Macquarie Capital

Metro Martin Place

Stage 1 SSDA Update Acoustic Assessment Report

Rev 03 | 7 August 2017

Job number 247838

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Contents

Acoustic Terminology

Executive summary

This report summarises assessment of noise and vibration associated with the construction and operation of the Metro Martin Place development.

This report is updated from the previous submission and has been amended predominantly to address cumulative impacts from both the Metro Martin Place and Sydney Metro developments. In order to do this, further detailed analysis and alignment with Sydney Metro assessments has been implemented and relevant amendments to methodologies and predictions incorporated herein.

Noise and vibration survey data have been collated based on current and recent surveys undertaken across the site. Reference is also made to the Environmental Impact Statement and subsequent Submissions and Preferred Infrastructure Report for the Sydney Metro project.

In accordance with State Environmental Approval Requirements for the development, assessment criteria have been selected based on relevant state and national guidelines and legislation and as commensurate with developments of this nature.

Specific assessment of operational noise emission from the project is not feasible at this stage of development due to the level of detail available. It is anticipated that control of operational noise and vibration emission from the development will be readily achieved via standard engineering solutions. For information, indicative design solutions are provided and are based on experience with developments of similar type and scale.

Assessment of noise and vibration impact on the development has been based on survey data. Vibration levels from the existing and proposed rail tunnels is not anticipated to be an issue, however additional measurements at closer a location to the proposed South Tower basement levels is recommended. Indicative glazing build-ups are provided for various heights of each of the Over Station Developments.

In response to State requirements, the proposed development is not anticipated to adversely affect the viability of the proposed Sydney Metro or otherwise increase the likely cost of developing the rail line.

Construction noise and vibration impacts have been assessed to the nearest potential affected sensitive receiver locations. This includes airborne noise, groundborne noise, and vibration impacts from the construction of the project. Reference is also made to the relative impacts as compared against the Sydney Metro scheme. Noise and vibration impacts are expected to be significant during all stages of works. Recommendations are provided to manage and mitigate noise and vibration impact.

The assessment has been undertaken based on information available at the time of writing the report and will need to be updated as the design progresses.

1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Macquarie Capital (Macquarie) is seeking to create a World Class Transport and Employment Precinct at Martin Place, Sydney.

The application seeks Stage 1 approval for the establishment of building envelopes, maximum Gross Floor Areas and design parameters for two predominantly commercial office Over Station Development (OSD) towers, located above the site of the future Martin Place Metro Station (part of the NSW Government's Sydney Metro project).

In particular this report summarises the assessment of noise and vibration impacts associated with the proposed operation and construction of the development.

A glossary of acoustic terminology is provided in Appendix A.

1.1 Background

The New South Wales (NSW) Government is implementing Sydney's Rail Future (Transport for NSW, 2012), a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future.

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro Northwest (Stage 1) and Sydney Metro City & Southwest (Stage 2).

Stage 2 of the Metro entails the construction and operation of a new Metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and eventually onto to Bankstown through the conversion of the existing line to Metro standards. The project also involves the delivery of seven (7) new Metro stations, including Martin Place.

This step-change piece of public transport infrastructure once complete will have the capacity for 30 trains an hour (one every two minutes) through the CBD in each direction catering for an extra 100,000 customers per hour across the Sydney CBD rail lines.

On 9 January 2017 the Minister for Planning approved the Stage 2 (Chatswood to Sydenham) Metro application lodged by Transport for NSW (TfNSW) as a Critical State Significant Infrastructure (CSSI) project (reference SSI 15_7400).

TfNSW is also making provision for future Over Station Development (OSD) on the land it has acquired for the Stage 2 Sydney Metro project, including land acquired for the purposes of delivering Martin Place Station. The OSD development is subject to separate applications to be lodged under the relevant provisions of the EP&A Act.

An Unsolicited Proposal submission has been lodged by Macquarie to the NSW Government for the delivery of a single fully integrated station/OSD solution for the new Sydney Metro Martin Place Station.

1.2 Site description

The Metro Martin Place precinct (the Precinct) project relates to the following properties (refer to Figure 1):

- 50 Martin Place, 9 – 19 Elizabeth Street, 8 – 12 Castlereagh Street, 5 Elizabeth Street, 7 Elizabeth Street, and 55 Hunter Street (North Site);
- 39 – 49 Martin Place (South Site); and
- Martin Place (that part bound by Elizabeth Street and Castlereagh Street).

The land the subject of this application relates only to the North and South Site (refer to Figure 2). Each site will accommodate one OSD tower above the future Sydney Metro Martin Place Station (representing the northern and southern entries/gateways to the Sydney Metro station). The land acquired for the Sydney Metro Martin Place Station is the same as for the Macquarie proposal, except that the Macquarie proposal includes the two properties north of Martin Place owned by Macquarie, namely 50 Martin Place and 9-19 Elizabeth Street.

Both the North and South Sites are regular in shape and have area of approximately 6,022m2 and 1,897m2 respectively, totalling 7,919m2.

Figure 1: Location map of the Precinct
Source: Google maps and JBA

Figure 2: Aerial photo of the North and South Site
Source: Nearmap and JBA

Located close to the centre of the Sydney CBD, the Precinct comprises of the entire City block bounded by Hunter Street, Elizabeth Street, Martin Place and Castlereagh Street; that portion of Martin Place located between Elizabeth Street and Castlereagh Street and the northern most property in the block bounded by Martin Place, Elizabeth Street, Castlereagh Street, and King Street. Together it constitutes an above ground site area of approximately 9,400 square metres, with a dimension from north to south of approximately 210 metres and from east to west of approximately 45 metres. It incorporates a significant portion of one of Sydney’s most revered public spaces – Martin Place.

Martin Place is recognised as one of Central Sydney’s great public, civic and commemorative spaces, as well as being a historically valued commercial and finance location of Sydney’s CBD. Martin Place and a large number of buildings on, or in close proximity to, Martin Place are identified as heritage items, either as items of National, State or Local significance. Number 50 Martin Place, which forms part of the Macquarie North Site, is one of these major heritage items.

There has been a number of redevelopment and refurbishment proposals in recent years along Martin Place to improve existing assets and recapture their premium commercial status (e.g. 5 Martin Place, 50 Martin Place, 20 Martin Place, upgrades of the MLC Centre, and 60 Martin Place). The City of Sydney Council has also identified a need to reinvigorate Martin Place and upgrade the public spaces.

The surrounding locality is characterised by a variety of built forms and architectural styles, with many of the buildings, including those of relatively recent years, not complying with the current planning controls with respect to building heights, setbacks and street wall heights.

In terms of land use the area is characterised by a predominance of office uses, with some ground floor retailing, cafés, or restaurants and hotels (most notably the Westin and the Wentworth) to support its primary business centre function.

1.3 Overview of Proposed Development

The proposal by Macquarie is unique and innovative in aligning the aspirations for public transport, civic amenity and the long-term sustainability of Sydney as a financial centre. This will be achieved through a development designed to maximise the opportunities for an improved Metro Station, integration of the existing and new public transport infrastructure, integration of that infrastructure with modern commercial office towers and world class retailing, along with rejuvenating and complimenting some of Sydney's most revered public spaces, and substantially improving station access and connectivity.

More specifically the development will comprise a concept proposal (under section 83B of the EP&A Act) for the OSD for the North and South Sites. It will be designed as a fully integrated Station and OSD project that, subject to approval, will be built and delivered as one integrated project for opening at the same time as the Sydney Metro is commissioned.

The concept proposal establishes the vision and planning and development framework which will be the basis for the consent authority to assess future detailed development proposals (Stage 2 DAs).

1.3.1 The North Site

The Concept Proposal for the North Site is for a new 40+ storey, predominately commercial office building. The proposal seeks to integrate with the existing 50 Martin Place building, supporting large commercial floor plates. No connections to 50 Martin Place are proposed for the basement levels of that building, including the level of the significant heritage Safe Deposit Vault.

1.3.2 The South Site

The Concept Proposal for the South Site is for a new 28+ storey predominately commercial office building.

The detailed design of the OSD is still in its preliminary stages. Critically it requires an integrated design approach to be adopted between the commercial OSD components classified as SSD, and the Station components, which are classified as CSSI and have already been approved. This is to ensure:

- all the operational needs of the Metro Station are accommodated in accordance with TfNSW requirements and the structural and other requirements of the OSD are accommodated within the Station building beneath, in what is essentially one building; and
- a cohesive public domain and built form outcome is achieved for Sydney.

In this regard, OSD uses and structural elements are located within the below ground and lower podium levels, as conceptually approved under the CSSI consent for the Martin Place Station.

The Staged DA will seek consent for, amongst other things, land uses, gross floor area, building envelopes, and vehicle access arrangements.

A more detailed and comprehensive description of the proposal is contained in the CSSI PIR Report.

1.4 Planning Approvals Strategy

The State Environmental Planning Policy (State and Regional Development) 2011 (SEPP SRD) identifies development which is declared to be State Significant. Under Schedule 1 and Clause 19(2) of SEPP SRD, development within a railway corridor or associated with railway infrastructure that has a capital investment value of more than $30 million and involves commercial premises is declared to be State Significant Development (SSD) for the purposes of the EP&A Act.

The proposed development (involving commercial development that is both located within a rail corridor and associated with rail infrastructure) is therefore SSD.

Pursuant to Section 83B of the EP&A Act a Staged DA may be made setting out concept proposals for the development of a site (including setting out detailed proposals for the first stage of development), and for which detailed proposals for separate parts of the site are to be the subject of subsequent DAs. This SSD DA is a staged development application made under Section 83B of the EP&A Act.

A detailed development application(s) (Stage 2 DAs) will accordingly follow, seeking approval for the detailed design and construction of all or specific aspects of the proposal in accordance with the approved staged development application.

Submitted separately to this SSD DA are applications to modify the CSSI approval together with a Planning Proposal relating to the North Site (FSR only) and South Site (height and FSR).

