration identified that impacts are minimal if any at all, regardless these are considered in the CNVMP.

1.2.3 Environmental Planning Approval

The Project is subject to assessment by the Department of Planning and Environment and approval by the Minister for Planning under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) as State Significant Infrastructure (SSI).

The Project has been declared as Critical State Significant Infrastructure by virtue of clause 5 of Schedule 5 of the *State Environmental Planning Policy (State and Regional Development) 2011* (NSW) and under Section 115V of the EP&A Act. The Project, its impacts, consultation and mitigation were documented in the following suite of documents:

- Critical State Significant Infrastructure Application SSI 15_7400;
- *Sydney Metro City & Southwest – Chatswood to Sydenham – Environmental Impact Statement – Construction Noise and Vibration Strategy* (TfNSW, 2016).
- *Sydney Metro City & Southwest – Chatswood to Sydenham – Submissions and Preferred Infrastructure Report* (TfNSW, October 2016).

The Minister for Planning granted Approval for SYAB in the Minister's Recommended Conditions of Approval (CoA, 9 January 2017 (SSI 15_7400).

1.2.4 Project-Specific Environmental Management System

The SYAB CEMP is the primary Environmental Management System (EMS) document for the delivery of the proposed works. This CNVMP (Sub Plan) is one of a suite of aspect-specific support plans to the CEMP that have been prepared to support the CEMP.

1.3 Objectives and Targets

The objectives and targets related to construction noise and vibration are as identified in **Table 1.1**.

Table 1.1 Objectives and Targets

Objectives	Performance Targets
<ul style="list-style-type: none"> • Minimise unreasonable noise and vibration impacts on residents and businesses; • Avoid structural damage to buildings or heritage items as a result of construction vibration; • Undertake active community consultation; and • Maintain positive, cooperative relationships with schools, childcare centres, local residents and building owners. 	<ul style="list-style-type: none"> • Noise levels would be minimised with the aim of achieving the noise management levels where feasible and reasonable • The Project would avoid any damage to buildings from vibration.

1.4 Consultation

The **CoA - C3(a)** and **C9(a)** for the SYAB requires that the CNVMP (and monitoring plan) be prepared in consultation with the EPA and/or Sydney City Council. This consultation has occurred during the preparation of this CNVMP and the CNVMP was updated as required following receipt of comments. Records of consultation are provided in Appendix D. Sections 4, 9 and 10 of this CNVMP detail the requirement of further consultation.

2. Legal and Other Requirements

2.1 Legislation

In NSW, noise pollution is typically regulated through the Protection of the *Environment Operations Act 1997* (POEO Act) as the key piece of environment protection legislation. Noise pollution is defined under the POEO Act as:

'the emission of offensive noise, which means noise that by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances, is harmful (or is likely to be harmful) to or interferes unreasonably (or is likely to interfere unreasonably) with the comfort or repose of a person outside the premises from which the noise is emitted'.

Under the POEO Act, the 'POEO (Noise Control) Regulation 2008' addresses common noisy activities that occur in residential situations; it limits the time of day that noisy articles (such as lawn mowers, stereos and leaf blowers) are permitted to be heard in neighbouring residences, however it does not specify noise limits and an applicable approach for the assessment of construction noise.

The SYAB works will be delivered under the Sydney Trains Environment Protection Licence (EPL) 12208. Compliance with all relevant licence conditions will be tracked, monitored and ensured.

Various construction noise and vibration assessment guidelines (and policy) are endorsed by NSW regulators and provide a framework and methodology for deriving acceptable levels and standard methods for assessing, managing and measuring construction noise and vibration impacts with due regard to the POEO Act. For the CNVMP the applicable policy and guidelines are presented in **Section 2.2** below.

2.2 Policy and Guidelines

The CNVMP has been prepared with due regard to and in accordance with the:

- NSW Department of Environment and Climate Change – *NSW Interim Construction Noise Guideline* (ICNG), July 2009; and
- NSW Government – *Sydney Metro Construction Noise and Vibration Strategy* (CNVS), August 2017.

The ICNG is the key guideline relating to construction noise and vibration in NSW with the CNVS developed to address other noise and vibration issues associated with the broader project.

The CNVMP has also considered and applied the following additional policy, guidelines and standards as relevant:

- NSW Environment Protection Authority – *NSW Environmental Noise Management – Industrial Noise Policy* (INP), January 2000 and relevant application notes;
- NSW Department of Environment, Climate Change and Water – *NSW Road Noise Policy* (RNP), March 2011;
- NSW Government – Transport for NSW (TfNSW) *Construction Noise Strategy* (CNS), April 2013;
- Standards Australia AS 2436–2010™ (AS2436) – *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*;
- Standards Australia AS1055–1997™ (AS1055) – *Description and Measurement of Environmental Noise*;
- Standards Australia AS IEC 61672.1–2004™ (AS61672) – *Electro Acoustics - Sound Level Meters Specifications Monitoring* or Standards Australia AS1259.2-1990™ (AS1259) – *Acoustics – Sound Level Meters – Integrating/Averaging* as appropriate to the device;
- Standards Australia AS/IEC 60942:2004/IEC 60942:2003 (IEC60942) – *Australian Standard™ – Electroacoustic – Sound Calibrators*;
- German Institute for Standardisation – DIN 4150 (1999-02) Part 3 (DIN4150:3) – *Structural Vibration - Effects of Vibration on Structures*;
- 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; and
- NSW Department of Environment and Conservation – *NSW Environmental Noise Management – Assessing Vibration: a Technical Guideline* (the NSW Vibration Guideline), February 2006.

2.3 Structure of this Plan

This CNVMP has been prepared to address all requirements tabulated in the consolidated compliance matrix. They are addressed throughout this Plan which is structured in the following format:

- **Section 1 – Introduction:** provides an overview of the purpose and application of this CNVMP, a background to the SYAB works and the broader Sydney Metro City and Southwest Project, identifies the location of work areas, identifies the likely works duration and summarises potential noise and vibration issues;.

- **Section 2 – Legal and Other Requirements:** provides an overview of the legal context of the Plan and summarises the applicable policy, standards and guideline;
- **Section 3 – Existing Environment and Noise/Vibration Guidelines:** summarises the existing noise environment, presents the measured baseline (background noise) data from the EIS, identifies potentially sensitive receptors, and describes how the baseline data is applied in the content of the applicable noise and vibration guidelines;
- **Section 4 – Work Hours and Management Levels:** describes the SYAB hours of work and the management levels (for noise and vibration) that will apply during construction works and activity;
- **Section 5 – Aspects, Impacts & Risks:** presents the SYAB works and activity, lists the likely noise and vibration generating sources and reproduces the predicted noise and vibration impacts from the CNVIS;
- **Section 6 – Mitigation and Management Measures:** describes the overall approach to managing and mitigating noise and vibration impacts as a result of the SYAB works based on the predicted impacts as summarised in this CNVMP. It details the relevant noise and vibration mitigation measures to be implemented during the works;
- **Section 7 – Training:** summarises the training that will be provided during SYAB works as applicable to the management of noise and vibration;
- **Section 8 – Noise and Vibration Monitoring Plan:** details the requirements of any noise and vibration monitoring that is required and the technical methods that will be adopted;
- **Section 9 – Enquiries, Complaints and Incident Management:** summarises the enquiries, complaints and incident management that will be undertaken as per the SYAB CEMP and Communications Strategy, including that related to noise and vibration;
- **Section 10 – CNVMP Administration:** provides information regarding relevant roles and responsibilities associated with this Plan and the CNVMP review process;
- **Section 11 – References:** lists the documents, policy, standards and guidelines applicable to this Plan, those that were considered during the preparation of the CNVMP;
- **Appendix A – Acoustics: Glossary of Terms and Definition:** provides an overview of relevant acoustical terminology and concepts; and
- **Appendix B – Sydney Metro Out of Hours Works Application Form:** presents the OOHW application process that will apply during the SYAB construction works.

3. Existing Environment and Noise/Vibration Guidelines

3.1 Existing Environment

The SYAB site is located in the rail corridor near the Sydney Yard just beyond rail access gate at Regent Street, Sydney NSW. It is situated within the City of Sydney local Government Area (LGA). The SYAB site is located approximately 400 metres south west of Central Station and approximately 550 metres north of Redfern Station. Regent St provides the main road access to the SYAB site.

The SYAB will be 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. The Sydney Yard area is currently used as a maintenance area by Sydney Trains.

The existing noise environment in the vicinity of the SYAB site is best described as 'urban', being an area with an acoustical environment that:

- is dominated by 'urban hum' or industrial source noise;
- has through traffic with characteristically heavy and continuous traffic flows during peak periods;
- is near commercial districts or industrial districts; and
- has any combination of the above, where 'urban hum' means the aggregate sound of many unidentifiable, mostly traffic-related sound sources.

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).

3.2 Background Noise Levels

Quantifying the existing noise environment (via measurement) at the closest and/or potentially most affected receptors situated within the potential area of influence of a site is a key feature of assessing and managing potential noise impacts.

For the purpose of the CNVMP, surrounding precincts were divided into Noise Catchment Areas (NCAs). These NCAs (adapted from those presented in the EIS) are shown in **Figure 3.1** and described in **Table 3.1** below.

Rating Background Levels (RBL) at sensitive receptor locations considered representative of each of the eight NCA were established via measurements as documented in the EIS and GHD reports in accordance with the INP.

The RBLs adapted from those presented in the EIS and modified based on additional information provided by LOR in the GHD 2012 and 2014 reports are presented in **Table 3.2** below. Values for the daytime, evening and night-time periods are provided. 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. 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).

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.

Table 3.1 Sensitive Receptors / Noise catchment Areas

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

Table 3.2 Rating Background (Noise) Levels

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

Source: CNVIS, EIS

Guidance Note

The measured overall RBL values summarised in **Table 3.2** are typical of urban areas already experiencing natural, traffic, urban hum or existing commercial/industrial noise within the overall noise environments. Decreasing noise levels in the evening and night are evident in the data and consistent with that anticipated for urban environments.

RBLs were adopted based on measured data presented in chapter 10 of the EIS. Where measured data was provided directly for a NCA, this was the value adopted; however where there was no measured data, the lowest value of the measured data in adjacent NCA was adopted for each period, daytime, evening and night time.



Figure 3.1: Noise catchment areas and sensitive receptor locations (Adapted from: Figure 16, EIS: Technical paper 2)

3.3 Noise and Vibration Guidelines

The ICNG and CNVS are relevant to the SYAB works and provide guidance to establishing noise (and vibration) management levels (criteria) for the purpose of assessing and managing noise impacts.

For residential receptors, the noise management levels are established based on existing background noise levels i.e. thresholds above which the background noise level may be exceeded. For other sensitive receptors the management levels are fixed values.

For residential and other sensitive receptors (human); and potentially sensitive structures (buildings) vibration management levels are fixed values established for either human comfort or structural/cosmetic damage. The levels vary depending on the potential sensitivity of the receptor and do not rely on existing conditions.

A summary of each in the context of the ICNG and CNVS is provided in the sections below.

CoA- E37 and **CoA – E38** provide further internal noise management levels outlined below:

Construction noise (including ground-borne noise), should not exceed internal noise levels of:

- Leq 15 minute 60 dBA (inclusive of a 5 dBA penalty if rock breaking or any other annoying activity likely to result in ground-borne noise or a perceptible level of vibration is planned) between 7am – 8pm for more than 50 percent of the time; and
- Leq 15 minute 55 dBA (inclusive of a 5 dBA penalty if rock breaking or any other annoying activity likely to result in ground-borne noise or a perceptible level of vibration is planned) between 7am – 8pm for more than 25 percent of the time, unless an agreement is reached with those receivers. **CoA – E38** does not apply to noise associated with the cutting surface of a TBM as it passes under receivers.

Note: **CoA – E38** requires that noise levels be less than Leq 15 minute 60 dBA for at least 6.5 hours between 7am and 8pm, of which at least 3.25 hours must be below Leq 15 minute 55 dBA. Noise levels equal to or above the Leq 15 minutes 60 dBA threshold are allowed for the remaining 6.5 hours between 7am and 8pm.

In the event of any conflict between the noise management levels determined by the ICNG and the CNVS, and those specified in **CoA- E37** and **CoA – E38**, the noise management levels specified in **CoA- E37** and **CoA – E38** will prevail as per **CoA - A3**.

3.3.1 Residential Receptors (Noise)

The method for establishing ICNG Noise Management Levels for residential receptors is summarised in **Table 3.3** below. Separate criterion is provided for works during and outside the ICNG standard construction hours. The ICNG recommends more stringent noise criterion for works outside these standard hours. These hours of work are consistent with the approved hours described in **CoA – E36**.

Table 3.3 Construction Noise Management Levels – Residences

Time of Day	Noise Management Level (L _{Aeq, 15minute})	How to Apply
Recommended Standard Hours: Monday to Friday, 7am to 6pm Saturday, 8am to 1pm No work on Sundays or Public	Noise affected RBL + 10 dBA	<ul style="list-style-type: none"> • The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured L_{Aeq, 15minute} is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of Day	Noise Management Level (LAeq, 15minute)	How to Apply
Holidays	Highly noise affected 75 dB(A)	<ul style="list-style-type: none"> The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent would consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent would communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside the Recommended Standard Hours	Noise affected RBL + 5 dBA	<ul style="list-style-type: none"> A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the Guideline.

Source: INCG, CNVS

3.3.1.1 Sleep Disturbance (Noise)

For residential receptors it is also important to consider potential sleep disturbance impacts associated with OOHW conducted during the night time (10pm to 7am) period. The INP provides indicative sleep disturbance thresholds and was utilised as the basis for establishing 'sleep disturbance screening levels' in the CNVS and CNVIS.