For clarity, Figure 3 below is a diagrammatic representation of the suite of applications proposed by Macquarie, to show the relationship of the SSD DA (the subject of this report) to the Planning Proposal and the Martin Place Metro CSSI.

The Department of Planning and Environment have provided Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development.

This report has been prepared having regard to the SEARs as relevant.

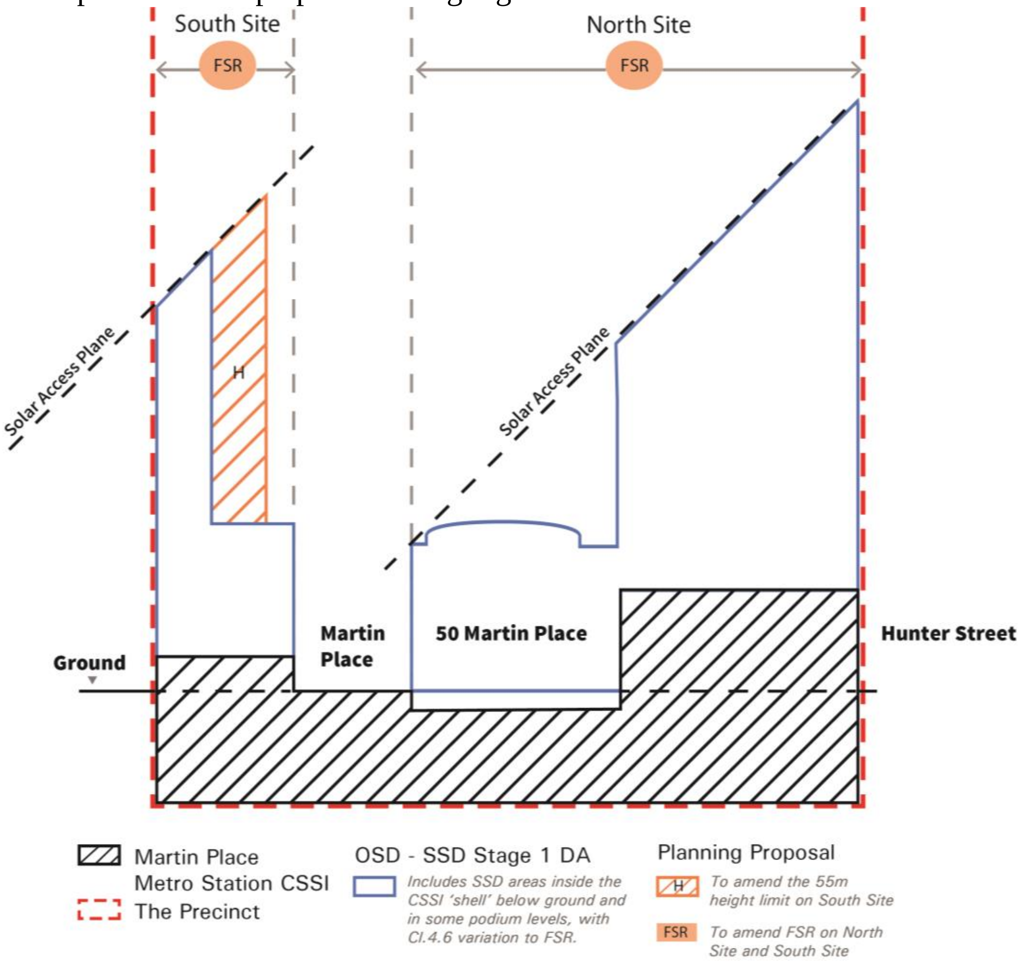

Figure 3: Relationship of planning applications
Source: JBA

1.5 Acoustic assessment requirements

The Department of Planning and Environment have provided Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development. This report has been prepared having regard to the SEARs as relevant.

The relevant policies and guidelines to construction and operational noise and vibration have been addressed in this report and are summarised in the list of references in Section 9.

2 Existing noise and vibration

Surveys of the existing noise and vibration environment have been undertaken via a combination of:

- Long term unattended noise logging
- Short term operator attended noise monitoring; and
- Operator attended vibration monitoring

The following sections summarise the results of each survey and comprise a range of information sources.

2.1 Noise sensitive receiver locations

The area surrounding the Project is zoned as 'B8 – Metropolitan Centre' and is predominantly comprised of general commercial and retail premises.

The following noise and vibration sensitive receivers were also identified within the vicinity of the site:

- 19 Martin Place: The Commercial Travellers Business Club in Martin Place which includes low-level hotel accommodation
- 1 Hosking Place: The Aston Apartments high rise serviced and residential apartment building
- 52 Martin Place: Seven Network television studios
- 55 Elizabeth Street: University of Newcastle campus
- 61-101 Phillip Street: Sofitel Sydney Wentworth Hotel
- 108 King Street: Theatre Royal within the basement of the MLC centre; and
- 165 Phillip Street: Travelodge Hotel temporary accommodation
- 1/17 O'Connell St, ELS Universal English College

Figure 4 depicts the proposed development and surrounding environment.

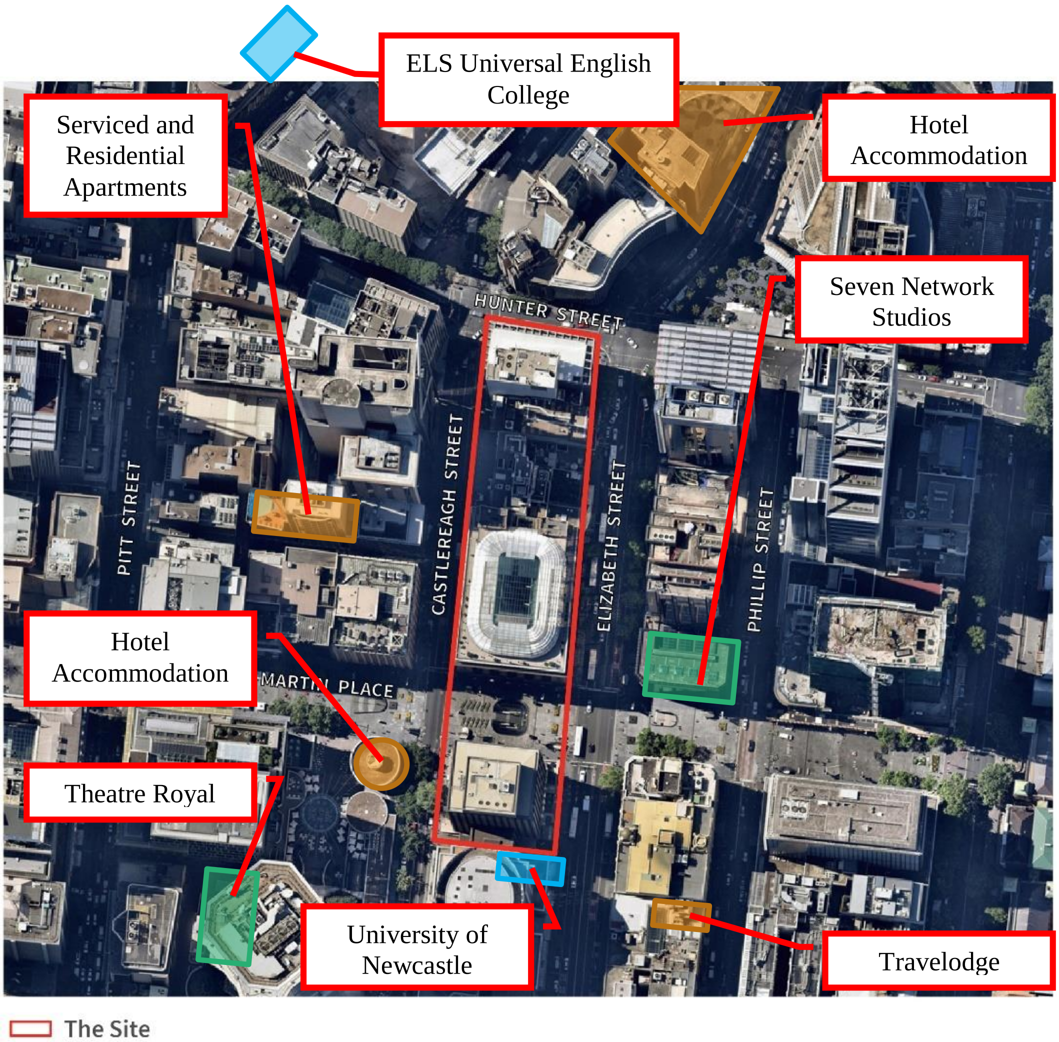

Figure 4: Proposed development site

2.2 Noise survey

2.2.1 Noise measurement locations

Attended and unattended noise monitoring was conducted at the locations identified in Figure 5.

Figure 5: Noise measurement locations

2.2.2 Long-term unattended noise monitoring

The unattended locations presented comprise a combination of measurements undertaken by Arup in 2012 (L1, L2) and February 2017 (L3, L4, L5), and others for the Sydney Metro project in 2016 (B11). These locations are considered to be representative of the prevailing ambient environment at the site and the nearest potentially affected receivers.

The general noise environment of the area can be characterised as being dominated by 'urban hum'. This includes significant contribution from road traffic on Castlereagh and Elizabeth Streets as well as various plant and equipment in the area. Occasional construction noise was also noted whilst on site.

Measured data has been processed in accordance with relevant Environmental Protection Authority (EPA) guidelines and is presented for each logger location in Table 1.