This method (RBL + 15 dB) is widely accepted as the appropriate method for assessing and managing sleep disturbance impacts (using the LA1, 1minute or LMax parameters) and is adopted here to establish criteria for use in the CNVMP.

3.3.2 Non-Residential Receptors (Noise)

As noted above the ICNG defines fixed management levels for other sensitive receptors and non-residential sensitive land uses. These values are reproduced in **Table 3.4** below.

Table 3.4 Noise Levels for non-residential sensitive land use

Land Use	Noise Management Level: LAeq, 15minute (applies when properties are being used)
Classrooms at schools and other educational Institutions	Internal Noise Level 45dB ¹
Hospital wards and operating theatres	Internal Noise Level 45dB ¹
Places of worship	Internal Noise Level 45dB ¹
Active recreation	External noise level 65dB
Passive recreation	External noise level 60dB
Community centre	Depends on intended use – see AS2107
Industrial premises	External Noise Level 75 dB
Offices, retail outlets	External Noise Level 70 dB.

Land Use**Noise Management Level: LAeq, 15minute
(applies when properties are being used)***Source: ICNG, CNVS*

1. External goal of 55dBA applies. The ICNG recommends that construction noise levels do not exceed 45 dB (LAeq, 15minute) internally within school classrooms when in use. For the purpose of the CNVIS (and as adopted here to verify criteria for use in the CNVMP) the internal noise level has been translated to an external level of 55dB (LAeq, 15minute) based on the accepted level of attenuation (10dB) that is readily achieved through windows, partially opened for ventilation.

3.3.2.1 Vibration (All receptors)

Vibration refers to the oscillating movement of any object. In relation to construction projects, ground-borne vibration is the most likely outcome of intensive piling, demolition, vibratory rolling or hammering works. For the SYAB works this is limited to demolition activities and the use of vibratory rollers which have two potential effects on sensitive receptors: ground-borne vibration that may cause annoyance and ground-borne vibration that may have an adverse effect (cosmetic or structural damage) on a structure e.g. a building.

Each of these two potential effects are assessed in accordance with the relevant standard. For human comfort the NSW Vibration Guideline and British Standard BS 6472-1992 applies in accordance with the CNVS. For cosmetic or structural damage the British Standard BS 7385:1993 applies in accordance with the CNVS and **CoA – E28**. To meet the requirements of the CNVS, BS7385 is also considered in this CNVMP to provide guidance for potential cosmetic damage issues. Each of these relevant guidelines and standards are technical in nature but ultimately present fixed (frequency dependant) criterion values that may apply to either human or building receptors.

Heritage buildings and structures are also considered in the CNVMP, assessed as per the screening criteria in BS7385, as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound conservative cosmetic damage criteria from German standard DIN 4150 will apply. Each standard is considered and adopted in the CNVMP to establish the applicable management levels for vibration that will apply to the SYAB works and activity.

4. Work Hours and Management Levels

4.1 Hours of Work

The approved SYAB standard construction hours are as follows (**CoA – E36**). General construction works and activities will be scheduled to occur between these hours, unless OOHW becomes necessary (see below):

- 7:00am to 6:00pm Mondays to Fridays, inclusive;
- 8:00am to 1:00pm Saturdays; and
- at no time on Sundays or public holidays.

EPL 12208 and the Sydney Metro City and Southwest Chatswood to Sydenham Conditions of Approval apply. Out of hours works approval process will be undertaken in accordance with Out of Hours Works Assessment Procedure. The EPL requirements apply to all areas of the project within the rail corridor boundary. The Regent Street works area is outside of the boundary of the rail corridor and as such EPL 12208 does not apply. The CoA requirements apply to all areas of the project.

LOR must consult with all receptors identified in the CNVIS/CNVMP/EIS in accordance with **CoA – E37** and **CoA – E38** with the objective of determining appropriate hours of respite so that construction noise (including ground-borne noise), does not exceed internal noise levels outlined in **CoA – E38**.

Noise generating works in the vicinity of potentially-affected community, religious, educational 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.

4.1.1 Works Outside of the Approved Standard Hours

Out of Hours Work (OOHW) (i.e. works outside the approved SYAB standard hours) at this stage are proposed for a number of work phases. Impacts for these phases are assessed in the CNVIS. Other activities may become necessary as the construction methodology develops, during both design and actual implementation of the works at the site.

Where OOHW is required or becomes necessary the Sydney Metro OOHW Protocol developed in accordance with **CoA – E44(f)** and **CoA – E47** will be implemented. Consultation with Sydney City Council, local residents and other affected stakeholders and sensitive receptors is a requirement under **CoA – E37, CoA – E38, CoA - E44** and **CoA - E45** where variations to standard construction hours occur. In accordance with **CoA – E44(f)**, where construction activities are undertaken outside of the approved hours the notification must be made not less than 5 days and not more than 14 days before those activities are to be undertaken. The approval authority for areas outside ST EPL is AA endorsement and ER/DPE approval. The approval authority for areas within ST EPL is TfNSW approval. Where high noise impact generating works are undertaken outside of the hours stipulated in EPL 12208, an EPL variation will be required for the works.

In addition to the OOHW protocol the Additional Mitigation Management (AMM) requirements will be considered as outlined in **Section 6.2** of this CNVMP and in accordance with the CNVIS. If required, a task specific Out Of Hours Work Application Form (OOHWAF) will be submitted with the OOHW approval to identify noise generating items, identify receptors, predict noise levels, quantify impacts and provide for suitable mitigation and management measures. An example OOHWAF is provided in Appendix B outlining the format, content and features of a task specific form that would be developed when and if required.

4.1.2 Emergency Construction

Notwithstanding **CoA – E36** construction associated with the CSSI may be undertaken outside the hours specified under those conditions where it is required in an emergency to avoid injury or the loss of life, to avoid damage or loss of property or to prevent environmental harm.

On becoming aware of the need for emergency construction in accordance with **CoA – E44(b)**, the LOR must notify the AA, the ER and the EPA of the need for those activities or work. LOR must also use best endeavours to notify all affected sensitive receptors of the likely impact and duration of those works in accordance with **CoA – E45**.

4.2 **Noise Management Levels**

Based on the ICNG and CNVS methodology summarised in **Section 3** the following construction Noise Management Levels (NMLs) will apply to the SYAB works as presented in **Table 4.1**.

4.2.1 General Construction Noise

The following general construction NML will apply externally and will be assessed at the most-affected point on or within the receptor property boundary or, if that is more than 30 metres (m) from the receptor, at the most-affected point within 30 m of the receptor.

For other sensitive receptors (classrooms at schools and other educational institutions; hospital wards and operating theatres; and places of worship) the external criteria value translated from the ICNG internal goal may be adopted as relevant and if other receptors are identified. The NML of other sensitive receptors are further outlined in the CNVIS and identified in **Table 4.1**.

Section 4.1 of the ICNG notes that the NML apply at a height of 1.5 m and also notes that noise levels may be higher at upper floors of a noise affected residence. The NML presented in this CNVMP will apply only at an assessment height of 1.5 m above ground level. Where multi-storey buildings/receptors are identified their features will be noted (i.e. double storey brick house etc) however no additional assessment will be undertaken at any height above 1.5 m.

'Sleep disturbance screening thresholds' have been developed as per the guidance summarised in **Section 3** and will be assessed externally, at a boundary location consistent with other NML and at a height of 1.5 m above ground level. 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 4.1 Construction Noise Management Levels

Acceptable LAeq, 15 minute Noise Level				
Noise Catchment Area (NCA)	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: CNVIS, EIS

1. Standard (daytime): 7:00am to 6:00pm Mondays to Fridays, inclusive and 8:00am to 1:00pm Saturdays;
2. Outside standard (daytime): 1:00pm to 6:00pm Saturdays, and 8:00am to 6:00pm on Sundays or public holidays;
3. Outside standard (evening): 6:00pm to 10pm Monday to Sunday, inclusive; and
4. 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 Highly Noise Affected Management Level does not apply outside the recommended standard hours and does not apply to other sensitive receptors. LOR will consult with all receptors identified in accordance with **CoA - E37**, **CoA - E38** and **CoA E44** with the objective of determining appropriate hours of respite so that construction noise (including ground-borne noise), do not exceed the Highly Noise Affected Management Level, the noise levels specified in **CoA – E44(d)** and the internal noise levels outlined in **CoA - E37 and CoA - E38**.

Table 4.2 Sleep Disturbance Screening Levels

Noise Catchment Area (NCA)	Sleep Disturbance Screening Level (LA1,1minute / LMax) ¹
A	60
B1	60
B2	60
B3	61
J2	60

Source: CNVIS, 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).

4.2.2 Construction Road Traffic Noise

The ICNG does not include any criteria to assess off-site traffic noise associated with construction and demolition. Criteria for off-site road traffic noise applicable to 'existing residences affected by additional traffic on existing roads generated by land use developments' are specified in the RNP.

Whilst these criteria do not specifically apply to construction/demolition traffic movements, they have been conservatively adopted here in the CNVMP and are summarised in **Table 4.3** below.

Table 4.3 Road Traffic Noise Management Levels

Road	Category	Management Level, dBA	
		Daytime ¹	Night time ²
Regent St / Lee St	Sub-arterial road	L _{Aeq} ,1 hour ≤ 60 (external)	L _{Aeq} ,1 hour ≤ 55 (external)
Chalmers St	Sub-arterial road	L _{Aeq} ,1 hour ≤ 60 (external)	L _{Aeq} ,1 hour ≤ 55 (external)

Source: EIS

1. Daytime means between 7:00am and 10:00pm, Monday to Sunday inclusive; and
2. Night time means between 10:00pm to 7:00am, Monday to Sunday inclusive.

The **Table 4.3** criteria do not apply to vehicle movements within the SYAB Site. For the purpose of this CNVMP any noise generated by on-site vehicle movements is considered as construction noise and managed holistically with on-site mobile plant in accordance with the ICNG. Additionally, it is typically recognised that for existing residences and other sensitive land uses affected by additional traffic on existing roads, any increase in the total traffic noise level should preferably be limited to 2dB above the existing road traffic noise levels as an increase of 2dB is typically considered not noticeable.

The road traffic noise management levels differ from general construction NML and apply 1 m from the property façade. Road traffic impacts are not anticipated such that direct assessment of SYAB road traffic noise will not be undertaken unless it becomes necessary (i.e. impacts are identified or complaints are received) during the works. Where impacts are identified or complaints are received the extent of assessment will be determined on a case by case basis.

4.3 Vibration Management Levels

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). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

Refer **Section 5.2.2** which describes how the human comfort structural/cosmetic damage criteria will be evaluated, selected and applied as appropriate to the receptor and potential impacts.

4.3.1 Human Comfort (or Annoyance)

The NSW Vibration Guideline provides guidance for assessing human exposure to vibration. The publication is based on British Standard BS 6472:1992.

BS 6472-1992 provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV). The vibration dose value is dependent upon the level and duration of the short term vibration event, as well as the number of events occurring during the daytime or night-time period.

Table 4.4 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

Note: 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.

It is noted however that the direct measurement (or equivalent estimation via calculation) of VDV is often impractical and does not allow for the assessment of impacts in real-time e.g. whilst works are occurring. VDV provides an indication of impacts after the works have occurred based on the duration, intensity and characteristic frequency of the measured vibration events throughout a work day. To provide greater flexibility and to enable the assessment of potential impact via the PPV parameter (which can be measured and evaluated during works) the following thresholds identified in **Table 4.5** will be applied to assess the probability for adverse comment from residential receptors. These values have been established as per Table C1.1 of the NSW Vibration Guideline and will be applied in combination with the VDV presented in **Table 4.4**.

Table 4.5 Perceptible Vibration Criteria for Exposure to Continuous and Impulsive Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Continuous Vibration			
Residences	Daytime	0.28	0.56
	Night-time	0.20	0.40
Offices	Day- or Night-time	0.56	1.1
Workshops	Day- or Night-time	1.1	2.2
Impulsive Vibration			
Residences	Daytime	8.6	17.0
	Night-time	2.8	5.6
Offices	Day- or Night-time	18.0	36.0
Workshops	Day- or Night-time	18.0	36.0

1. Values given for the most critical frequency range >8Hz assuming sinusoidal motion.

Source: Table C1.1 – The NSW Vibration Guideline

4.3.2 Building Damage (Structural/Cosmetic Damage)

There are currently no Australian Standards or guidelines to provide guidance on assessing the potential for building damage from vibration and it is common practice to derive goal levels from international standards.

To achieve the requirements of the CNVS, vibration from construction activities must not exceed the vibration limits set out in the British Standard BS 7385:1993. The Standard is presented (refer **Table 4.6**) in the CNVMP and provides safe limit guideline values, below which vibration is considered insufficient to cause structural or cosmetic damage to buildings.

The recommended limits (guide value, refer CNVS) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented in **Table 4.6** with each “Line” shown in **Figure 4.1**.

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.