Table 1: Processed unattended noise logger measurement results

Logger ID	Logger location	Time period	Industrial Noise		Road Traffic Noise	
			Rating Background Level (RBL) – dB(A)	$L_{Aeq\ (period)}$ – dB(A)		$L_{Aeq\ (1hr)}$ – dB(A)
L1[1]	50 Martin Place: Rooftop west (Level 10 edge)	Day (7am – 6pm)	63	64	-	-
		Evening (6pm – 10pm)	57	61		
		Night (10pm – 7am)	54	59	-	-
L2[1]	Aston Apartments: South east balcony of Level 23	Day (7am – 6pm)	63	64	-	-
		Evening (6pm – 10pm)	57	61		
		Night (10pm – 7am)	56	58	-	-
B11[2]	Hosking Place	Day (7am – 6pm)	61	66	-	-
		Evening (6pm – 10pm)	56	62		
		Night (10pm – 7am)	52	63	-	-
L3[3]	50 Martin Place: Rooftop west (Level 10 edge)	Day (7am – 6pm)	64	66	66	67
		Evening (6pm – 10pm)	61	64		
		Night (10pm – 7am)	58	62	62	65
L4[3]	50 Martin Place: Rooftop east (Level 10 edge)	Day (7am – 6pm)	63	66	66	67
		Evening (6pm – 10pm)	61	64		
		Night (10pm – 7am)	58	62	62	64
L5[3]	50 Martin Place: Rooftop south (Level 10 edge)	Day (7am – 6pm)	63	66	66	68
		Evening (6pm – 10pm)	61	65		
		Night (10pm – 7am)	59	63	62	65

1 Noise logging locations L1 and L2 are taken from the noise and vibration survey undertaken for the 50 Martin Place development in 2012.

2 Noise logging location B11 results have been taken from the Chatswood to Sydenham Environmental Impact Statement Technical Paper 2: Noise and Vibration (May, 2016) [1] and are considered relevant to this assessment.

Logger ID	Logger location	Time period	Industrial Noise		Road Traffic Noise
			Rating Background Level (RBL) – dB(A)	$L_{Aeq\ (period)}$ – dB(A)	$L_{Aeq\ (1hr)}$ – dB(A)
3 Noise logging locations L3, 4 and 5 results are taken from the noise survey undertaken by Arup, February 2017.					

Measured noise levels are reasonably consistent across the development site and, as is to be expected in the CBD, the ambient noise environment of the area has not significantly changed in the last 5 years.

2.2.3 Short-term attended noise monitoring

To supplement and verify the noise logger data, attended noise measurements were taken at a range of locations in the vicinity of the development site between 1 and 3 February 2017. The meter was set up on a tripod so that the microphone on the meter was approximately 1.5 m above the ground, and was located in the free-field. Calibration of the meter was checked prior and subsequent to measurement with no significant drift being observed.

The overall attended noise levels measured were generally comparable with or slightly louder than the long term noise measurement data.

2.3 Vibration Survey

2.3.1 Vibration measurement locations

Measurements were conducted by Arup in 2012 in the lower basement of the existing 50 Martin Place building in order to determine vibration levels from train pass-bys in the Eastern Suburbs line rail tunnels. The measurement locations were selected, taking into account access restrictions, as being the most affected location within the lower basement of the 50 Martin Place building.

Figure 6 shows the measurement locations in relation to the existing rail tunnels.

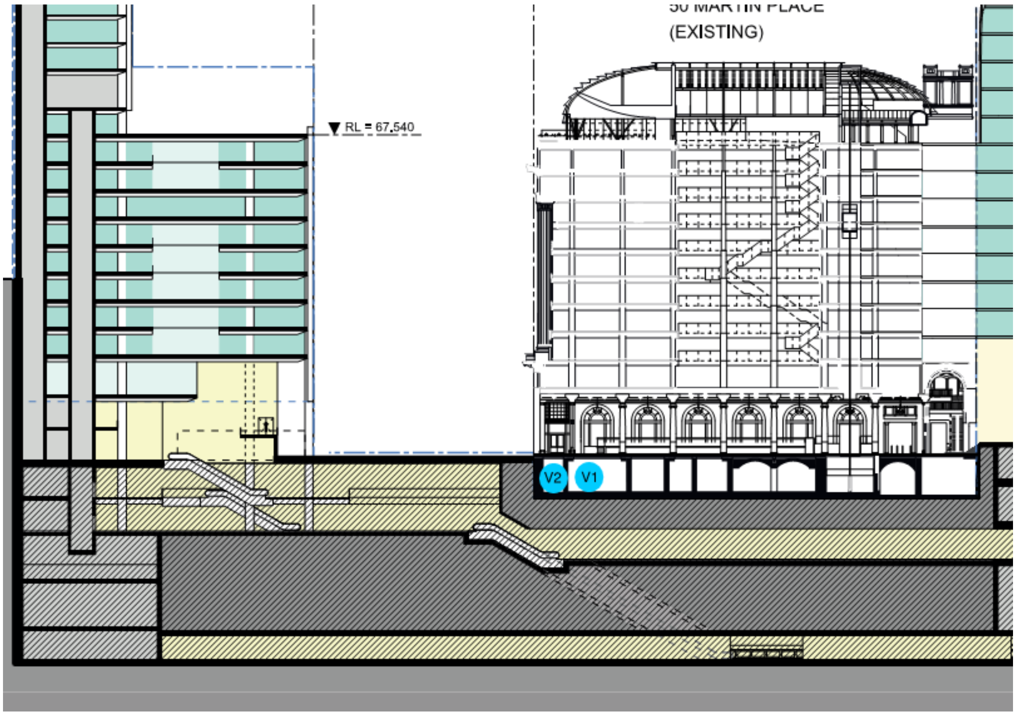

Figure 6: Vibration survey measurement locations

Unattended

2.3.2 Vibration measurement results

Measured vibration levels from the survey are presented in Figure 7 as maximum acceleration spectra. Information is presented in this way to inform assessment against human exposure discussed in Section 3.4.4.

Curve 4 from AS 2670.2 [2] is also provided for comparison and is discussed further in Section 5.1.2.

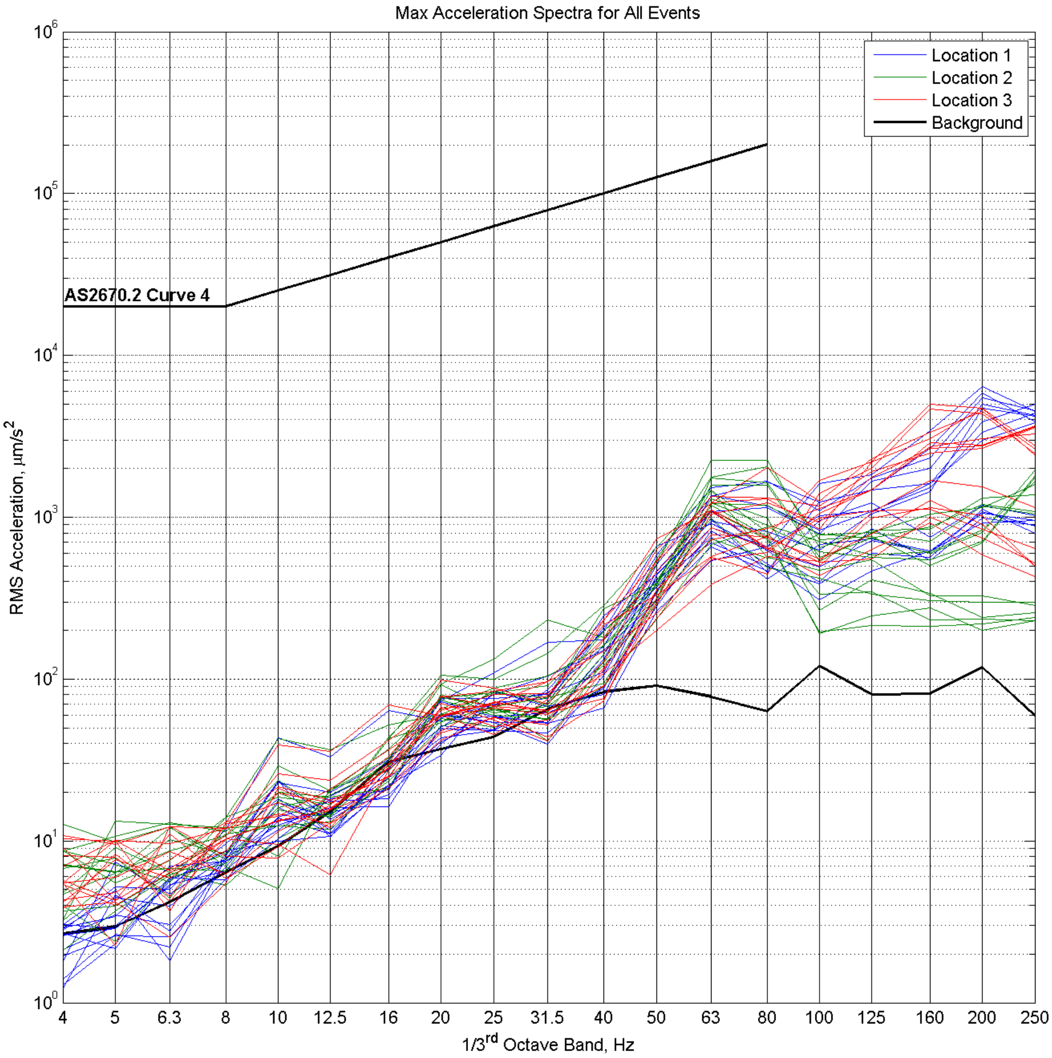

Figure 7: Measured train vibration levels, lower basement – 50 Martin Place

3 Assessment criteria

3.1 Assessment requirements

The following sections summarise acoustic assessment criteria for the Project. These have been selected to address SEARs issued by the Department of Planning specific to the Project.

3.2 Operational noise criteria

3.2.1 Environmental noise

3.2.1.1 Industrial noise

Noise emission from the Project has been assessed in accordance with the NSW *Industrial Noise Policy* (INP) [3], which is primarily concerned with controlling intrusive noise impacts in the short-term for residences, and maintaining long-term noise level amenity for residences and other land uses.

Intrusive noise criteria

The intrusiveness criteria is applicable to residential premises only. The intrusiveness criterion is summarised as follows:

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

As the intrusiveness criteria is established from the prevailing background noise levels at the residential receiver locations, the rating background noise level is required to be quantified in order to establish Project noise goals.