Table 4.6 Building Damage Vibration Management Levels (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 & 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

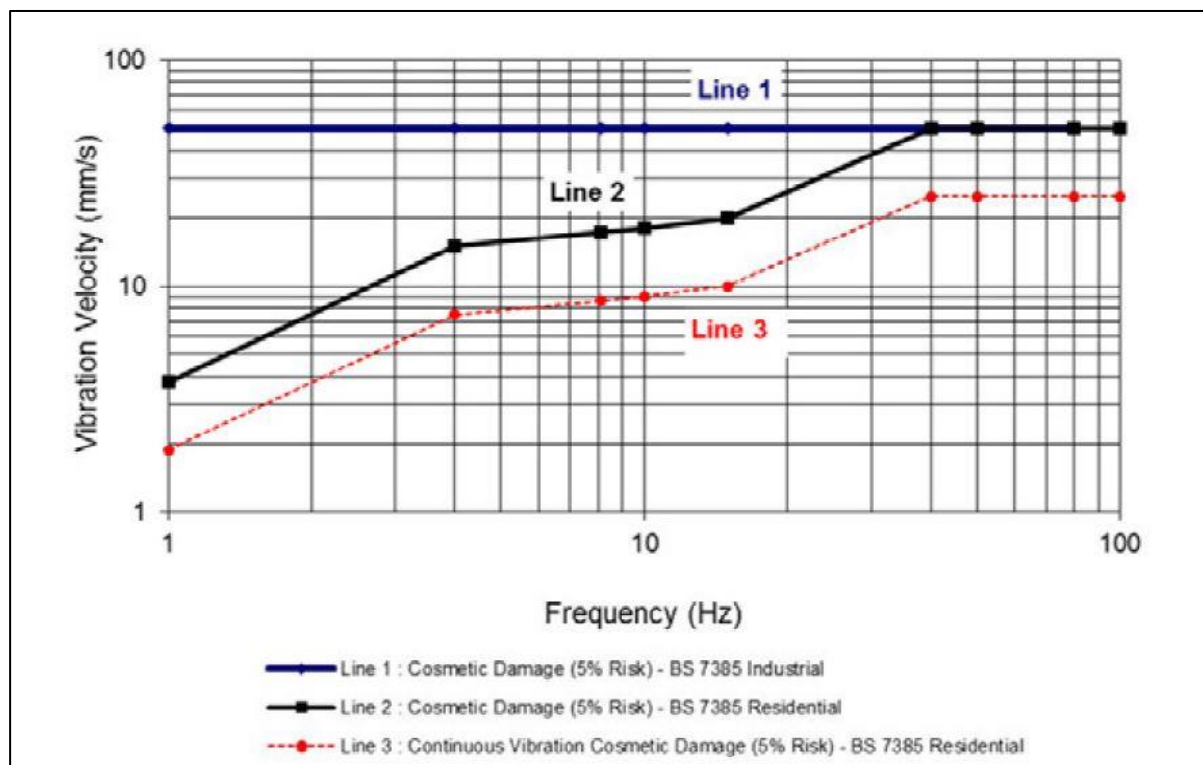


Figure 4.1: Building Damage Vibration Management Levels (BS 7385)

Guidance Note

With regard to these levels BS 7385 states, “Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.”

Also that: “A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.”

Heritage buildings and structures will also be assessed as per the screening criteria in **Table 4.6** as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound.

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 DIN 4150) would be considered. The applicable German Standard DIN 4150:3 management levels are tabulated in **Table 4.7** with each “Line” shown in **Figure 4.2**.

Table 4.7 Building Damage Vibration Management Levels (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: CNVS, CNVIS

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.

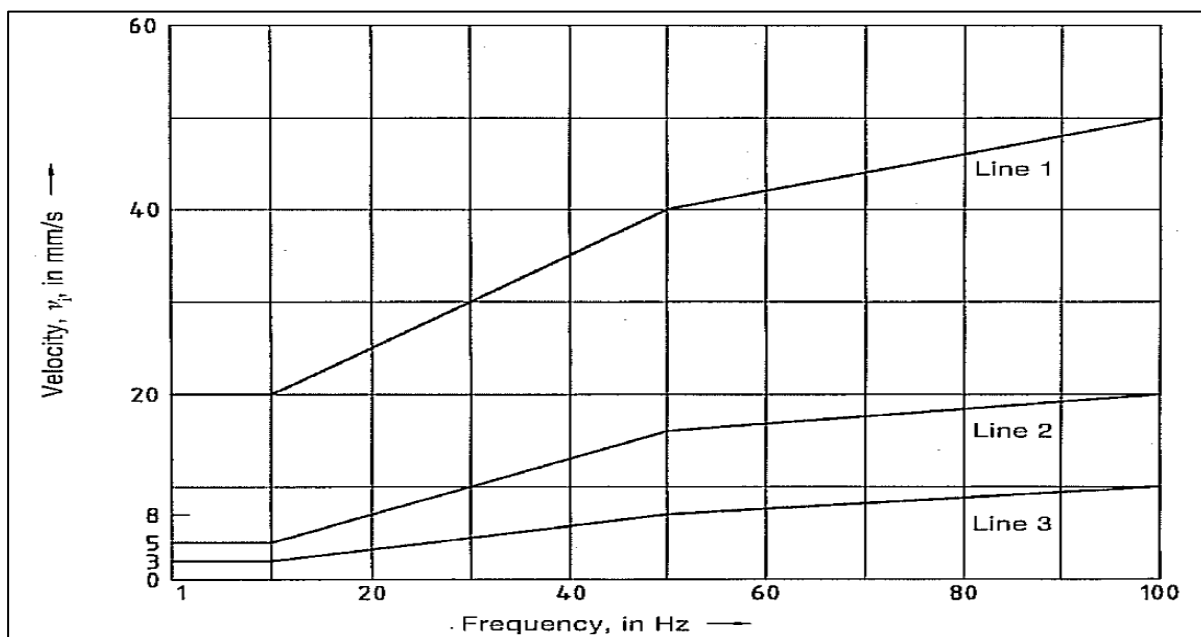


Figure 4.2: Building Damage Vibration Management Levels (DIN4150:3)

Guidance Note

With regard to these levels DIN 4150:3 states, “experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding [these] values does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary.”

5. Aspects, Impacts & Risks

This section outlines relevant aspects of the construction methodology and the predicted construction noise and vibration impacts. The predicted noise and vibration impacts are detailed in the CNVIS and summarised here as relative to the surrounding community or nearby by structures.

5.1 Construction Methodology

A number of key construction scenarios (SCN / Work Phases) were identified in the CNVIS as follows:

- SCN01 - Demolition of Terrace Buildings.
- SCN02 - Site Investigation and Setup.
- SCN03 - Removal of part of Up Shunting Neck.
- SCN04 - Piling of Bridge Abutments & Piers.
- SCN05 - Abutments and Piers – Precast.
- SCN06 - Abutments and Piers – Cast in Situ.
- SCN07 - Construction of Deck Spans.
- SCN08 - Construction of Reinforced Earth Wall.
- SCN09 - Construction of Deck.
- SCN10 - Regent St Services.

These scenarios were advised by LOR and are consistent with the current construction methodology of SYAB as described in **Section 1**. Details of these construction works (reproduced from the CNVIS) and scenarios are presented in **Table 5.1**. There may be some overlap between these work phases.

Table 5.1 Construction Works and Associated Activities

ID	Work Phase	Details	Activity
SCN01	Demolition of Terrace Buildings	Mid-week works.	<ul style="list-style-type: none"> Demolition of Terrace Building; Separating and stockpiling material for disposal or reuse; and Removal of decommissioned underground services.
SCN02	Site Investigation and Setup	Plant will be utilised one at a time for minor works / compound setup only.	<ul style="list-style-type: none"> Site investigation and Setup; Establishment of a compound with portable offices and amenities and connection to utilities; and Excavation and filling of land on-site.
SCN03	Removal of part of Up Shunting Neck	May be both possession and mid-week works.	<ul style="list-style-type: none"> Removal of part of Up Shunting Neck; and Establish detailed construction platform and place under-slab base course.
SCN04	Piling of Bridge Abutments & Piers	Abutment A & B will be mid-week works Piers 1 & 2 may be mid-week or possession based.	<ul style="list-style-type: none"> Piling of Bridge Abutments & Piers; and Misc. structural construction, utilities and finishing works.
SCN05	Abutments and Piers - Precast	May be both possession and mid-week works.	<ul style="list-style-type: none"> Abutments and Piers – Precast; and Misc. structural construction, utilities and finishing works.
SCN06	Abutments and Piers – Cast in Situ	May be both possession and mid-week works.	<ul style="list-style-type: none"> Abutments and Piers – Cast in Situ; and Misc. structural construction, utilities and finishing works.
SCN07	Construction of Deck Spans	Will be possession works only.	<ul style="list-style-type: none"> Construction of Deck Spans; and Misc. structural construction, utilities and finishing works.
SCN08	Construction of Reinforced Earth Wall	Will be mid-week works.	<ul style="list-style-type: none"> Construction of Reinforced Earth Wall; and Misc. structural construction, utilities and finishing works.
SCN09	Construction of Deck	Will be mid-week works.	<ul style="list-style-type: none"> Construction of Deck; and Misc. structural construction, utilities and finishing works.
SCN10	Regent St Services	Mid-week nights.	<ul style="list-style-type: none"> Misc. structural construction, utilities and finishing works.

Source: CNVIS

1. The duration of each work phase will vary, the indicative duration for each phase is available in the CEMP

5.2 Predicted Construction Impacts

In general, noise (and vibration) impacts may occur due to SYAB Project emissions that are considered offensive by the community and may result in complaints being received, additional mitigation or management measures being implemented, or additional monitoring being required.

For noise impacting residential and other sensitive receptors, the potential impacts relate to annoyance or an unacceptable noise amenity. The noise receptors considered in the CNVIS and the predicted value at each is presented in **Table 5.3** below.

For vibration impacting building structures, the potential impacts relate to structural or cosmetic damage. These however are unlikely to occur with good practice construction management, adherence to safe work distances and monitoring of significant vibration activities to verify compliant levels.

In all cases the comparison of predicted vibration 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.

5.2.1 Potential Noise Impacts

The CNVIS provided a detailed breakdown of the key construction periods and associated equipment, and their source noise emission (Sound Power Levels, L_w or SWL). These values and the predicted $L_{Aeq, 15\text{minute}}$ noise levels from the CNVIS (determined via modelling for each scenario) are reproduced in **Table 5.2** and **Table 5.3**. Values that exceed the NML are highlighted in **bold** typeset. Values that exceed the HNAML (fixed at 75 dB for residential receptors) are highlighted in **bold and underlined** typeset.

In each scenario, it was assumed in the CNVIS that all plant would operate simultaneously, which is considered to be representative of potential worst-case conditions. The CNVIS results (reproduced in this CNVMP for ease of reference) indicated that construction noise emissions would exceed the Project NMLs at a number of locations during each scenario. The magnitude by which they exceeded the NML did however vary depending on the work phase and necessary equipment. The extent by which they exceeded the NML is constrained to the closest receptors; although elevated levels are predicted at other more distance locations, the highest impacts are limited to those directly adjacent the site.

Based on these general construction noise levels exceeding the NML it is also considered likely that sleep disturbance screening criteria will be exceeded at the nearest and most sensitive residential receptor **R4 (A)** during OOHW.

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 outlined in the AMMM in **Section 6.2**.

In accordance with **CoA -E35**, LOR will review alternative methods to rock hammering and blasting for excavation and demolition as part of the detailed construction planning with a view to adopting methods that minimise impacts on sensitive receptors. Construction Noise and Vibration Impact Statements will be updated for each location or activity to adopt the least impact alternative in any given location unless it can be demonstrated, to the satisfaction of the AA, why it should not be adopted.

Under **CoA – E37, E38, E41 and E42**, LOR will identify and consult with all receptors likely to experience internal noise levels greater than $L_{eq, 15\text{ minute}}$ 60 dBA, regenerated (ground-borne) noise or a perceptible level of vibration, with the objective of determining appropriate hours of respite. These receptors will be offered additional mitigation in accordance with AMMM in **Section 6.2**.

Table 5.2 Indicative Sound Power Levels – Construction Equipment

Work Phase	Equipment	Sound Power Level (LW in LAeq, 15 minute)	Equipment Quantity	Potential OOHW Required
Demolition of Terrace Buildings	35t Excavator with: Hydraulic demolition shears or hydraulic hammer with dampener	113		N
	Bogie	120	2	
	Bogie	107	4	
	Bobcat	104	1	
Site Investigation and Setup	Vac Truck	107	1	Y
	Cranes	105	1	
	6t Excavator	95	1	
	Road sweeper	107	1	
Removal of part of Up Shunting Neck	Loader	111	1	Y
	8t Excavator + tamping head	100	1	
	10t Roller	114	1	
	Bogie	107	2	
	Semitrailer	107	1	
	Rail saw	117	1	
Piling of Bridge Abutments & Piers	Piling Rig	134	1	Y
	8t Excavator	100	1	
	Bogie Tipper	107	1	
	Concrete Pump	109	1	
	Concrete Agitator	112	1	
	50t All Terrain	117	1	
	Semitrailer	107	1	
Abutments and Piers - Precast	Tower Crane (Favco)	110	1	Y
	Cherry Picker	102	2	
Abutments and Piers – Cast in Situ	Concrete Pump	109	1	Y
	Concrete Agitator	112	1	
Construction of Deck Spans	Tower Crane (Favco)	110	1	Y
	Cherry Picker	102	2	
	Jinkers	107	3	
	Rattle gun	116	1	
Construction of Reinforced Earth Wall	10t Roller	114	1	N
	City crane	105	1	
	8t Excavator	100	1	
	Bogie	107	2	
Construction of Deck	Concrete Pump	109	1	N
	Concrete Agitator	112	1	
Regent St Services	5t Excavator	95	1	Y
	Road saw	117	1	
	Bogie	107	1	
	2.5t Roller	108	1	
	Concrete Agitator	112	1	

Source: Table 3.1, CNVIS

Table 5.3 Predicted LAeq, 15minute Construction Noise Levels

Receptor	Works Period / Activity									
	SCN01	SCN02	SCN03	SCN04	SCN05	SCN06	SCN07	SCN08	SCN09	SCN10
R1 (A) Service Station	91	66	72	76	70	74	73	70	71	77
R2 (B1) Hotel	81	59	67	67	63	67	66	63	65	68
R3 (B2) Residential	86	58	69	69	69	69	70	64	66	73
R4 (A) Residential	91	71	76	74	86	76	86	71	73	77
R5 (B2) Residential	65	56	47	56	51	44	58	57	42	52
R6 (B3) Residential	57	57	61	55	46	60	57	56	58	44
R7 (B3) Residential	52	50	46	50	44	42	52	51	39	39
R8 (C) Commercial	56	52	54	53	47	53	55	54	51	42
R9 (H) Industrial	65	56	56	57	51	55	59	57	52	52
R10 (H) Commercial	69	59	60	61	55	59	63	62	56	56
R11 (J1) Recreational	70	56	60	60	56	59	62	60	56	57
R12 (J1) Educational	62	47	50	50	47	50	52	50	47	48
R13 (J2) Church	73	56	63	61	58	62	63	61	60	60
R14 (J2) Residential	68	48	56	54	52	55	55	53	53	55
R15 (B1) Residential	73	52	61	57	52	62	59	58	59	60

Source: CNVIS

Note: Values that exceed the applicable NML (NML varies dependent on whether scenario is to be conducted during day or night time) are highlighted in **bold** typeset. Values that exceed the Highly Noise

Affected Management Level (fixed at 75dBA for residential receptors during standard construction hours and during the daytime period only) are highlighted in **bold and underlined** typeset. Refer to CNVIS for background discussion.