Amenity noise criteria

The INP amenity criteria are for the purpose of maintaining noise amenity, for which the INP recommends 'acceptable' and 'recommended maximum' cumulative noise levels for all industrial noise at different receiver types, including residential, commercial, industrial receivers and other sensitive receivers.

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

<table>
<tr><th rowspan="2">Type of receiver</th><th rowspan="2">Indicative Noise Amenity Area</th><th rowspan="2">Time of day[1]</th><th colspan="2">Recommended $L_{Aeq(Period)}$ noise level</th></tr>
<tr><th>Acceptable</th><th>Recommended maximum</th></tr>
<tr><td rowspan="12">Residence</td><td rowspan="3">Rural</td><td>Day</td><td>50</td><td>55</td></tr>
<tr><td>Evening</td><td>45</td><td>50</td></tr>
<tr><td>Night</td><td>40</td><td>45</td></tr>
<tr><td rowspan="3">Suburban</td><td>Day</td><td>55</td><td>60</td></tr>
<tr><td>Evening</td><td>45</td><td>50</td></tr>
<tr><td>Night</td><td>40</td><td>45</td></tr>
<tr><td rowspan="3">Urban</td><td>Day</td><td>60</td><td>65</td></tr>
<tr><td>Evening</td><td>50</td><td>55</td></tr>
<tr><td>Night</td><td>45</td><td>50</td></tr>
<tr><td rowspan="3">Urban/Industrial Interface - for existing situations only</td><td>Day</td><td>65</td><td>70</td></tr>
<tr><td>Evening</td><td>55</td><td>60</td></tr>
<tr><td>Night</td><td>50</td><td>55</td></tr>
<tr><td>School classrooms
- internal</td><td>All</td><td>Noisiest
1 hour period when in use</td><td>35</td><td>40</td></tr>
<tr><td>Hospital ward
- internal</td><td>All</td><td>Noisiest
1 hour period</td><td>35</td><td>40</td></tr>
</table>

Type of receiver	**Indicative Noise Amenity Area**	**Time of day**[1]	**Recommended $L_{Aeq(Period)}$ noise level**	
			Acceptable	**Recommended maximum**
Hospital ward - external			50	55
Place of worship - internal	All	When in use	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75
1 – Daytime, 7.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night-time 10.00pm to 7.00am On Sundays and Public Holidays, Daytime 8.00am - 6.00pm; Evening 6.00pm - 10.00pm; Night-time 10.00pm - 8.00 am.				

Reference should be made to the INP for full assessment procedures and application, including modifying factor adjustments, background measurement procedures, adverse meteorological effects as well as assessment of sleep disturbance.

In order to facilitate assessment, for receivers where noise criteria are internal, an equivalent external noise criterion of 25 dB higher is considered appropriate (i.e. for educational facilities 35+25=60dBA). This is based on the assumption that glazing elements in the CBD would be well sealed and would provide at least 25 dB attenuation.

Area classification

The INP classifies the noise environment of the subject area as ‘urban’. The INP characterises the ‘urban’ noise environment as an area 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
- has any combination of the above,

where ‘urban hum’ means the aggregate sound of many unidentifiable, mostly traffic-related sound sources.

Project Specific Criteria

The following noise emission criteria have been derived for the Project and are based on measured noise logger data presented in Table 1. These criteria relate to steady state industrial noise emissions (e.g. from plant serving the development) and apply at the boundary of nearest receivers.

The project specific industrial noise emission criteria are taken as the more stringent of Intrusive and Amenity criteria for residential receivers. Where multiple monitoring locations can be construed to be relevant to a specific receiver location, the more stringent of criteria are adopted for assessment.

Table 3: INP noise emission criteria for new industrial plant

<table>
<tr><th rowspan="2">Time Period</th><th>Intrusive Criteria dBL$_{Aeq(15min)}$</th><th colspan="2">Amenity Criteria dBL$_{Aeq(Period)}$</th></tr>
<tr><th colspan="2">Residential Receivers</th><th>Commercial Receivers</th></tr>
<tr><td>Day
(7am – 6pm)</td><td>66</td><td>56</td><td rowspan="3">65</td></tr>
<tr><td>Evening
(6pm – 10pm)</td><td>61</td><td>52</td></tr>
<tr><td>Night (10pm – 7am)</td><td>57</td><td>53</td></tr>
</table>

In addition to the INP noise targets listed in Table 3, we recommend controlling noise emissions to preserve amenity on the site. The criterion for this will be as follows:

- 55 dBL$_{Aeq}$ at outdoor occupied areas or at 1m from louvre/air openings

Modifying factor corrections

The INP has provision for modifying assessment criteria based on frequency and duration. Table 4 is an excerpt from the INP Section 4 – Modifying factor adjustments, summarising applicable adjustments to acceptable noise level based on duration.

Table 4: INP noise criteria modifying factor corrections for duration

Duration of Noise (one event in any 24 hour period)	Increase in acceptable noise level at receiver, dB(A)	
	Day 0700 – 2200 hours	Night 2200 – 0700 hours
1.0 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

Emergency plant and equipment

For the purposes of design, it is assumed that smoke exhaust fan tests and emergency generator tests will fall in the 15 minutes to 1 hour band during the daytime, and thus attract an allowable increase of 5 dB(A) to the acceptable noise level for typical building daytime operation.

For this project, INP amenity criteria represent the limiting criteria for the development. As such, the limiting criteria for generator and smoke exhaust testing is based on the “Daytime” acceptable noise level as presented in Table 3 and the additional allowance due to the limited duration presented in Table 5.

Therefore the limiting criterion, measured at the site boundary of the nearest potentially affected receivers, for noise from testing of equipment such as emergency generators and smoke exhaust fans is given in

Table 5: Project specific noise emission criteria for emergency plant and equipment

Receiver type	Limiting criterion, dB(A)
Residential	61
Commercial	62
Educational	61
Outdoor occupied areas	60

Generator testing is also recommended to be carried out under reduced test loads where possible. Lower sound levels are typically produced when operating under reduced loads because of variable speed fans.

3.2.1.2 Licensed Premises

The specific uses of the retail component of the development has not been decided at this stage of the development. Should future uses include licensed premises, assessment will be required to mitigate noise nuisance to noise sensitive receivers.

Liquor and Gaming NSW (L&GNSW), through the Liquor Act 2007, is the regulatory authority that deals with noise pollution issues pertaining to licensed premises. Noise emission from licensed premises in NSW, such as restaurants, bars and clubs, should aim to comply with the standard noise criteria set by L&GNSW. While not necessarily a prescribed requirement, L&GNSW recommends the use of their standard noise criteria when assessing noise impact from licensed premises and when determining the occurrence of noise nuisance and annoyance. The criteria is also typically adopted by local Councils for applicable development. The criteria is considered to apply to all noise emission associated with activities from the licensed area of the premises, including music and patron noise, however excludes mechanical plant.

The L&GNSW ‘Standard Noise Condition’ states:

> *“The LA10* noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5Hz –*

8kHz inclusive) by more than 5dB between 7:00am and 12:00 midnight at the boundary of any affected residence.

The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5Hz – 8kHz inclusive) between 12:00 midnight and 7:00am at the boundary of any affected residence.*

Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of 12:00 midnight and 7:00am.

Interior noise levels which still exceed safe hearing levels are in no way supported or condoned by the NSW Office of Liquor, Gaming and Racing.

This is a minimum standard. In some instances the Board may specify a time earlier than midnight in respect of the above condition.

**For the purposes of this condition, the LA10 can be taken as the average maximum deflection of the noise emission from the licensed premises."*

3.2.1.3 Road traffic noise

The NSW Road Noise Policy (RNP) [4] includes assessment criteria for existing noise sensitive receivers affected by additional traffic on existing roads generated by land use developments. These criteria are reproduced in Table 6 below for reference.

Table 6: Road traffic noise assessment criteria for residential land uses

Road category	Type of project / land use	Assessment criteria – dB(A)	
		Day (7am–10pm)	Night (10pm–7am)
Freeway / arterial / sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq, (15 hour)}$ 60 (external)	$L_{Aeq, (9 hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq, (1 hour)}$ 55 (external)	$L_{Aeq, (1 hour)}$ 50 (external)

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

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

Given the high noise levels measured on site and the high number of existing vehicle movements commensurate with the CBD, the proposed development is not anticipated to significantly increase existing road traffic noise levels during either construction or operation. This is also the finding of the Sydney Metro EIS noise and vibration study. Road traffic noise impacts will therefore not be discussed further in this report.

3.2.2 External Noise Intrusion

3.2.2.1 Airborne Noise

AS 2107:2016 [5] provides design criteria for conditions affecting the acoustic environment within occupied spaces that take into account the function of the area(s). The sound levels are to apply for a fully fitted out and completed building, but excluding occupant noise. The Standard is applicable to steady-state or quasi-steady state sounds such as mechanical services equipment and road traffic noise intrusion, but not intended for transient or variable sources such as aircraft noise, railways and construction noise.

Where strict compliance with criteria are required, cumulative contribution from airborne noise intrusion and internal mechanical plant noise should be considered to ensure overall noise levels remain below the specified design targets.

3.2.2.2 Groundborne Noise

Guidance for groundborne noise levels from railways is provided in Interim Guidance for Applicants [6], and more recently in the NSW Infrastructure SEPP (ISEPP) [7]. It is noted that this guidance does not apply to commercial developments. Rather, the criteria for projects such as this are generally developed with reference to international guidance and experience from previous local railway and development projects.