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 Leq, 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.

5.2.2 Potential Vibration Impacts

Activities undertaken on the site during construction may generate ground-borne vibration. With respect to the construction plant identified in **Table 5.2**, the highest levels of vibration would be expected to occur due to the use of a vibratory roller and an excavator with hydraulic hammer (demolition).

The CNVIS noted that other construction activities were considered and deemed to produce insignificant levels of vibration with limited or no risk in terms of human comfort and certainly no risk of building damage issues.

To assess potential vibration impacts the CNVIS adopted a combined approach of research and predictive methods. 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 & 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.

The CNVIS concluded that predicted values complied with the most stringent BS 7385 criteria (15 mm/s) at distances of 3 metres and beyond for vibratory roller usage and comply with the most stringent heritage structure criteria (2.5 to 3 mm/s) at distances of 14 metres and beyond. Predicted demolition values comply with the most stringent BS 7385 criteria (15 mm/s) at distances of 3 metres and beyond and comply with the most stringent heritage structure criteria (2.5 to 3 mm/s) at distances of 9 metres and beyond.

Based on this predictive approach 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.

These predicted compliant results also aligned with those presented in the WM 2014 report. They also identified that any impacts will be localised as 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 and only the closest receptors will be affected.

The CNVIS also concluded that given the minimal setback distances to nearby sensitive receptors complying with the recommended safe working distances from the TfNSW CNS for vibration intensive plant presented **Table 6.2** may not be possible in all cases. This identifies that best-practice construction vibration management and control techniques will be required to reduce vibration levels as far as practicable. For example, vibration intensive activities may start at a position far away from a receptor and move closer as compliant levels are verified. To minimise impacts 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 6.2** of this CNVMP.

Vibration Dose Values (VDV in $\text{m/s}^{1.75}$) were also 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. The CNVIS predicted values exceeded 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 exceeded criteria for vibratory roller works are marginal ($0.1 \text{ m/s}^{1.75}$) 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.

These cosmetic/structural damage and human annoyance outcomes are 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.

The monitoring and compliance assessment focus will initially be for SCN01 demolition works. Additional monitoring for the following scenarios will be considered: SCN03, SCN04, SCN08 and SCN10.

During the works, impacts from vibration will be considered both in terms of the effects on building occupants (human comfort) and the effects on the building structures (structural/cosmetic damage).

The applicable criteria (outlined in **Section 4.3**) will be evaluated, selected and applied based on the receptor type and potential impacts:

- **Human comfort criteria** will be applied on a case by case basis, where necessary (i.e. if impacts have the potential to occur) and where appropriate to the vibration type being generated by the activity under assessment. The vibration type (impulsive, continuous or intermittent) and application of the relevant criteria will be evaluated and selected by a suitably experienced person or in consultation with a qualified technical specialist; and
- **Structural damage criteria** will be applied on a case by case basis, where necessary (i.e. if impacts have the potential to occur) and where appropriate to the structure under assessment. The structure type and application of the relevant criteria will be evaluated and selected by a suitably experienced person or in consultation with a qualified technical specialist.

In accordance with **CoA -E35**, LOR will review alternative methods to rock hammering and blasting for excavation and demolition as part of the detailed construction planning with a view to adopting methods that minimise impacts on sensitive receptors. Construction Noise and Vibration Impact Statements will be updated for each location or activity to adopt the least impact alternative in any given location unless it can be demonstrated, to the satisfaction of the AA, why it should not be adopted.

Under **CoA – E37, E38, E41 and E42**, LOR will identify and consult with all receptors likely to experience internal noise levels greater than Leq 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 in Section 6.2.

Table 5.4 Vibration Assessment Scenarios

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 & 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

6. Mitigation and Management Measures

This section describes the overall approach to managing and mitigating noise and vibration impacts as a result of the SYAB works based on the predicted impacts as summarised this CNVMP.

The management measures discussed in this section are based on the applicable compliance matrices for the relevant Project Approval as well as the requirements of the ICNG and standards of LOR, including application of the CNVS as relevant to the works. These measures have been informed further by the outcomes and recommendations of the CNVIS.

The CNVS was developed to address the assessment requirements documented in the ICNG. It also identifies the thresholds by which impacts can be qualified and the level of mitigation and management that is required for each stage of works.

The mitigation and management measures are consistent with the intent and recommendations of the ICNG for own best-practice techniques to be developed for managing construction noise and vibration, and implementing feasible and reasonable mitigation measures.

Some activities (such as rail sawing and road sawing) are expected to generate levels in excess of 75 dBA however they will only occur for very short periods of time and hence the duration of the potential impact will be considered when selecting any standard or additional mitigation measures.

The CNVS assessment and mitigation approach has been adopted, in conjunction with the requirements of the ICNG, for the measured described in this CNVMP.

6.1 Standard Mitigation Measures

The standard mitigation measures that will be adopted during SYAB works (in accordance with the CNVS) are described in **Table 6.1** and will be implemented for the works to manage and potentially reduce construction noise and vibration impacts. For each item the SYAB personnel responsible is nominated. For each item a unique identification number (ID) is provided, which correlates to the document references shown in the traceability matrix.

Table 6.1 Standard Noise and Vibration Mitigation Measures

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV1	Management	Implement community consultation measures	Noise and Vibration	<p>The Community Liaison Manager must consult with all receptors identified in accordance with CoA - E37 and CoA – E38 with the objective of determining appropriate hours of respite so that construction noise (including ground-borne noise), does not exceed internal noise levels of $L_{eq, 15 \text{ minute } 60 \text{ dBA}}$</p> <p>In accordance with CoA – E29 owners of properties at risk of exceeding the screening criteria for cosmetic damage must be notified before construction that generates vibration commences in the vicinity of those properties.</p> <p>In accordance with CoA - E39 Community Liaison Manager must consult with proponents of other construction works in the vicinity of the CSSI and take reasonable steps to coordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receptors.</p> <p>Consultation is also a requirement under CoA - E44 and CoA - E45 where variations to standard construction hours occur. On becoming aware of the need for emergency construction in accordance with Condition E44(b), LOR must notify the AA and the ER of the need for those activities or work. The Proponent must also use best endeavours to notify all affected sensitive receptors of the likely impact and duration of those works.</p> <p>A register of all noise and vibration sensitive receptors will be kept on site.</p>	Community Liaison Manager	All scenarios

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV2	Management	Site Inductions	Noise and Vibration	<p>In accordance with CoA – C2 (k), a site specific induction will be provided to all site personnel, contractors and sub-contractors with an emphasis on understanding and managing noise impacts from the work activities being undertaken.</p> <p>This will include the location of receptors, specific mitigation measures, site hours of operation, noise complaints procedure, etc. as well as the consequences of not complying with these mitigation measures.</p>	Environment Manager	All Scenarios
CNV3	Management	Behavioural Practices	Noise and Vibration	<p>At no time can noise generated by construction exceed the National Standard for exposure to noise in the occupational environment of an eight-hour equivalent continuous A-weighted sound pressure level of Leq,8h of 85dBA for any employee working at a location near the Project.</p> <p>Refer to Section 7 of this Plan for further detail.</p>	Environment Manager	All Scenarios
CNV4	Management	Noise Monitoring	Noise	<p>Refer to Section 8 of this Plan for further detail.</p> <p>Operator attended noise monitoring and vibration monitoring will be undertaken during in the early</p>	Environment Manager	All Scenarios

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV5	Management	Vibration Monitoring	Vibration	<p>phases of work to verify predicted noise levels and confirm that vibration levels satisfy the criteria. This will determine the appropriate mitigation and management measures required for remaining works.</p> <p>In accordance with CoA – E37 and 38, the ICNG penalties identified for ‘particularly annoying’ activities (that require the addition of 5dBA to the predicted level before comparing to the construction NML) will be applied.</p> <p>In accordance with CoA – E30 LOR must conduct vibration testing before and during vibration generating activities that have the potential to impact on heritage items (i.e. Mortuary Station) to identify minimum working distances to prevent cosmetic damage.</p>	Environment Manager	SCN01 SCN02, SCN04, SCN05 and SCN06 (Refer to Table 8.1 and Table 8.2)

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV6	Source Control	Construction Hours and Scheduling	Noise and Vibration	<p>Where feasible and reasonable, construction will be carried out during the standard daytime working hours. The approved CoA – E36 SYAB standard construction hours are as follows:</p> <p>All general construction works and activity will be scheduled to occur between these hours, unless OOHW becomes necessary:</p> <ul style="list-style-type: none"> • 7:00am to 6:00pm Mondays to Fridays, inclusive; • 8:00am to 1:00pm Saturdays; and • at no time on Sundays or public holidays. <p>High noise generating activities would be scheduled for less sensitive period considering the nearby receptors as per PIR Condition NV1</p> <p>Refer Section 4 of this plan for further detail.</p>	Environment Manager Site Supervisor	All Scenarios (The Sydney Metro OOHW Protocol and OOHW Application Form will also be applied for any work outside the approved hours)

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV7	Source Control	Construction Respite Period	Noise and Vibration	<p>In accordance with EPL 12208, high noise impact generating activities may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block between the hours of 8:00am and 10:00pm Monday to Friday and between 0800am and 6:00pm Saturdays and Sundays. For high noise generating activities that need to be undertaken in a rail possession outside of these hours an EPL variation will be required.</p> <p>In accordance with CoA – E37, all receptors with the potential to experience internal noise levels of $L_{eq} 15$ minute 60 dBA from construction works and activities will be identified and where applicable works scheduled to occur between these hours 7am and 8pm to meet this criterion (refer to CNVIS for background information).</p> <p>In accordance with CoA – 38 and CoA – 39 LOR will take reasonable steps to coordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receptor</p> <p>In accordance with CoA 46 rock breaking and other particularly annoying activities are not permitted outside of standard construction hours, except at Central, unless the noise management level derived from the Interim Construction Noise Guideline can be achieved at sensitive receptors.</p> <p>Refer Section 4 of this plan for further detail.</p>	Environment Manager Site Supervisor	All scenarios where high noise and vibration generating activities are planned (Refer to Table 8.1 and Table 8.2)

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV8	Source Control	Equipment Selection	Noise	<p>Quieter and less vibration emitting construction methods will be used where feasible and reasonable. The following will occur:</p> <ul style="list-style-type: none"> • Selection plant and equipment based on least noise emission levels where reasonable • Select materials which require lower vibration generating activities to occur e.g. less compaction etc. • Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including excavators and trucks • Plant and equipment will be regularly maintained and repaired or replaced if it becomes noisy • Silenced generators and compressors will be used where possible • Quiet plant and processes will be selected wherever feasible, specifically, reversing alarms will be procured or retrofitted that are quieter and display less annoying characteristics. Such alarms will include “smart alarms” and “quacker alarms” will occur where possible. • Maximise use of hydraulic concrete shears in lieu of dampened hammers/rock breakers during demolition. The terrace structures on Regent St do not contain large amounts of reinforced concrete and are not anticipated to require extensive hydraulic hammer/shear use. 	<p>Environment Manager</p> <p>Site Supervisor</p>	All Scenarios

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV9	Source Control	Maximum Noise Levels	Noise	The noise levels of plant and equipment will be selected to have operating Sound Power Levels compliant with the values presented in Table 5.2 of this Plan.	Environment Manager	All Scenarios
CNV10	Source Control	Rental Plant and Equipment	Noise	Table 11 and 12 of the CNVS (or AS2436) will be utilised where necessary e.g. new equipment are introduced to the works.	Environment Manager	All Scenarios
CNV11	Source Control	Plan worksites and activities to minimise noise and vibration.	Noise	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.	Environment Manager	All scenarios
CNV12	Source Control	Non-tonal reversing alarms.	Noise	Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site (and for any out of hours work) where appropriate.	Site Supervisor	All Scenarios

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV13	Source Control	Use and siting of plant.	Noise and Vibration	<p>The Construction Noise and Vibration Strategy would be implemented with the aim of achieving the noise management levels where feasible and reasonable. This would include the following example standard mitigation measures where feasible and reasonable:</p> <ul style="list-style-type: none"> • Provision of hoarding around the demolition site • Where feasible, simultaneous operation of noisy plant would be avoided. • The offset distance between noisy plant and adjacent sensitive receptors will be maximised. • Plant used intermittently to be throttled down or shut down. • Noise-emitting plant to be directed away from sensitive Receptors. • Select and use lower vibrating generating equipment • Adhere to the safe working distances identified in Section 6.1.2 • Residential grade mufflers will be fitted to all mobile plant • Maximise use of hydraulic concrete shears in lieu of dampened rock hammers • Non-tonal reversing alarms will be fitted to all permanent mobile plant • The layout of construction sites will consider opportunities to shield receptors from noise. 	Environment Manager Site Supervisor	All Scenarios