RailCorp introduced its interim guidance for applicants in the consideration of rail noise and vibration from the adjacent rail corridor in 2003. The RailCorp guidance is primarily aimed at residential buildings, but does refer to 'other noise-sensitive developments'. The guidance states;

> *"For noise-sensitive uses other than residential, appropriate noise and vibration criteria should be determined by an experienced acoustic consultant, who will take into account the intended occupancy and activities proposed for the development.*
>
> *Developments that should be considered sensitive include:*
>
> - *places of worship;*
> - *hospitals;*
> - *nursing homes;*
> - *educational institutions;*
> - *passive recreation areas; and*

- *mixed use developments.*

In particular, studios, theatres and very high precision scientific and manufacturing facilities are considered sensitive to vibration impacts.

Commercial buildings should also be assessed, although in many cases, special measures are not required.

The Australian Standard in relation to railway noise is under development. In the interim, some guidance on internal noise levels may be obtained from the following Standards, however, that these are not directly applicable to railway noise.

- *AS 2107:2000 Acoustics - Recommended Design Sound Levels and Reverberation Times for Building Interiors*
- *AS 2021:2000 Acoustics - Aircraft Noise Intrusion - Building Siting and Construction*
- *AS 3671:1989 Acoustics - Road Traffic Noise Intrusion - Building Siting and Construction*
- *BS 6472:1992 Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*

An experienced acoustic consultant would be able to provide advice on appropriate noise and vibration criteria."

The Interim guidance has subsequently been superseded by the publication of the ISEPP, and the NSW Department of Planning's Development Near Rail Corridors and Busy Roads – Interim Guideline [8].

Clause 87 of the Infrastructure SEPP specifically identifies the following potentially affected developments;

- *Building for residential use*
- *A place of public worship*
- *A hospital*
- *And educational establishment or childcare centre.*

The Department of Planning's guideline notes that;

"Some commercial premises may incorporate special components that may be noise and or vibration sensitive, such as auditoria, laboratories and boardrooms, and although not a specific requirement of the Infrastructure SEPP, these areas should be assessed accordingly."

Since the development does not include any residential uses, it is not considered appropriate to require an additional assessment to demonstrate 'compliance' with interim guidance or the Infrastructure SEPP – since these are primarily concerned with residential uses.

Based on a review of applicable international groundborne noise level targets, the recommended groundborne noise targets for the commercial office areas are as follows:

- Open plan office areas: 45 dB $L_{Amax,slow}$
- Private offices, meeting/conference rooms: 40 dB $L_{Amax,slow}$

3.3 Construction noise criteria

The following sections summarise recommended construction noise targets for the Project.

It is important to note that these are provided as screening levels and not absolute assessment criteria and as such should not be taken as a deciding factor when determining project approval. This is discussed further below.

It is also noted that approval for the Sydney Metro CSSI has already been granted. Assessment of impacts from the Project and differences to the approved CSSI are discussed further in Section 7.

3.3.1 Airborne construction noise targets

3.3.1.1 External Receivers

The NSW *Interim Construction Noise Guideline* (ICNG) [9] provides recommended noise management levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all feasible and reasonable work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a ‘screening’ criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all ‘feasible and reasonable’ work practices to reduce noise levels.

The ICNG provides two methods for assessing construction noise, varying typically on the basis of the project duration, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement of background noise levels for determination of management levels and prediction of construction noise levels. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification. The Project is expected to warrant a quantitative assessment.

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These management noise levels for residential receivers are reproduced below, in Table 7 and other sensitive receivers in Table 8.

Table 7: Construction noise management levels at residential receivers

<table>
<tr><th>Time of day</th><th>Management level [1]
$L_{Aeq\ (15\ min)}$</th><th>How to apply</th></tr>
<tr><td rowspan="2">Recommended standard hours:
Monday to Friday
7am to 6pm
Saturday 8am to 1pm
No work on Sundays or public holidays</td><td>Noise affected
RBL + 10dB</td><td>The noise affected level represents the point above which there may be some community reaction to noise.
Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.
The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.</td></tr>
<tr><td>Highly noise affected
75dB(A)</td><td>The highly noise affected level represents the point above which there may be strong community reaction to noise.
Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:
• times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences
• if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.</td></tr>
<tr><td>Outside recommended standard hours</td><td>Noise affected
RBL + 5dB</td><td>A strong justification would typically be required for works outside the recommended standard hours.
The proponent should apply all feasible and reasonable work practices to meet the noise affected level.
Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community.
For guidance on negotiating agreements see section 7.2.2 of the ICNG.</td></tr>
<tr><td colspan="3">1 - Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.</td></tr>
</table>

Table 8: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)
1 - Noise management levels apply when receiver areas are in use only.		

The ICNG recommends that the internal construction noise levels at other premises are determined based on the 'maximum' internal levels presented in AS 2107:2000. For the purpose of this assessment, this is taken to be the upper limit of noise levels presented in AS 2107:2016.

As with industrial noise targets, for receivers with internal noise criteria, an equivalent external noise criterion of 25 dB higher is considered appropriate (i.e. for educational facilities 45+25=70dBA). This is based on the assumption that glazing elements in the CBD would be well sealed and would provide at least 25 dB attenuation.

For the purpose of assessment, highly sensitive receiver locations such as Network 7 Television Studios and Theatre Royal are treated as standard commercial premises. It is expected that the facades of each will be sufficiently designed to attenuate environmental noise accordingly to maintain relevant internal noise criteria. It is recommended that specific assessment criteria be negotiated with these sensitive receiver locations as part of the Construction Noise and Vibration Management Plan to be prepared by the successful contractor.

For work within standard construction hours, if after implementing all 'feasible and reasonable' noise levels the site still exceeds the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community. While there is no 'highly-noise affected level' outlined in the ICNG for out-of-hours work, this report adopts the terminology where the construction noise level is 5 dB above the noise affected level.

Measured noise data obtained at the logger location most representative of each receiver type has been used to derive appropriate noise management levels for the project. These are summarised in Table 9.

Table 9: Project construction noise management levels

Receiver type	Noise management levels (dB$L_{Aeq(15min)}$)			
	Recommended standard hours	Outside recommended standard hours		
		Day	Evening	Night
Residential	71	66	61	57
Commercial	70			
Educational	70			

3.3.2 Groundborne construction noise targets

Groundborne noise impacts may occur at sensitive receivers located nearby to construction works. As a guide, 'upper limit' internal noise levels stipulated in AS 2107-2016 are adopted as 'screening criteria' to determine whether disturbance to occupants is likely due to groundborne noise from construction works.

For consistency, the following internal ground-borne noise levels have been adopted as a screening target for residential receivers as per the EIS / PIR:

- Daytime $L_{Aeq(15minute)}$ 45 dBA
- Evening $L_{Aeq(15minute)}$ 40 dBA
- Night-time $L_{Aeq(15minute)}$ 35 dBA

The 50 dBA internal groundborne noise screening criterion adopted for commercial receivers within the EIS / PIR is also used for this assessment.

For highly noise sensitive receivers such as theatres and studios, engagement and negotiation with affected receivers will be required to establish appropriate noise limits on a case by case basis.

3.4 Vibration criteria

Vibration criteria relate to both operation and construction of the development and are generally assessed against two considerations:

- Structural damage; and
- Human exposure

The following sections summarise assessment criteria relevant to each.

3.4.1 Structural damage

3.4.1.1 Definition

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard BS 7385-2 [10] and/or

German Standard DIN4150-3 [11]. British Standard 7385-1 [12], defines different levels of structural damage as:

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

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

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

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

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)*

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

3.4.1.2 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 10 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 (1993, p.5) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 10: BS 7385-2 structural damage criteria

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

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

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

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

3.4.1.3 German Standard

German Standard DIN 4150-3 [13] are generally recognised to be conservative. DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The criteria are presented in Table 11.

Table 11: DIN 4150-3 structural damage criteria

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

3.4.1.4 CSSI PIR Vibration Screening Criteria

The CSSI EIS and PIR documentation adopts the following linewide screening criteria for vibration impacts:

- Reinforced or framed structures: 25 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

The following is noted with respect to Heritage structures:

> *Heritage buildings are to be considered on a case by case bases, as a heritage listed structure may not (unless it is structurally unsound) be assumed to be more sensitive to vibration resulting in application of the 7.5 mm/s screening criterion. Where a historic building is deemed to be sensitive to damage from vibration (following inspection), more conservative superficial cosmetic damage criterion of 2.5 mm/s peak component particle velocity (from DIN 4150) should be considered.*

It is noted that the EIS and PIR adopted the 7.5 mm/s screening criterion for 50 Martin Place as being a heritage structure. The following is an excerpt from the Submissions and Preferred Infrastructure Report (SPIR):

> *a conservative cosmetic damage screening criterion of 7.5 mm/s has been applied to all heritage items (which is half the value when cosmetic damage would be expected to occur for light-frame structures).*

It is noted that implementation of this screening criterion is considered a conservative approach to assessment in the context of the 50 Martin Place building as it is not considered a light-framed structure. This is discussed further in Section 7.4.

3.4.2 Buried services

DIN 4150-2 sets out guideline values for vibration effects on buried pipework and reproduced in Table 12 below.

Table 12: Guideline values for short-term vibration impacts on buried pipework

	Pipe material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50
Note: For gas and water supply pipes within 2m of buildings, the levels given in Table 11 should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.		

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's *Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties* (report T/SP/SSW/22, UK National Grid, Rev 10/06, October 2006). This specification states that no piling is allowed within 15 meters of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/s the ground vibration is required to be monitored.

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50 mm/s and 100 mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

3.4.3 Existing Rail Tunnels

There are no specific local or national guidance for acceptable level of construction vibration affecting railway tunnels. RailCorp do not provide specific guidance, but it is understood that vibration velocity levels between 15–20 mm/s have been adopted by their Rail Corridor Management Group for previous projects as limits for tunnel structures.

In addition to the structural damage vibration criteria presented in Section 3.4.1, the following sections discuss further criteria relevant to rail tunnels.

3.4.3.1 Vulnerability of ground-related structures and services

BS5228-2:2009 [14] provides a code of practice for vibration control on construction sites. It recommends that the following limits are applied for ground-related structures and services, where no specific criteria are provided by authorities;

- Maximum PPV for intermittent or transient vibrations 30 mm/s
- Maximum PPV for continuous vibrations 15 mm/s

It also notes that for elderly and dilapidated brickwork sewers, the base data should be reduced by 20% to 50%, but for metal and reinforced concrete service pipes, the values above are expected to be quite tolerable.

3.4.3.2 Summary

The guidance discussed above provides a range or recommended limits that are potentially applicable to the existing railway tunnel structures.

It is recommended that an initial limit of 15–20 mm/s is adopted for the construction works for the Project as a conservative limit. 15 mm/s would be adopted as an 'alert' limit, with 20 mm/s used as an absolute stop-work limit, although it is anticipated that the tunnel structure would not be adversely affected by vibration at even higher levels than this.

3.4.4 Human exposure

Potential vibration disturbance to human occupants of buildings is made in accordance with the NSW DEC '*Assessing Vibration; a technical guideline*' [15]. The criteria outlined in the guideline is based on the British Standard BS 6472-1 [16]. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent', as described in Table 13.

Table 13: Types of vibration – Definition

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

Table 14 is a reproduction of the ‘Preferred’ and ‘Maximum’ values for continuous and impulsive vibration from Table 2.2 of the Guideline.

Table 14: Preferred and maximum vibration acceleration levels for human comfort, m/s^2

Location	**Assessment period**[1]	**Preferred values**		**Maximum values**	
		z-axis	**x- and y-axes**	**z-axis**	**x- and y-axes**
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

1 - Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2 - Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Alternative criteria is outside the scope of the policy and other guidance documents should be referred to.

Table 15 reproduces the ‘Preferred’ and ‘Maximum’ values for intermittent vibration from Table 2.4 of the Guideline.

Table 15: Acceptable vibration dose values (VDV) for intermittent vibration ($m/s^{1.75}$)

Location	**Daytime**[1]		**Night-time**[1]	
	Preferred value	**Maximum value**	**Preferred value**	**Maximum value**
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1- Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2 - Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess

intermittent values against the continuous of impulsive criteria for critical areas. Source: BS 6472-1992

4 Operational acoustic assessment

4.1 Operational noise sources

Acoustically significant noise sources associated with the operation of the development are as follows:

- Mechanical plant and equipment
- Licensed premises

4.1.1 Mechanical plant and equipment

The noise emission of mechanical plant and equipment associated with the development will be controlled so that the operation of such plant does not adversely impact nearby noise sensitive receivers including those within the proposed development site.

At this stage of the project the location and selection of mechanical plant and equipment has not been finalised. Therefore appropriate assessment will need to be conducted at the early design stages of the project. No particular issues with achieving appropriate noise levels are anticipated.

It is envisaged that the mechanical plant noise sources will be controllable by common engineering methods that may consist of:

- Judicious location and selection of low noise plant
- Noise barriers (e.g. for roof plant)
- Silencers and acoustic louvres
- Acoustically lined ductwork
- Vibration isolators

Preliminary provisions for acoustic treatment are included on the mechanical and electrical documentation for the project to enable space planning and have been based on current level of detail available.

4.1.2 Licensed premises

Being a metropolitan zoned area, licensed premises are not uncommon for the locale. It is envisaged that noise impacts from any future licensed premises will be adequately controlled via appropriate engineering design and the suitable management of operations.

At this stage of design, it is not clear whether licensed premises will form part of the development. As the design progresses, once details on future proposed licensed premises become available, assessment against the criteria presented in Section 3.2.1.2 will be required.

- The specification will include requirements that the elevator contractor ensures that lift noise levels in occupied areas do not exceed the recommended mechanical internal target services noise criteria outlined in Section 3.2.1.3.

5 Noise and vibration impact upon development

5.1 Noise and vibration sources

The following acoustically significant noise and vibration sources are anticipated to impact on the proposed development:

- Environmental noise (incl. road traffic, building services); and
- Groundborne rail noise and vibration

The acoustic assessment provided below summarises an analysis of potential noise and vibration impacts on the proposed commercial development in sufficient detail to allow the building developers to understand the potential impacts and options to mitigate noise and vibration.

5.1.1 Road traffic noise

Measured road traffic noise levels presented in Section 2.2 have been scaled taking into account distance loss and ‘canyon’ effect of the urban environment to predict future noise levels at different heights up the OSD towers.

Figure 8 shows predicted noise levels for low, mid and high rise sections of the proposed towers. Calculations have been carried out to determine potential noise intrusion into the development. Indicative single and double glazed solutions to achieve recommended internal noise levels within typical open plan and private office areas are provided in Table 16 for information and will need to be reviewed as the design progresses.

Table 16: Indicative glazing selections to address road traffic noise intrusion

Level	Indicative glazing selection	
	Single glazed	Double glazed
Low rise	17 mm acoustic laminate	10 mm laminate / 16 mm air gap / 8.8 mm laminate
Mid rise	10.8 mm laminate	6.4mm laminate / 12 mm air gap / 10 mm float
High Rise	10.4 mm laminate	6 mm float / 12 mm air gap / 10 mm float

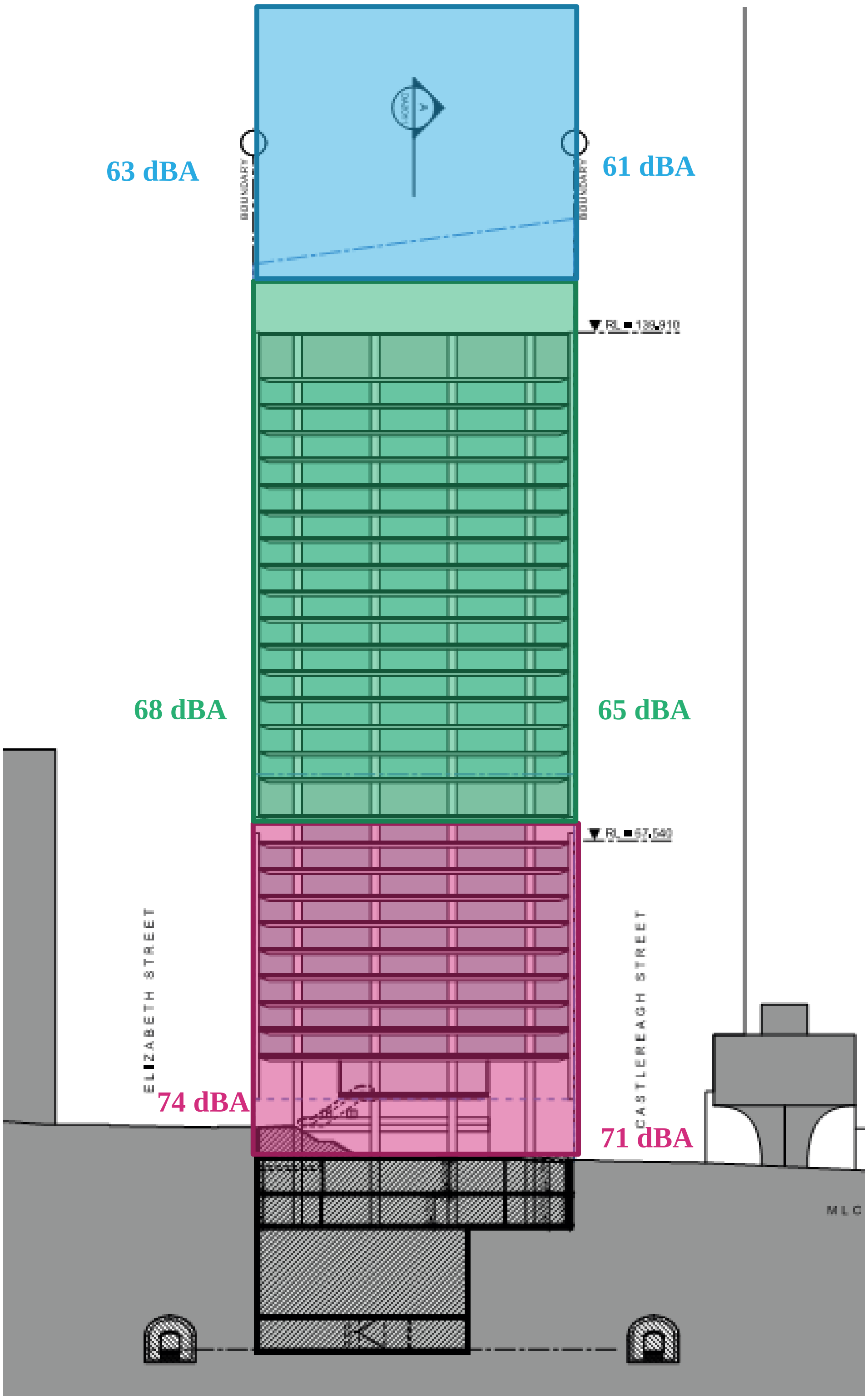

Figure 8: Predicted road traffic noise levels

5.1.2 Building services noise

Once detail is available, analysis will be undertaken to ensure that noise break-in from future mechanical and electrical equipment servicing the development is maintained to within noise targets summarised in Section 3.2.1.3. This will be achieved via a combination of mechanical and façade design.

5.1.3 Groundborne rail noise and vibration

Noise and vibration impacts from existing and proposed rail tunnels beneath the development site have the potential to adversely impact the development. The following sections summarise an analysis of the potential impact from both the existing Eastern Suburbs Rail Line tunnels under the South Tower and the future proposed Sydney Metro tunnels that traverse the site.

5.1.3.1 Eastern Suburbs Rail Line (existing)

Vibration

Measured vibration levels shown in Figure 7 are presented as maximum acceleration for comparison against human exposure criteria in Section 3.4.4. Curve 4 from AS2670.2 is also presented as relevant to office spaces. This assessment curve is equivalent to BS 6472 on which DEC Assessing Vibration criteria are based and therefore serves to demonstrate compliance with project specific vibration criteria. The measured acceleration levels show that train vibration is well below the assessment criteria and therefore complies with human exposure criteria for the project at the measurement location.