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV14	Source Control	Minimise disturbance arising from delivery of goods to construction sites.	Noise	<p>Construction vehicles will be operated so as to minimise any construction noise impacts from the construction site. To achieve this the following will occur:</p> <ul style="list-style-type: none"> • Loading and unloading of materials/deliveries will occur as far as possible from receptors. • Site access points and roads will be selected as far as possible away from receptors. • Dedicated loading/unloading areas to be shielded if close to receptors. • Delivery vehicles will be fitted with straps rather than chains for unloading, wherever reasonable and feasible. • Delivery personnel and truck drivers to be made aware of approved haulage routes and access in and out of the construction site. • Prevention of vehicles and plant queuing and idling outside the site prior to the morning start time. • Pre-determined delivery times will be issued to suppliers and radio communication will be used to confirm status of the delivery. • Any unsatisfactory noise performance for specific vehicles and/or the operators will be dealt with on a case by case basis. 	Environment Manager Site Supervisor	All Scenarios

ID	Measure	Action Required	Applies To	Details	Responsible	Applicable to SYAB Work Phase or Activity
CNV15	Emission Path (source to receptor)	Shield stationary noise sources such as Cranes and Concrete Pumps etc.	Noise	<p>This may include a site boundary fence optimised to reduce construction noise.</p> <p>Where item specific shielding becomes necessary, stationary noise sources will be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained.</p> <p>Guidance for noise reducing shielding/barriers will be taken from AS2436 or other relevant standards where necessary.</p>	Environment Manager	All Scenarios where item specific shielding becomes necessary (Refer to Table 8.1)
CNV16	Emission Path (source to receptor)	Shield sensitive receptors from noisy activities.	Noise	<p>This may include a site boundary fence optimised to reduce construction noise.</p> <p>Where shielding becomes necessary, structures will be used to shield residential receptors from noise.</p> <p>This may include site shed placement; fencing; when situating plant.</p> <p>Guidance for noise reducing shielding/barriers will be taken from AS2436 or other relevant standards where necessary.</p>	Environment Manager	All Scenarios – this measure will be considered on a case by case basis and incorporated into the construction design if feasible and reasonable.
CNV17	Emission Path (source to receptor)	Safe Working Distances	Vibration	Refer Section 6.1.2	Environmental Manager	SCN01 SCN02, SCN04, SCN05 and SCN6 (Refer to Table 8.2)

6.1.1 Construction Observed to Exceed Management Levels

Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.

Where construction is observed to exceed management levels the following will occur:

- Alternate work methodologies and plant will be investigated and considered to lower noise levels of construction works at the relevant receptors;
- Excessively noisy or vibration generating activities would cease or reduced under direction of the Environment Manager or Site Supervisor. Remedial measures would be implemented prior to recommencing work, and monitoring undertaken to verify noise or vibration levels if necessary;
- Plant and machinery will be checked and verified for noise levels and appropriate exhaust/fittings/noise attenuators.
- In the event of appreciable vibration levels arising, measures would be put in place to reduce vibration to within acceptable levels. Such measures may include reducing equipment size, changing operational settings, using other plant in lieu of that which is generating the vibration or a combination of these.

These actions are the responsibility of the Environment Manager and Site Supervisor and will be documented with the monthly environmental reporting refer **Section 8.1.8**.

6.1.2 Ground Vibration – Safe Working Distances

In accordance with the CNVS, attended vibration measurements are required 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 would be conducted at the nearest sensitive receptors whenever vibration generating activities need to take place inside the calculated safe-working distances.

The TfNSW CNS defines safe working distances for vibration intensive activities. As was adopted for the CNVIS and reproduced in **Table 6.2**. These safe work distances will be adopted during SYAB works as a guideline to determine further mitigation. The safe working distances are defined for both cosmetic damage (BS 7385) and human comfort (the NSW Vibration Guideline).

Table 6.2 Safe Working Distances

Plant Item	Rating/Description	Safe Working Distance – metres (m)	
		Cosmetic Damage (BS 7385)	Human Comfort (the NSW Vibration Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m

Plant Item	Rating/Description	Safe Working Distance – metres (m)	
		Cosmetic Damage (BS 7385)	Human Comfort (the NSW Vibration Guideline)
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	n/a
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Source: CNS

These safe working distances are indicative only and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

For significant equipment not listed above or for any highly sensitive receptors identified during works, specific assessment may be undertaken during works to ensure satisfactory operation of the equipment and to determine if any other mitigation or management measures are required to minimise the potential impacts.

In relation to human comfort, the safe working distances above relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed. A targeted assessment may be undertaken during works to evaluate any decrease in human comfort safe work distance offsets and to determine if any other mitigation or management measures are required to minimise the potential impacts.

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 6.2** 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. Refer to **Section 8** for vibration monitoring requirements.

6.1.3 Managing Potential Impacts to Heritage Structures

Details of specific monitoring requirements for heritage structures are described in **Section 8**. The monitoring is designed to prevent damage to any heritage items and includes procedures for identifying minimum working distances.

Impacts to heritage structures are not expected, such that detailed options for any alteration of construction methodology will be evaluated and implemented on a case-by-case basis and if specific circumstances arise that deem it necessary.

This management practice will be based on the monitoring procedures described in **Section 8** of this CNVMP. The Mortuary Station has been identified as a state significant heritage structure in close proximity to the site and will therefore require monitoring to confirm that vibration levels satisfy the heritage criteria specified by DIN4150:3.

6.2 Additional Mitigation Measures

The CNVIS has concluded that noise and vibration impacts associated with SYAB works are likely to occur. A range of feasible and reasonable mitigation measures designed to minimise noise and vibration levels at the nearest receptors have been established as documented in **Section 6.1** of this CNVMP. These standard measures will be implemented during SYAB works in accordance with Section 7 of the CNVS, consistent with the intent of the ICNG and to achieve all CoA.

The implementation of the standard mitigation measures and community consultation should significantly reduce the noise and vibration impacts on nearby sensitive receptors. Nevertheless, due to the highly variable nature of activities associated with the SYAB construction; noise and vibration exceedances could occur under exceptional circumstances.

As this potential exists a number of additional measures to mitigate such exceedances (primarily aimed at pro-active engagement with affected sensitive receptors) should be explored as per the requirements of Section 8 of the CNVS and have been included in this CNVMP. The additional mitigation measures to be applied are outlined in **Table 6.3** below. Additional mitigation measures will apply to residential receivers located in non-residential zones if the noise and vibration levels outlined in CoA E41 are reached, and residential receivers located in residential zones if the noise and vibration levels outlined in CoA E42 are reached.

A full description of each measure is provided in Appendix C of the CNS.

Table 6.3 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

In circumstances where, after the application of the standard mitigation measures, the construction noise and vibration levels are still predicted to exceed the noise or vibration objectives, the relevant Additional Mitigation Measures Matrix (AMMM) from the CNVS are to be used to determine the additional measures to be implemented.

Using the relevant AMMM, the following steps will be carried out to determine the additional mitigation measures to be implemented:

- Determine the time period when the work is to be undertaken;

- Determine the level of exceedance; and
- Identify the relevant additional mitigation measures from **Table 6.3**, **Table 6.4** and **Table 6.5**.

The relevant AMMM for the SYAB air-borne noise is reproduced in **Table 6.4** and the relevant AMMM for the SYAB ground-borne vibration is reproduced in **Table 6.5**. Those applicable to ground-borne noise are excluded from this CNVMP as any impacts are unlikely to occur.

Table 6.4 Additional Mitigation Measures Matrix (AMMM) – (Airborne Construction Noise)

Time Period		Mitigation Measures			
		Leq, 15minute Noise Level above Background (RBL) in dBA			
		0 to 10	11 to 20	21 to 30	>30
		Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive
Standard	Mon-Fri (7am-6pm)				
	Sat (8am-1pm)	-	-	M, LB	M, LB
	Sun/Pub Hol (Nil)				
OOHW Period 1	Mon-Fri (6pm-10pm)				
	Sat (7am-8am & 1pm-10pm)	-	LB	M, LB	M, IB, LB, PC, RO, SN
	Sun/Pub Hol (8am-6pm)				
OOHW Period 2	Mon-Fri (10pm-7am)				
	Sat (10pm-8am)	LB	M, LB	M, IB, LB, PC, SN	AA, M, IB, LB, PC, RO, SN
	Sun/Pub Hol (6pm-7am)				

Source: CNVS

Table 6.5 Additional Mitigation Measures Matrix (AMMM) – (Ground-borne Vibration)

Time Period		Mitigation Measures	
		Predicted Vibration Levels Exceed Maximum Levels (refer Table 4.5 for criteria)	
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 & 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)		
<i>Source: CNVS</i>			

Guidance Note

As stated in the CNVS (and as applicable to any additional mitigation considered) for some types of construction activities, a qualitative assessment of the potential noise impacts can be undertaken in lieu of detailed noise modelling. For these activities, noise mitigation measures should be evaluated on the basis of the noise levels being noticeable, clearly audible, moderately intrusive or highly intrusive.

The qualitative assessment should consider the type of equipment being used, the character of the noise emissions, times of day, the location of the nearest receptors and the noise sensitivity of the nearest receptors.

For the SYAB works, potential noise and vibration impacts for activities undertaken during the standard hours of construction have been comprehensively assessed in the CNVIS via modelling. Such that any qualitative assessment will be limited to new or ad-hoc works not considered in the CNVIS.

7. Training

As per the **CoA – C2 (k)**, recommendations of the CNVIS and commitments made in the EIS, training will be undertaken in accordance with the SYAB CEMP and any additional measures set out in the SYAB sub-plans, including this CNVMP.

In summary, all site personnel, contractors and sub-contractors shall undergo site specific induction training, which will include noise and vibration management training developed with an emphasis on understanding and managing impacts from the work activities being undertaken.

This site specific induction training will include:

- the location of potentially sensitive receptors;
- site hours of operation i.e. the permissible hours of work, including deliveries;
- any limitations on high noise generating activities;
- construction employee parking areas;
- details of the complaints handling procedure; and
- details of the environmental incident procedures.

The site specific induction will also outline the consequences of not complying with these measures.

Toolbox meetings will also be undertaken as and when required; covering specific environmental issues and will include noise and vibration control measures where required, including but not limited to:

- Ensuring work occurs within approved hours;
- Relevant noise and vibration mitigation measures;
- Locating noisy equipment away from sensitive receptors;
- Ensuring plant and equipment is well maintained and not making excessive noise;
- Emphasis that there should be no swearing, shouting or loud stereos/radios on site
- Turning off machinery when not in use; and
- Designated loading/unloading areas and procedures.

Toolbox training on noise and vibration management requirements and measures will be completed by the Environmental Manager (or nominated delegate) during the Project.

Personnel directly involved in implementing noise and vibration control measures on site will be given specific training in the various measures to be implemented. Records of all training will be filed in accordance with LOR project filing system.

8. Noise and Vibration Monitoring Program

Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals (as is the case for select SYAB works), noise or vibration monitoring may 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. In accordance with CoA – C9 and C10, this section of the CNVMP provides a monitoring program for noise and vibration.

8.1 Baseline data

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 was no requirement or benefit for measuring existing vibration levels during pre-construction as they are typically (in the absence of any significant vibration generating source) imperceptible. Nonetheless, monitoring during construction has found perceptible background levels of vibration due to the close proximity of railway operations to the project. 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 8.1. 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 8.1 – 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.

8.2 General Monitoring Requirements

All construction noise and vibration monitoring will be undertaken in accordance with the construction noise and vibration monitoring guideline which is included in Appendix A of the CNVS. This outlines the minimum requirements for contractors undertaking monitoring on the Sydney Metro Project. Requirements for further consultation are detailed in Sections 4, 9 and 10 of this CNVMP:

In accordance with the CNVIS, attended measurements will be the focus of all noise monitoring however unattended noise (and vibration) monitoring may be undertaken where specific circumstances warrant. The benefit of attended noise monitoring is that the results can be fed back directly to the Project team and actions taken without delay. For vibration it is typical that unattended monitoring is undertaken, however the device may be observed by LOR (or their specialist) during the early stages of certain works to provide real time feedback of results to the Project team, based on which actions can be taken without delay.

A Noise and Vibration and Blast Monitoring Plan has been prepared by Sydney Metros in accordance with **CoA – C11**. Monitoring data will be available to the construction team, LOR, ER, AA, the Department and the EPA as required. Unattended monitoring will continuously measure noise or vibration levels for the duration of the monitoring period, except during device maintenance or down time. Real time noise logging will be undertaken at the nearest sensitive receiver from commencement of construction to the completion of the bridge superstructure (end February 2018) so as to cover the key risk periods during noisy works in rail possessions. Further detail on noise and vibration requirements are outlined below.

All attended measurements will be conducted by appropriately trained personnel in the measurement and assessment of construction noise and vibration. They will be familiar with the requirements of the relevant standards and procedures.

8.2.1 Noise Measurement Requirements

Attended noise measurements will be conducted by an operator using a hand held Type 1 or Type 2 'integrating-averaging' sound level meter. The device will be calibrated prior to and after all measurement rounds, with any change in calibration levels noted. Measurements will be completed with the sound level meter mounted to a tripod (if possible) and with a windscreen fitted. Instantaneous noise levels for all noted noise emission sources (extraneous or otherwise), meteorological conditions (average and maximum wind speeds, temperature, precipitation and cloud cover etc.) shall be recorded during all measurements. The location of monitoring, time of measurement and all relevant measurement parameters (i.e. LAeq, LAmin, LAmax, LA1, LA10 and LA90) should also be recorded.

Unattended noise measurements would be conducted using a Type 1 or Type 2 environmental noise logger. The device will be calibrated prior to and after installation (and periodically during the monitoring period), with any change in calibration levels noted. Measurements will be completed with a windscreen fitted.

Noise monitoring will not be completed within 3 m of any reflective structure or wall, if possible. Where it is not possible to measure more than 3 m from any reflective structure or wall, a reduction of up to 2.5 dB will be applied to the measured ambient and site noise contribution (LAeq, 15 minute) to account for the likely increase in noise associated with reflective surfaces. No noise monitoring will be completed during periods where wind speeds exceed 5 m/s at the microphone or during any rain events.

Monitoring will be conducted as per the requirements of this CNVMP and with due regard to AS1055; AS61672, AS1259 (or similar); IEC60942; or the NSW Vibration Guideline as relevant to the monitoring being conducted.

All noise samples shall be recorded using the "fast" time response of the sound level meter.

Site activity records will be maintained during any noise (or vibration) monitoring events.

8.2.2 Vibration Measurement Requirements

Unattended vibration monitoring would be undertaken with due regard to and in accordance with the requirements of the CNVS and ICNG using a calibrated vibration logger.

When vibration intensive activities are required e.g. vibratory compaction and demolition, the device will be placed (fixed to the structure, or embedded in the ground nearby the structure) at the potentially most affected receptor or structure prior to works commencing.

Where other activities are identified to include risk that levels may exceed structural damage criteria attended vibration monitoring will also be conducted, with measured values to be observed during the first 30 minutes of works to ensure structural damage criteria are not exceeded.

The device will be set to continuously record vibration levels (Peak Particle Velocity (PPV) data in mm/s) at sample intervals (e.g. 5 second, 15 second or 1 minute) appropriate to the activity. Vibration Dose Values (VDV, m/s^2) are reliant on 1) the duration of vibration events and 2) the component frequency (in Hz) associated with the vibration being generated. Hence VDV will be estimated and evaluated regularly during the early stages of the activity and monitoring period. A PPV trigger level will be established during these early stages to inform the real time management of vibration e.g. alternate construction methods or respite.

8.2.3 Noise Monitoring in the Community

Attended noise measurements will be undertaken at the potentially most affected receptors identified in the CNVIS (**R4 (A)**) 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 will also be considered as part of the monitoring regime depending on the phase of works.

Noise monitoring will be undertaken on all work phases as detailed in **Table 6.1**. Monitoring for the Project will be required 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 would be conducted at the most affected receptor in accordance with Appendix A of the CNVS.

Community noise monitoring will ensure the LA_{eq, 15minute} and LA_{90, 15minute} parameters are recorded as a minimum. The site noise level contribution (LA_{eq, 15minute}) shall be determined in the absence of any influential source not associated with the SYAB works for direct comparison to the relevant criteria. The LA_{max}, LA_{min}, LA₁ and LA₁₀ parameters should be recorded for each measurement with the LA_{1, 1minute} parameter measured directly or calculated where possible and if applicable.

The community noise measurement sample height will be 1.5 m above ground level. The duration of each community noise measurement sample will be 15 minutes. All measurements will be completed with the sound level meter mounted to a tripod (if possible) and with a windscreen fitted. The devices microphone will be focused on the noise emission centre of the equipment being tested.

If community noise monitoring identified that predicted noise levels are being exceeded, LOR will revisit construction practices/sequencing etc. in order to reduce noise levels, minimise impacts and to enable provision of information on noise levels to surrounding and potentially affected residents should this be required (i.e. on request or following a complaint).

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 above.

A summary of the SYAB noise monitoring program is given below in table 8.2.

Table 8.2 - SYAB noise monitoring program summary

ID	Work Phase	Noise Monitoring Type	Location	Frequency
SCN01	Demolition of Terrace Buildings	Real time monitoring	R4	• Daily during works with rock breaker or hydraulic shears

ID	Work Phase	Noise Monitoring Type	Location	Frequency
SCN02	Site Investigation and Setup	Attended	R4	<ul style="list-style-type: none"> During OOH works (rail possessions)
SCN03	Removal of part of Up Shunting Neck	Real time monitoring	R4	<ul style="list-style-type: none"> During OOH works (rail possessions)
SCN04	Piling of Bridge Abutments & Piers	Real time monitoring	, R4	<ul style="list-style-type: none"> Commencement of piling works at each abutment location During OOH works (rail possessions)
SCN05	Abutments and Piers - Precast	Real time monitoring	, R4	<ul style="list-style-type: none"> Commencement of each activity then weekly During OOH works (rail possessions)
SCN06	Abutments and Piers – Cast in Situ	Real time monitoring	R4	<ul style="list-style-type: none"> Commencement of each activity then weekly During OOH works (rail possessions)
SCN07	Construction of Deck Spans	Real time monitoring	, R4	<ul style="list-style-type: none"> Commencement of each activity then weekly During OOH works (rail possessions)
SCN08	Construction of Reinforced Earth Wall	Real time monitoring	R4	<ul style="list-style-type: none"> During OOH works (rail possessions)
SCN09	Construction of Deck	Real time monitoring	R4	<ul style="list-style-type: none"> Commencement of each activity then weekly During OOH works (rail possessions)
SCN10	Regent St Services	Attended	R4,	<ul style="list-style-type: none"> During OOH works (road and footpath closures)

8.2.4 Vibration Monitoring in the Community

Vibration monitoring will be undertaken at the potentially most affected receptor identified in the CNVIS (**R4 (A)**) from the commencement of vibration generating activities to confirm that the vibration levels at the nearest sensitive receptor are compliant with the criteria outlined the CNVIS and **Section 4.3** of this CNVMP. Where there is potential for levels to exceed criteria, further vibration site law investigations will be undertaken to determine the site-specific safe working distances for that vibration generating activity. Additionally noise and/or vibration monitoring may be required at any receptor in response to a complaint which may arise at any stage during the construction works.

If and when site specific safe working distances are established, continuous unattended vibration monitoring will be conducted at the nearest sensitive receptors whenever vibration generating activities need to take place inside the calculated site specific safe-working distances.

At this stage any vibration monitoring will target SCN01 with monitoring of other work phases and activities being considered on a case by case basis, as detailed in **Table 6.1**.

The implementation of all noise and vibration mitigation measures will be monitored regularly throughout the works and audited as per the CEMP audit cycle. Where vibration levels are measured and verified to be compliant, no further vibration monitoring may be undertaken, unless for example complaints for human comfort are received.

The **Mortuary Station** has been identified as a state significant heritage structure in close proximity to the site and therefore requires monitoring in the early stages of work to confirm that vibration levels satisfy the heritage criteria from DIN 4150.

Other heritage buildings and structures would be assessed as per the screening criteria in **Section 4.3** as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound.

In accordance with CoA - E31, LOR have sought the advice of a heritage specialist on methods and locations for installing equipment used for vibration, movement and noise monitoring of heritage-listed structures.

A summary of the SYAB vibration monitoring program is given below in table 8.3.

Table 8.3 - SYAB vibration monitoring program summary

ID	Work Phase	Vibration Monitoring Type	Location	Frequency
SCN01	Demolition of Terrace Buildings	Unattended	R4	<ul style="list-style-type: none"> Daily during demolition works
SCN02	Site Investigation and Setup and Demobilisation	Unattended	Mortuary Station	<ul style="list-style-type: none"> Daily during installation of site compound offices and fencing adjacent Mortuary Station
SCN03	Removal of part of Up Shunting Neck	N/A	N/A	<ul style="list-style-type: none"> No vibration intensive works required
SCN04	Piling of Bridge Abutments & Piers	Unattended	R4,	<ul style="list-style-type: none"> Commencement of piling works at each abutment location to confirm compliance with criteria
SCN05	Abutments and Piers - Precast	Unattended	R4,	<ul style="list-style-type: none"> Commencement of each activity to confirm compliance with criteria
SCN06	Abutments and Piers – Cast in Situ	Unattended	R4,	<ul style="list-style-type: none"> Commencement of each activity to confirm compliance with criteria
SCN07	Construction of Deck Spans	N/A	N/A	<ul style="list-style-type: none"> No vibration intensive works required
SCN08	Construction of Reinforced Earth Wall	N/A	N/A	<ul style="list-style-type: none"> No vibration intensive works required
SCN09	Construction of Deck	N/A	N/A	<ul style="list-style-type: none"> No vibration intensive works required
SCN10	Regent St Services	N/A	N/A	<ul style="list-style-type: none"> No vibration intensive works required



Figure 8.1 - SYAB sensitive receiver locations

8.2.5 Actions Following Monitoring in the Community

Actions to mitigate or manage noise or vibration emissions will be considered as per the measures described in **Section 6** of this CNVMP and the overall monitoring protocol identified in **Figure 8.2** below.

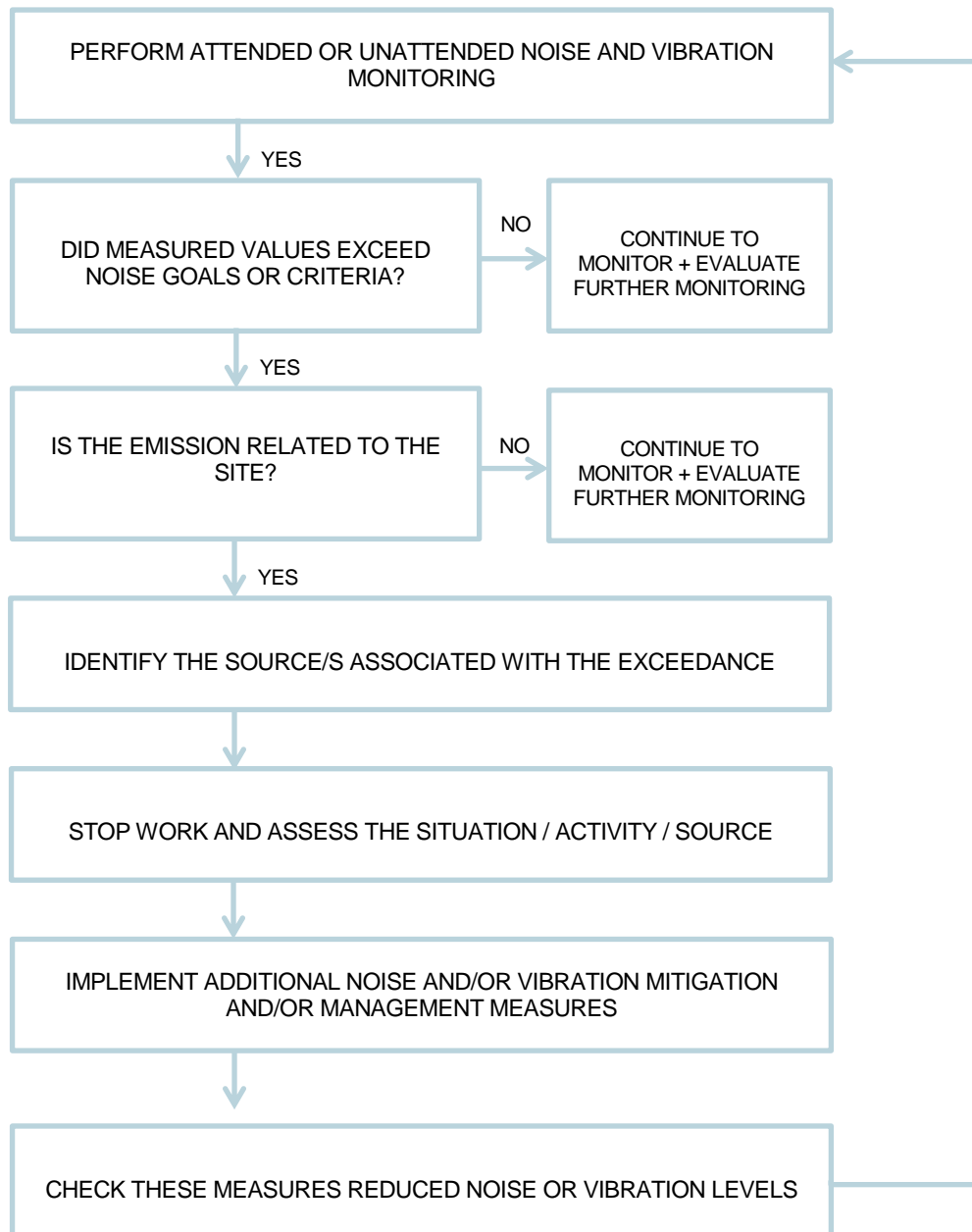


Figure 8.2: Monitoring and Action Protocol

8.2.6 Maximum Noise Levels for Plant and Equipment

All significant noise generating items of plant would have noise audits conducted in accordance with Section 9 of the CNVS. Where required, plant and equipment would be measured while operating under typical conditions. If this is not practical, it may be appropriate to conduct a stationary test at high idle. In the case of a sound power level exceeding the values identified in **Table 5.2** the item of plant would either be replaced, or the advice of an acoustic consultant would be sought to provide suitable mitigation measures.

8.2.7 Noise and Vibration Reporting

All noise and vibration monitoring results would be assessed against the nominated goals. Noise and vibration reporting will be included in the monthly environmental reporting as per conditions of the SMR-E and the monthly noise and vibration report prepared by the AA as per **CoA – A27**. Also as per **CoA - C16**, the results of the Construction Monitoring Program must be submitted in a Construction Monitoring Report to EPA and the City of Sydney Council and the DPE for information on a monthly basis.