Groundborne noise

With reference to Figure 7, measured data was extracted from monitoring location V2 (being the worst affected location) to derive a representative “1 in 20” train pass-by maximum vibration velocity spectrum. The calculated velocities are summarised in Table 17 for 31.5Hz and above and are presented as decibel units for the purpose of groundborne noise predictions.

Table 17: Representative “1 in 20” train pass-by maximum vibration velocity spectrum

RMS Vibration Velocity, dB re: 10 µm/s 1/3rd octave band centre frequency, Hz											
20	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**
53	55	51	57	64	75	73	60	61	58	60	59

Using the measured vibration spectrum in Table 17, the predicted reverberant sound pressure level radiated into a typical open plan office is in the order of 30 dBA. Taking into account a typical loss of 2 dB per floor, the nearest affected office space within the South Tower is predicted to experience groundborne noise levels in the order of 20 dBA. Compliance is therefore demonstrated against the lowest limit of 40 dBA for private offices. It is noted that this is based on the maximum spectrum from a typical “1 in 20” train event and is therefore considered conservative.

Recommendations

The South Tower OSD is to be situated directly above the existing Eastern Suburbs Rail Line tunnels and hence closer in proximity to existing train pass-bys than the location at which vibration measurements were undertaken (i.e. lower basement of 50 Martin Place). Given the margins predicted, compliance with noise and vibration criteria is considered likely regardless of this discrepancy between locations. However, it is recommended that further vibration measurements be undertaken once access is possible to the lower levels of the existing 39 Martin Place building. Should updated measurements show that groundborne noise or vibration is an issue for the development, this would be readily addressed via appropriate design of building isolation.

5.1.3.2 Sydney Metro (future)

Figure 9 is an excerpt from the Technical Paper 2: Noise and Vibration [1] for the Sydney Metro project. It displays predicted groundborne noise levels from the proposed metro line to commercial and other sensitive receivers.

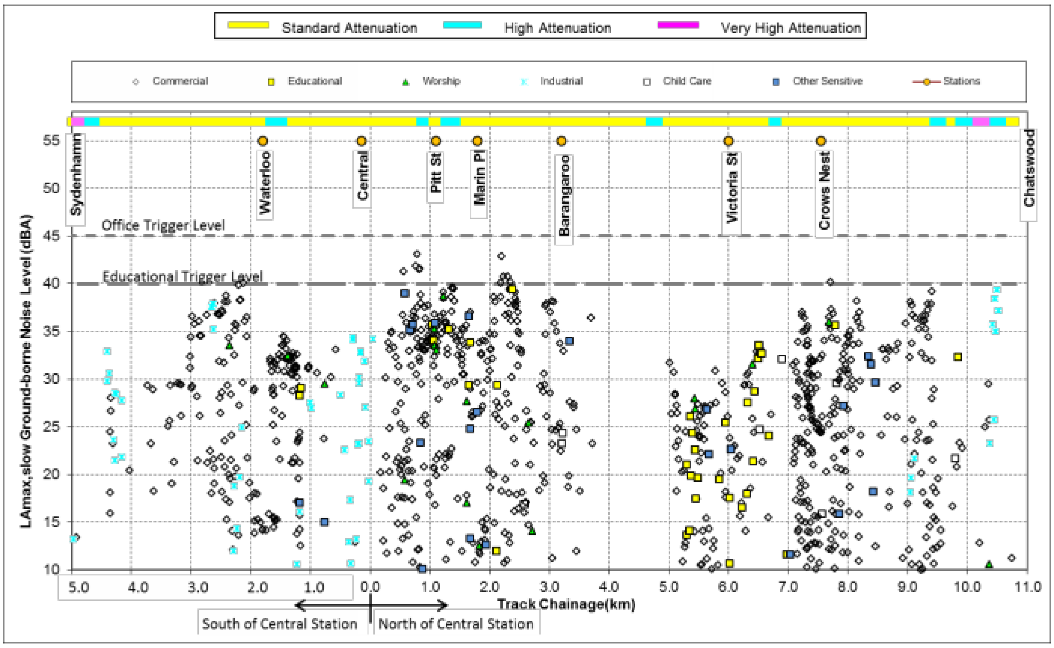

Figure 9: Predicted groundborne noise levels for commercial and other sensitive receivers

From the data presented, predicted groundborne noise levels are generally below 40 $dBL_{Amax,slow}$. There are four instances where predicted groundborne noise levels are 41-43 $dBL_{Amax,slow}$. These predicted levels are within internal groundborne noise targets for office areas summarised in Section 3.2.2.2.

5.1.3.3 Recommendations

Based on the above analysis, it is not anticipated that groundborne noise and vibration due to either existing or proposed rail tunnels will be an issue for the proposed development. This should be reviewed as the design progresses, however, it is reiterated that there are no specific groundborne noise criteria requirements for commercial and retail spaces.

In order to further understand potential groundborne noise impacts on the development, it is recommended that further vibration measurements be undertaken of the existing Eastern Suburbs rail line within the basement levels of the existing 39 Martin Place (i.e. location of the South Tower).

6 Impact upon rail corridors

The NSW State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) states the following:

> *88A Major development within Interim Metro Corridor*
>
> *1. This clause applies to land within the City of Sydney that is within the Interim Metro Corridor.*
>
> *…3 A consent authority must not grant consent to major development on land to which this clause applies if the development would have an adverse affect on the viability of the proposed metro, including by increasing the likely cost of developing the proposed metro.*

6.1 Discussion

The proposed development is consistent with the existing surrounding land use in the area being predominately commercial office and retail. Furthermore, the proposed scheme replaces existing commercial buildings with the same usage.

The introduction of basement levels and additional concourse connection in closer proximity to the Sydney Metro rail tunnels will not result in an increase in vibration and structure radiated noise at occupied levels above ground.

The proposed development will specifically be designed to integrate with the proposed Sydney Metro and will therefore be designed to ensure adequate integration with the scheme.

The proposed development is therefore not anticipated to adversely affect the viability of the proposed Sydney Metro or otherwise increase the likely cost of developing the rail line.

7 Construction noise and vibration assessment

The following sections summarise the cumulative noise and vibration impacts from the construction works associated with Sydney Metro Martin Place station and OSD towers to nearby receivers. At this stage of the project, there is very little detail available as to specific methodologies, equipment, or scheduling for the works. In lieu of this information, typical activities and associated equipment have been selected as being indicative of how the Project may be constructed.

Reference has also been made to the EIS and PIR documentation for the project as the bases of comparison. For consistency, further coordination was undertaken with Sydney Metro to understand baseline assumptions made in acoustic modelling for the construction works.

Once the full design of the development is understood and the development tendered, it will be the responsibility of the successfully contractor to undertake a detailed assessment and develop an appropriate construction noise and vibration management plan for the Project.

7.1 Noise catchment areas

To enable assessment, receiver locations have been grouped into noise catchment areas (NCA) around the proposed construction works. For direct comparison, these areas assessed have been derived in alignment with Sydney Metro SPIR Construction Noise and Vibration report.

Table 18 summarises receiver types within each catchment area. An aerial image of the proposed construction site and surrounding NCAs is also provided in Figure 10 for reference.

Table 18: Nearest noise sensitive receivers and noise catchment areas

Noise Catchment Areas	Type of receiver	Location
NCA - A	Commercial	Commercial receivers to the west, west of Castlereagh Street and south of Martin Place.
	Residential	Residential receivers to the west, west of Castlereagh Street and south of Martin Place. MLC auxiliary building.
	Theatre	Theatre Royal, south east of MLC centre
NCA – B	Residential	Residential receivers to the west, west of Castlereagh Street and north of Martin Place.
	Commercial	Commercial receivers to the west, west of Castlereagh Street and north of Martin Place.
NCA – C	Residential	Residential receivers to the north, north of Hunter Street
	Commercial	Commercial receivers to the north, north of Hunter Street
	Educational	Educational receivers to the north, north of Hunter Street between O’Connell and Spring St.

Noise Catchment Areas	Type of receiver	Location
NCA – D	Studio	Studio receivers to the east, between Hunter Street and Martin Place. Channel 7.
	Commercial	Commercial receivers to the east, between Hunter Street and Martin Place.
	Residential	Residential receivers east of site
NCA – E	Commercial	Commercial receivers between the two construction sites. 50 Martin Place.
NCA – F	Residential	Residential receivers to the east, between King Street and Martin Place.
	Commercial	Commercial receivers to the east, between King Street and Martin Place.
NCA - G	Educational	Educational receivers to the south, between Castlereagh Street and Elizabeth Street.
	Commercial	Commercial receivers to the south, between Castlereagh Street and Elizabeth Street

Figure 10: Aerial image of noise catchment areas

7.2 Proposal

In general, the project incorporates the same locations and methodologies for demolition, excavation and construction as summarised in the EIS/SPIR for the Sydney Metro project. A general description of the construction scenarios and anticipated timeframes is provided therein and is provided in Table 19 for reference.

Table 19: General staging and duration of construction works

Sequence	Stage	Description	Duration
1	Demolition and site establishment	Demolition of buildings on the site and establishment of site compound facilities	~12 months
2	Earthworks	Initial surface excavation	~2 months
3	Acoustic shed construction	Piling and erection of the acoustic shed	~1 month
4	Excavation and structural works	Excavation of the station and structural works	~3 years
5	Building construction	Above ground station and services building construction and fit-out	~1.5 years

Noise and vibration impacts from these works are quantified in the Sydney Metro EIS and SPIR and will therefore not be discussed further in this report. Assessment will instead be concentrated on the cumulative impacts from all works associated with Metro Martin Place station and OSD towers.

The following sections include analysis of impacts from construction associated with the project assuming works are being undertaken concurrently rather than in isolation.

Assessment has been separated into airborne and ground-borne noise and vibration impacts.