The following should be included in as a minimum (where relevant) in noise/vibration monitoring reports:

- The type of monitoring conducted (for example, at a particular project stage or following complaints) and a brief statement of the measurement method;
- The noise/vibration conditions on the consent / licence, or the relevant noise management objectives;
- Descriptions of the nearest affected residences and other sensitive land uses or, in the case of complaints, description of the complainant location and complaint;
- Description of the instrumentation used;
- The results of monitoring at each monitoring location, including a comparison with the consent conditions or relevant noise management objectives;
- Vibration monitoring results summary together with notes describing any vibration intensive activities (if applicable);
- Summary of measurements exceeding the vibration criteria levels and descriptions of the plant or operations causing these exceedances (if available);
- Details of corrective action applicable to vibration criteria exceedances and confirmation of its successful implementation. Where corrective action has not yet been implemented, it may be shown as pending and the status of its implementation will be carried forward to following reports;
- The location of the construction works in relation to the monitoring position. (sketch plan & sections, photos);
- Details of the various construction equipment in use during the measurement period;
- Details as to the likely dominant noise sources;
- Meteorological conditions (i.e. temperature, humidity, cloud cover, and wind speed and direction);
- A clear statement outlining the Project's compliance or non-compliance with the conditions or objectives where the monitored level is higher than the conditions or objectives; and
- The reasons for non-compliance should be stated, strategies for minimising noise identified and stated, and the appropriate actions to implement the mitigation and or management strategies.

9. Enquiries, Complaints and Incident Management

All complaints handling would be in accordance with the Sydney Metro Construction Complaints Management System. All community consultation would be in accordance with Sydney Metro Overarching Stakeholder and Community Involvement Plan. Various lines of communication will be made available for enquiries and complaints during construction of the Project with suitably qualified or experienced personnel made available to manage and respond, refer **Table 10.1**.

Complaints arising from Project works will be treated sensitively and in a manner that recognises the potential for noise and vibration to cause environmental impacts. Special consideration will be given to complaints related to noise and vibration during highly intrusive works (particularly those activities when increased impacts are predicted) in order that any necessary additional mitigation can be implemented in a timely manner.

10. CNVMP Administration

Specific operational controls to manage environmental issues are defined in either or all of the following:

- ERAPs
- CEMP Sub-plans as standalone documents
- SWMS, JSEA's, HAZID, CRAW, Inspection and Test Plans / check sheets (as appropriate)
- Work instructions (e.g. refuelling and servicing)

Significant environmental issues, with a risk ranking of High (10 – 16) or Medium (5 – 9), will be controlled Environmental Risk Action Plans and issue specific Sub-plans as required.

Additional controls and criteria will be established and maintained where the absence of such could result in the environmental policy, objectives and targets not being met.

10.1 Pre-construction Compliance Requirements and Hold Points

The activities outlined in the table below are not to proceed without objective review and approval by the nominated authority. These hold points should be incorporated into the working plans for the project (SWMS, work instructions, construction methodologies, etc.)

Table 10.1 Hold Points

Item	Process Held	Acceptance Criteria	Approval Authority
Construction Environmental Management Plan and sub-plans	Site activities	Site specific Construction Environmental Management Plan and sub-plans have been developed, reviewed and approved.	Department of Planning and Environment.
Out of Hours Work (OOHW)	Works to be performed outside of approved construction hours	OOHW Protocol and Application Form and Community Notification EPL 12208	ER/Acoustic Advisor (Endorsement) TfNSW (Approval) EPA (Information to be provided on request)

10.2 Roles and Responsibilities

Relevant roles and responsibilities associated with this CNVMP are presented in **Table 10.1**.

Table 10.2 Roles and responsibilities

Roles	Responsibilities
Environment Manager / Site Supervisor	<ul style="list-style-type: none"> • Oversee the overall implementation of this CNVMP • Ensure that sufficient resources are allocated for the implementation of this CNVMP • Consider and advise senior management on compliance obligations • Ensure that the outcomes of compliance monitoring / incident reporting are systematically evaluated as part of ongoing management of construction activities • Ensure all appropriate noise and vibration mitigation measures are implemented • Where standard mitigation measures are deemed insufficient, undertake reasonable steps to manage adverse impacts and implement all additional measures • Authorise cessation of construction activities on-site if exceedances are identified • Ensure construction activity records / monitoring records/ incident reports are kept and maintained on-site • Ensure audits of construction site activity records / monitoring records/ incident reports are undertaken as needed, findings are shared with relevant site personnel and corrective actions are implemented • Ensure all relevant personnel have and understand the most up-to-date copy of this CNVMP • Ensure that all requirements of this CNVMP are effectively implemented • Ensure that any required actions arising from incident investigation processes during compliance construction monitoring are reported to the relevant personnel for further action and ensure that the actions are effectively implemented • Coordinate the implementation of monitoring requirements and corrective actions • Ensure that experienced, trained or qualified personnel conduct the noise (or vibration) monitoring • Ensure all monitoring reporting requirements are met and maintained on site • Acts as a primary site contact for any valid complaints received via the Community Liaison Manager • Authorise all monitoring reports and any revisions to this CNVMP
Site personnel and subcontractors	<ul style="list-style-type: none"> • Understand and implement mitigation as required in the CNVMP and any additional required measures identified during construction • Participate (or conduct if authorised) in relevant training to implement the requirements of this CNVMP
Noise and Vibration Monitoring Personnel (LOR / consultants)	<ul style="list-style-type: none"> • Undertake relevant training to implement the requirements of this CNVMP • Undertake all monitoring activities in accordance with this CNVMP • Ensure regular maintenance of monitoring equipment • Ensure all relevant monitoring quality control / assurance procedures are effectively implemented

Roles	Responsibilities
Environment Representative	<p>In accordance with CoA - A24 the ER has the following roles and responsibilities:</p> <ul style="list-style-type: none"> • receive and respond to communications from the Secretary in relation to the environmental performance of the CSSI • consider and inform the Secretary on matters specified in the terms of this approval • consider and recommend any improvements that may be made to work practices to avoid or minimise adverse impact to the environment and to the community • review all documents required to be prepared under the terms of the CoA, ensure they address any requirements in or under the CoA and if so, endorse them before submission to the Secretary (if required to be submitted to the Secretary) or before implementation (if not required to be submitted to the Secretary) • review all noise and vibration documents required to be prepared under the terms of EPL 12208 and, should they be consistent with the EPL, endorse them before submission to Sydney Trains (if required to be submitted to the EPA) or before implementation (if not required to be submitted to the EPA); • regularly monitor the implementation of all documents required by the terms of the CoA or implementation in accordance with what is stated in the document and the terms of the CoA • notify the Secretary of an incident in accordance with CoA - A41 • as may be requested by the Secretary, help plan, attend or undertake Department audits of the CSSI, briefings, and site visits • if conflict arises between LOR and the community in relation to the environmental performance of the CSSI, follow the procedure in the Community Communication Strategy approved under CoA - B3 to attempt to resolve the conflict, and if it cannot be resolved, notify the Secretary; • review any draft consistency assessment that may be carried out by LOR, and provide advice on any additional mitigation measures required to minimise the impact of the work • consider any minor amendments to be made to the CEMP, CEMP sub-plans and monitoring programs that comprise updating or are of an administrative nature, and are consistent with the terms of the CoA and the CEMP, CEMP sub-plans and monitoring programs approved by the Secretary and, if satisfied such amendment is necessary, approve the amendment. This does not include any modifications to the terms of the CoA • assess the impacts of minor ancillary facilities as required by CoA - A18 • prepare and submit to the Secretary and other relevant regulatory agencies, for information, a monthly Environmental Representative Report detailing the ER's actions and decisions on matters for which the ER was responsible in the preceding month (or other timeframe agreed with the Secretary). The Environmental Representative Report must be submitted within seven (7) days following the end of each month for the duration of works and construction of the CSSI, or as otherwise agreed with the Secretary.
Acoustics Advisor	<p>In accordance with CoA - A25 the AA has the following roles and responsibilities:</p> <ul style="list-style-type: none"> • receive and respond to communication from the Secretary in relation to the performance of the CSSI in relation to noise and vibration; • consider and inform the Secretary on matters specified in the terms of this approval relating to noise and vibration; • consider and recommend, to LOR, improvements that may be made to

Roles	Responsibilities
	<p>work practices to avoid or minimise adverse noise and vibration impacts;</p> <ul style="list-style-type: none"> • review all noise and vibration documents required to be prepared under the terms of this approval and, should they be consistent with the CoA, endorse them before submission to the Secretary (if required to be submitted to the Secretary) or before implementation (if not required to be submitted to the Secretary); • review all noise and vibration documents required to be prepared under the terms of EPL 12208 and, should they be consistent with the EPL, endorse them before submission to Sydney Trains (if required to be submitted to the EPA) or before implementation (if not required to be submitted to the EPA); • regularly monitor the implementation of all noise and vibration documents required to be prepared under the terms of this approval to ensure implementation is in accordance with what is stated in the document and the terms of this approval; • notify the Secretary of noise and vibration incidents in accordance with CoA - A41; <p>In conjunction with the ER, the AA must:</p> <ul style="list-style-type: none"> • consider requests for out of hours construction activities and determine whether to endorse the proposed activities in accordance with CoA - E47; • as may be requested by the Secretary or Complaints Commissioner, help plan, attend or undertake audits of noise and vibration management of the CSSI including briefings, and site visits; • if conflict arises between LOR and the community in relation to the noise and vibration performance during construction of the CSSI, follow the procedure in the Community Communication Strategy approved under CoA - B3 to attempt to resolve the conflict, and if it cannot be resolved, notify the Secretary; • consider relevant minor amendments made to the CEMP, relevant sub-plans and noise and vibration monitoring programs that require updating or are of an administrative nature, and are consistent with the terms of CoA and the management plans and monitoring programs approved by the Secretary and, if satisfied such amendment is necessary, endorse the amendment. This does not include any modifications to the terms of the CoA; • assess the noise impacts of minor ancillary facilities as required by CoA – A18; and • prepare and submit to the Secretary and other relevant regulatory agencies, for information, a monthly Noise and Vibration Report detailing the AAs actions and decisions on matters for which the AA was responsible in the preceding month (or other timeframe agreed with the Secretary). The Noise and Vibration Report must be submitted within seven (7) days following the end of each month for the duration of construction of the CSSI, or as otherwise agreed with the Secretary.

10.3 CNVMP Review

The CNVMP will be reviewed on a case by case basis and where circumstances arise during the works that require amends to the plan. The type of circumstances that may trigger a CNVMP review could include, but are not limited to, significant changes in construction procedures, management protocols or environmental requirements; trends in validated noise or vibration complaints are identified; and/or an increase in noise and vibration impacts is identified.

Where noise (or vibration) levels are repeatedly identified (e.g. via monitoring) to be above management levels or the predicted values in the CNVIS, a review of this CNVMP will be undertaken. The following steps will be completed:

- review and identify the cause of any noise (or vibration) exceedances. This should focus on the plant, equipment or machinery in use at the time, or activities undertaken so that any trends can be identified;
- confirm the type and extent of any mitigation or corrective actions implemented during the non-compliant events;
- identify, develop and implement any opportunities for improvement or additional mitigation or management measures that will assist to minimise impacts associated with any trends; and
- revise this management plan document, or supplement this plan (e.g. with separate work instructions) to reflect the outcomes of the review.

The revised management plan (or supplementary documentation) will be developed to the satisfaction of the Environmental Manager, Environmental Representative and the Acoustics Advisor, so that the management strategy and management measures continue to assist to minimise impacts at receptors and to ensure that the plan remains an effective instrument for noise management and mitigation. Any review of the CNVMP will also be undertaken in consultation with relevant government agencies (i.e. Sydney City Council).

The CNVMP review will reflect these considerations and upon final approval of the revised CNVMP, the document will be circulated to relevant personnel.

11. References

- British Standard (BS 6472–1992) – **Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)** dated 1992
- 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
- Degnan Constructions Pty Ltd - **Sydney to Burwood Compressor House Detailed Design Operational Noise Assessment**, prepared by GHD Pty Ltd, dated November 2012
- German Institute for Standardisation – DIN 4150 (1999-02) Part 3 (DIN4150:3) – **Structural Vibration - Effects of Vibration on Structures**, dated 1999
- Laing O'Rourke - Sydney Metro City and Southwest Sydney Yard Access Bridge (K26-LOR-PLN-011) Draft **Construction Environmental Management Plan (CEMP)**, dated February 2017
- NSW Department of Environment and Climate Change – **NSW Interim Construction Noise Guideline (ICNG)**, July 2009
- NSW Department of Environment and Conservation – **NSW Environmental Noise Management – Assessing Vibration: a Technical Guideline** (the NSW Vibration Guideline), February 2006;
- NSW Department of Environment, Climate Change and Water – **NSW Road Noise Policy (RNP)**, March 2011
- NSW Environment Protection Authority – **NSW Environmental Noise Management – Industrial Noise Policy (INP)**, January 2000 and relevant application notes
- NSW Government – Sydney Metro **Construction Noise and Vibration Strategy (CNVS)**, August 2017
- NSW Government – Transport for NSW (TfNSW) **Construction Noise Strategy (CNS)**, April 2013
- Standards Australia AS 2436–2010™ (AS2436) – **Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites**
- Standards Australia AS1055–1997™ (AS1055) – **Description and Measurement of Environmental Noise**
- Standards Australia AS IEC 61672.1–2004™ (AS61672) – **Electro Acoustics - Sound Level Meters Specifications Monitoring** or Standards Australia AS1259.2-1990™ (AS1259) – **Acoustics – Sound Level Meters – Integrating/Averaging** as appropriate to the device
- Standards Australia AS/IEC 60942:2004/IEC 60942:2003 (IEC60942) – Australian Standard™ – **Electroacoustic – Sound Calibrators**
- TfNSW - Sydney Metro - Chatswood to Sydenham **Construction Environmental Management Framework (CEMF)** – Appendix B of SPIR, dated August 2016
- 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
- TfNSW - Sydney Metro - Chatswood to Sydenham **Sydney Metro Requirement- Environment – SYAB (SMR-E)**, dated August 2016
- TfNSW - Sydney Metro - Chatswood to Sydenham **Submissions and Preferred Infrastructure Report (SPIR)**, dated October 2016
- TfNSW – Power supply Upgrade Program – *Lee Street Substation Noise and Vibration Assessment* prepared by GHD Pty Ltd, dated February 2014
- WestConnex Enabling Works (Airport East) - Construction Noise & Vibration Impact Statement**, prepared for Roads and Maritime Services (RMS) by Wilkinson Murray, Version B - dated November 2014 (WM 2014). Refer <http://www.rms.nsw.gov.au/documents/projects/sydney-south/sydney-airport/westconnex-enabling-works-ref-appendix-h.pdf>
- Sydney Yard Access Bridge - Construction Noise and Vibration Impact Statement (CNVIS)**, prepared by ERM and dated April 2017

Appendix A – Acoustics: Glossary of Terms and Definitions

Noise is often defined as a sound, especially one that is loud or unpleasant or that causes disturbance or simply as unwanted sound, but technically, noise is the perception of a series of compressions and rarefactions above and below normal atmospheric pressure.

Vibration refers to the oscillating movement of any object. In a sense noise is the movement of air particles and is essentially vibration, though in regards to an environmental assessment vibration is typically taken to refer to the oscillation of a solid object(s). The impact of noise on objects can lead to vibration of the object, or vibration can be experienced by direct transmission through the ground, this is known as ground-borne vibration.

Essentially, noise can be described as what a person hears, and vibration as what they feel.

What Factors Contribute To Environmental Noise?

The noise from an activity, like construction works, at any location can be affected by a number of factors, the most significant being:

- How loud the activity is;
- How far away the activity is from the receptor;
- What type of ground is between the activity and the receptor location e.g. concrete, grass or water;
- How the ground topography varies between the activity and the receptor (is it flat, hilly, mountainous) as blocking the line of sight to a noise source will generally reduce the level of noise; and
- Any other obstacles that block the line of sight between the sources to receptor e.g. buildings or purpose built noise walls.

How To Measure And Describe Noise?

Noise is measured using a specially designed 'sound level' meter which must meet internationally recognised performance standards. Audible sound pressure levels vary across a range of 107 Pascals (Pa), from the threshold of hearing at 20 μ Pa to the threshold of pain at 200 Pa. Scientists have defined a statistically described logarithmic scale called Decibels (dB) to more manageably describe noise.

To demonstrate how this scale works, the following points give an indication of how the noise levels and differences are perceived by an average person:

- 0 dB - represents the threshold of human hearing (for a young person with ears in good condition);
- 50 dB – represents average conversation;
- 70 dB – represents average street noise, local traffic etc;
- 90 dB – represents the noise inside an industrial premises or factory; and
- 140 dB - represents the threshold of pain – the point at which permanent hearing damage may occur.

Human Response to Changes in Noise Levels

The following concepts offer qualitative guidance in respect of the average response to changes in noise levels:

- Differences in noise levels of less than approximately 2 dBA are generally imperceptible in practice, an increase of 2 dB is hardly perceivable;
- Differences in noise levels of around 5 dBA are considered to be significant;
- Differences in noise levels of around 10 dBA are generally perceived to be a doubling (or halving) of the perceived loudness of the noise. An increase of 10 dB is perceived as twice as loud. Therefore an increase of 20 dB is four times as loud and an increase of 30 dB is eight times as loud etc;
- The addition of two identical noise levels will increase the dB level by about 3 dB. For example, if one car is idling at 40 dB and then another identical car starts idling next to it, the total dB level will be about 43 dB;

- The addition of a second noise level of similar character which is at least 8 dB lower than the existing noise level will not add significantly to the overall dB level; and
- A doubling of the distance between a noise source and a receptor results approximately in a 3 dB decrease for a line source (for example, vehicles travelling on a road); and a 6 dB decrease for a point source (for example, the idling car discussed above). A doubling of traffic volume for a line source results approximately in a 3 dB increase in noise, halving the traffic volume for a line source results approximately in a 3 dB decrease in noise.

Terms to Describe the Perception of Noise

The following terms offer quantitative and qualitative guidance in respect of the audibility of a noise source:

- **Inaudible / Not Audible:** the noise source and/or event could not be heard by the operator, masked by extraneous noise sources not associated with the source. If a noise source is 'inaudible' its noise level may be quantified as being less than the measured LA90 background noise level, potentially by 10 dB or greater;
- **Barely Audible:** the noise source and/or event are difficult to define by the operator, typically masked by extraneous noise sources not associated with the source. If a source is 'barely audible' its noise level may be quantified as being 5 - 7 dB below the measured LA90 or LAeq noise level, depending on the nature of the source e.g. constant or intermittent;
- **Just Audible:** the noise source and/or event may be defined by the operator. However there are a number of extraneous noise sources contributing to the measurement. The noise level should be quantified based on instantaneous noise level contributions, noted by the operator;
- **Audible:** the noise source and/or event may be easily defined by the operator. There may be a number of extraneous noise sources contributing to the measurement. The noise level should be quantified based on instantaneous noise level contributions, noted by the operator; and
- **Dominant:** the noise source and/or event are noted by the operator to be significantly 'louder' than all other noise sources. The noise level should be quantified based on instantaneous noise level contributions, noted by the operator.

The following terms offer qualitative guidance in respect of acoustic terms used to describe the frequency of occurrence of a noise source during an operator attended environmental noise measurements:

- **Constant:** this indicates that the operator has noted the noise source(s) and/or event to be constantly audible for the duration of the noise measurement e.g. an air-conditioner that runs constantly during the measurement;
- **Intermittent:** this indicates that the operator has noted the noise source(s) and/or event to be audible, stopping and starting intervals for the duration of the noise measurement e.g. car pass-bys; and
- **Infrequent:** this indicates that the operator has noted the noise source(s) and/or event to be constantly audible, however; not occurring regularly or at intervals for the duration of the noise measurement e.g. a small number of aircraft are noted during the measurement.

How to Calculate or Model Noise Levels?

There are two recognised methods which are commonly adopted to determine the noise at particular location from a proposed activity. The first is to undertake noise measurements whilst the activity is in progress and measure the noise, the second is to calculate the noise based on known noise emission data for the activity in question.

The second option is preferred as the first option is largely impractical in terms of cost and time constraints, notwithstanding the meteorological factors that may also influence its quantification. Furthermore, it is also generally considered unacceptable to create an environmental impact simply to measure it. In addition, the most effective mitigation measures are determined and implemented during the design phase and often cannot be readily applied during or after the implementation phase of a project.

Because a number of factors can affect how 'loud' a noise is at a certain location, the calculations can be very complex. The influence of other ambient sources and the contribution from a particular source in question can be difficult to ascertain. To avoid these issues, and to quantify the direct noise contribution

from a source/site in question, the noise level is often calculated using noise modelling software packages. The noise emission data used in each noise model of this assessment has been obtained from ERM's database of measured noise emissions.

Acoustics Terminology and Statistical Noise Descriptors

Environmental noise levels such as noise generated by industry, construction and road traffic are commonly expressed in dBA. The A-weighting scale follows the average human hearing response and enables comparison of the intensity of noise with different frequency characteristics. Time varying noise sources are often described in terms of statistical noise descriptors. The following descriptors are commonly used when assessing noise and are referred to throughout this acoustic assessment:

- **Decibel (dB is the adopted abbreviation for the decibel):** the unit used to describe sound levels and noise exposure. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure;
- **dBA:** the unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear;
- **dBC:** the unit used to measure 'A-weighted' sound pressure levels. C-weighting is an adjustment made to sound-level measurements which takes account of low-frequency components of noise within the audibility range of humans;
- **dBZ or dBL:** the unit used to measure 'Z-weighted' sound pressure levels with no weighting applied, linear;
- **Hertz (Hz):** the measure of frequency of sound wave oscillations per second. 1 oscillation per second equals 1 hertz;
- **Octave:** a division of the frequency range into bands, the upper frequency limit;
- **1/3 Octave:** single octave bands divided into three parts;
- **Leq:** this level represents the equivalent or average noise energy during a measurement period. The Leq, 15minute noise descriptor simply refers to the Leq noise level calculated over a 15 minute period. Indeed, any of the below noise descriptors may be defined in this way, with an accompanying time period (e.g. L10, 15 minute) as required;
- **Lmax:** the absolute maximum noise level in a noise sample;
- **LN:** the percentile sound pressure level exceeded for N% of the measurement period calculated by statistical analysis;
- **L10:** the noise level exceeded for 10 per cent of the time and is approximately the average of the maximum noise levels;
- **L90:** the noise level exceeded for 90 per cent of the time and is approximately the average of the minimum noise levels. The L90 level is often referred to as the "background" noise level and is commonly used as a basis for determining noise criteria for assessment purposes;
- **Sound Power Level (LW):** this 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;
- **Sound Pressure Level (LP):** the level of sound pressure; as measured at a distance by a standard sound level meter with a microphone. This differs from LW in that this is the received sound as opposed to the sound 'intensity' at the source;
- **Background noise:** the underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the LA90 descriptor;
- **Ambient noise:** the all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far;

- **Cognitive noise:** the noise in which the source is recognised as being annoying;
- **Masking:** the phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.
- **Assessment Background Level (ABL):** is defined in the INP as a single figure background level representing each assessment period (day, evening and night). Its determination is by the tenth percentile method (of the measured LA90 statistical noise levels) described in Appendix B on the INP;
- **Rating Background Level (RBL):** is defined in the INP as the overall single figure background level representing each assessment period (day, evening and night) over the whole monitoring period (as opposed to over each 24hr period used for the ABL). This is the level used for assessment purposes. It is defined as the median value of:
 - all the day assessment background levels over the monitoring period for the day;
 - all the evening assessment background levels over the monitoring period for the evening; and
 - all the night assessment background levels over the monitoring period for the night.
- **Extraneous noise:** the noise resulting from activities that are not typical of the area. Atypical INP activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous;
- **Most affected location(s):** locations that experience (or will experience) the greatest noise impact from the noise source under consideration. In determining these locations, one needs to consider existing background levels, exact noise source location(s), distance from source (or proposed source) to receptor, and any shielding between source and receptor;
- **Feasible and Reasonable measures:** feasibility relates to engineering considerations and what is practical to build; reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors:
 - noise mitigation benefits (amount of noise reduction provided, number of people protected);
 - cost of mitigation (cost of mitigation versus benefit provided);
 - community views (aesthetic impacts and community wishes); and
 - noise levels for affected land uses (existing and future levels, and changes in noise levels).

How to Measure and Control Vibration

Vibration refers to the oscillating movement of any object. In relation to construction projects, ground-borne vibration is the most likely outcome of works and potentially has three (3) effects on vibration sensitive Receptors, these are:

- ground-borne vibration that may cause annoyance;
- ground-borne vibration that may have adverse effect on a structure e.g. a building; and
- regenerated noise due to ground-borne vibration.

Each of these potential effects can be assessed in accordance with the relevant standard. Perceptible levels of vibration often create concern for the surrounding community at levels well below structural damage guideline values; this issue needs to be managed as part of the vibration monitoring program.

Vibration is typically measured using specific devices that record the velocity or acceleration at a designated receptor location – usually being the closest premises to works. Modern vibration monitoring devices will typically capture amplitude data for the three (3) orthogonal axes being, the transverse, longitudinal and vertical and also the frequency at which the measured vibration event occurs. Monitoring of this level of detail enables analysis of significant vibration events to determine compliance with relevant guidelines.

Vibration propagates in a different manner to noise and can be difficult to control depending on the frequency of the source in question, although identifying the strategy best suited to controlling vibration follows a similar approach to that of noise. This includes elimination, control at the source, control along

the propagation path and control at the receptor and/or a combination of these, such as no work/respite periods.

Vibration Descriptors

The following terms are often used to describe measured vibration levels.

- **Parameter:** an attribute with a value - for example, weighting;
- **Particle Velocity:** the instantaneous value of the distance travelled by a particle per unit time in a medium that is displaced from its equilibrium state by the passage of a sound or vibration wave;
- **Peak Particle Velocity (PPV):** is the highest (maximum or peak) particle velocity which is recorded during a particular vibration event over the three (3) axes. PPV is measured in the unit, mm/s;
- **Phase:** the relative position of a sound wave to some reference point, the phase of a wave is given in radians, degrees, or fractions of a wavelength;
- **Acceleration:** the change in velocity over time. Acceleration is dependent on the velocity and the frequency of the vibration event (velocity is a vector), as such acceleration changes in two ways - magnitude and/or direction. Acceleration is measured in the unit; m/s²;
- **Perceptible:** vibration levels that a receptor of building occupant may 'feel'. 0.2 mm/s is typically considered to be the human threshold for perception of vibration;
- **Geophone or accelerometer:** the transducer/device typically used to measure vibration;
- **Damage:** is defined in DIN 4150-3 (1999-02) Structural vibration - Effects of vibration on structures to include minor non-structural effects such as cosmetic damage or superficial cracking in paint or cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls; and
- **Vibration Dose Value (VDV):** a concept outlined in the NSW Vibration Guideline which is a calculative approach to assessing the impact of intermittent vibration or extended periods of impulsive vibration. VDV require the measurement of the overall weighted RMS (Root Mean Square) acceleration levels over the frequency range 1Hz to 80Hz.

To calculate VDV the following formula (refer section 2.4.1 of “the guideline”) is used:

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

Where VDV is the vibration dose value in m/s^{1.75}, a (t) is the frequency-weighted RMS of acceleration in m/s² and T is the total period of the day (in seconds) during which vibration may occur.

Appendix B – Sydney Metro Out of Hours Works Application Form

Appendix C – Compliance Matrix

Appendix D– Consultation

----- END OF DOCUMENT -----