7.3 Airborne construction noise assessment

7.3.1 Equipment list and source noise levels

A list of assumed construction activities and associated items of equipment has been developed for each stage of demolition, excavation and construction. For consistency, this list of equipment and associated sound power levels has been replicated from the Sydney Metro EIS / SPIR documentation and confirmed with Sydney Metro. This forms the basis of assessment of noise impacts. It is noted that the selection and placement of activities and appliances mentioned in this document are indicative and are provided for information only.

Table 20 summarises equipment and associated sound power levels used in prediction of airborne construction noise.

Table 20: Sound power levels of proposed appliances

Equipment	Maximum SWL (dBA)	Max SPL @ 7m (dBA)
Excavator Hammer	118	93
Excavator (approx. 3 tonne)	90	65
Excavator (approx. 6 tonne)	95	70
Excavator (approx. 10 tonne)	100	75
Excavator (approx. 20 tonne)	105	80
Excavator (approx. 30 tonne)	110	85
Excavator (approx. 40 tonne)	115	90
Skidsteer Loaders (approx. 1/2 tonne)	107	82
Dozer (tracking) - equiv. CAT D7	110	85
Dozer (tracking) - equiv. CAT D8	118	93
Dozer (tracking) - equiv. CAT D9	120	95
Dozer (tracking) - equiv. CAT D10	121	96
Backhoe/FE Loader	111	86
Dump Truck (approx. 15 tonne)	108	83
Concrete Truck	112	87
Concrete Pump	109	84
Concrete Vibrator	105	80
Bored Piling Rig	110	85
Scraper	110	85
Grader	110	85
Vibratory Roller (approx. 10 tonne)	114	89
Vibratory Pile Driver	121	96
Impact Piling Rig	134	109
Compressor (approx. 600 CFM)	100	75
Compressor (approx. 1500 CFM)	105	80
Concrete Saw	118	93
Jackhammer	113	88
Generator	104	79
Lighting Tower	80	55
Flood Lights	90	65
Cherry Picker	102	77
Mobile Crane	110	85

7.3.2 Predicted noise levels

7.3.2.1 External receivers

A SoundPLAN model has been created for the development site in order to analyse potential above ground airborne construction noise impacts to nearby external receiver locations. This has been done to provide a more accurate analysis of noise propagation throughout the surrounding street network, taking into account the complex shielding configuration of the juxtaposed buildings within the city. Predictions have been made using the ISO 9613:1996 [17] prediction methodology in order to ascertain likely impacts during various stages of demolition, excavation and construction of the OSD towers and station entrances. To illustrate this, Figure 11 provides an axonometric view of the model showing grid noise maps.

The level of noise impact will vary depending on the specific location of each piece of equipment in relation to the nearest noise sensitive receivers. When an item of equipment is closer to the receiver location, the noise impacts will be higher. A distribution of equipment has therefore been adopted across the site when predicting noise impacts and has been derived based on typical construction methodologies for this type of project.

All inputs, assessment methodologies, and calculation settings have been confirmed with Sydney Metro noise specialists in order to provide a direct comparison to the EIS / PIR outputs. It is noted that, whilst every effort has been made to align these predictions, a margin of variability is to be expected with acoustic modelling of this type.

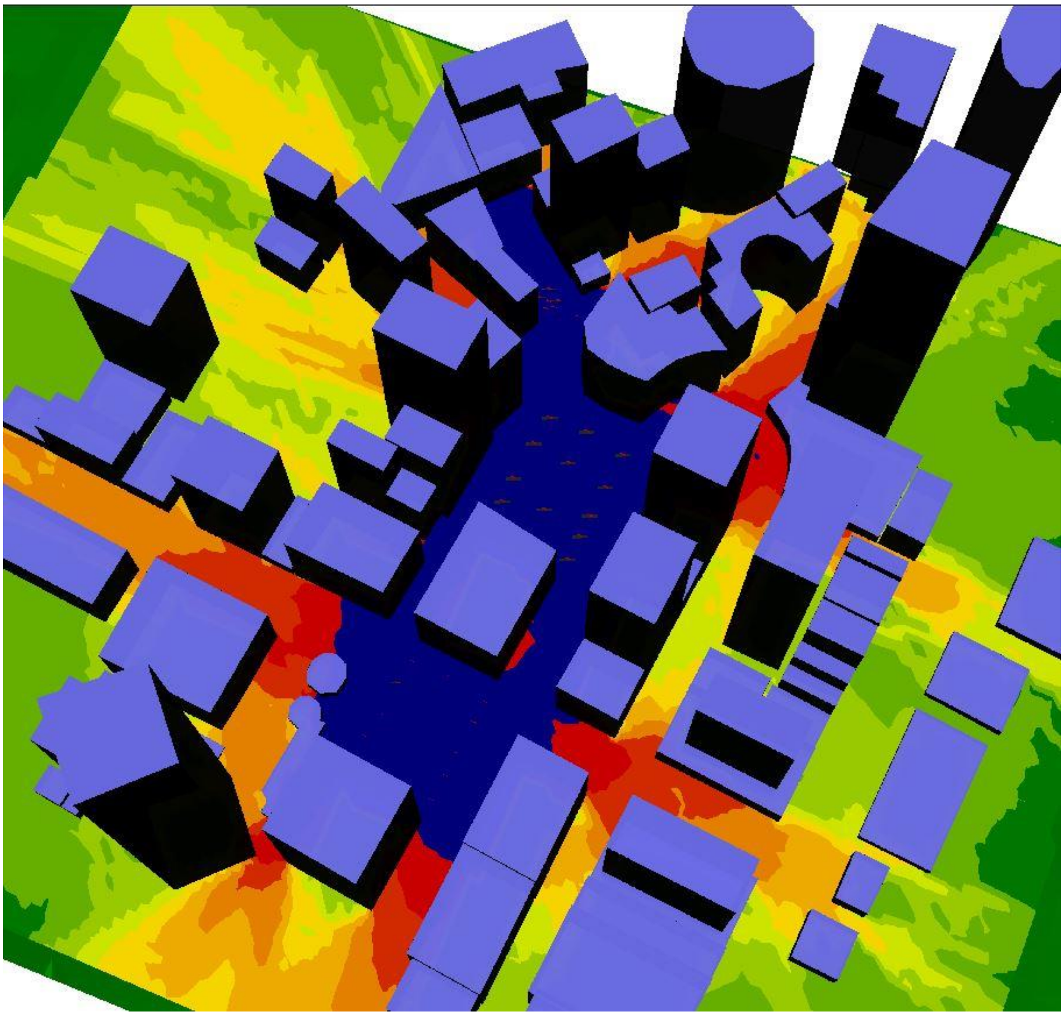

Figure 11: Grid noise maps illustrating noise impacts due to low excavation

A summary of predicted worst case airborne noise exceedances at the nearest affected external receivers is given in Table 21. Results have been grouped by noise catchment area as per Section 7.1. A discussion of results is provided below the table.

Table 21: Predicted airborne construction noise levels – External receivers

Noise Catchment Area	Type of Receiver	Construction
		Day
NCA - A	Commercial	1
	Residential	1
	Theatre	2
NCA - B	Residential	1
	Commercial	1
NCA – C	Residential	0
	Commercial	2
	Educational	1

Noise Catchment Area	Type of Receiver	Construction
		Day
NCA - D	Residential	0
	Commercial	1
	Studio	2
NCA – E	Commercial	2
NCA – F	Residential	0
	Commercial	1
NCA - G	Educational East	1
	Educational South	3
	Commercial	0

Legend

Category 0	Category 1	Category 2	Category 3
NML Compliance	NML exceedance of less than 10 dB	NML exceedance between 10 dB and 20 dB	NML exceedance of more than 20 dB

Note 1: The results presented in the Preferred Infrastructure Report are shown in brackets ( ).
Note 2: DOOH: Daytime out of hours (i.e. Saturdays 1pm to 6pm and Sundays 7am to 6pm)

As with the EIS / PIR predictions, exceedances of airborne noise management levels are expected for all stages of works. The predicted noise levels for the modification works show a variance in impact as compared with the works predicted in the PIR.

It should be noted that when assessing cumulative impacts from the MMP construction works, noise impacts have been focused around the noisiest items of plant with the greatest potential to adversely impact nearby receivers. Metro fitout works being undertaken concurrently with OSD construction works are understood to be relatively minor in terms of noise impact due to the type of construction works and the fact that they are below ground. These works are therefore not anticipated to contribute significantly to cumulative noise impacts.

There are instances where a lower category of impact is identified for the modification works as compared with the EIS / PIR. As discussed, a variance in acoustic model predictions is to be expected between EIS / PIR noise modelling and the modelling undertaken to assess modifications. It should also be noted that the presentation of results in bands of exceedance does not reflect the sometimes small variation in noise level (i.e. the difference between exceedance categories can be as low as 0.1 dB). In order to maintain a conservative approach to assessment the higher noise level as predicted for the EIS / PIR or modification works should be adopted.

While a change in noise impact is predicted as compared with the EIS / PIR works, the standard practice mitigation measures provided in the Construction Noise Strategy for the project are relevant to the additional works. As such, the strategy to mitigate the additional impacts would remain the same.

7.4 Ground-borne construction noise and vibration assessment

Ground-borne construction noise and vibration impacts will be dependent on:

- Specific activities and locations
- Structural connections between buildings
- Construction and condition of existing buildings
- Local geological conditions
- Duration and scheduling

Groundborne noise and vibration impacts are well quantified for significant demolition and excavation works as part of the Sydney Metro EIS / PIR and CSSI Mod documentation and will not be discussed in this report.

It is important to note that ground-borne noise and vibration transmission is very complicated since there are multiple paths by which vibrational energy may propagate throughout a building, and the losses associated between different points within the building are dependent on the actual details of the building structure.

Full prediction of ground-borne noise and vibration transmission requires a full structural model of the entire building and associated foundations and ground conditions, which is beyond the scope of this assessment.

As per the recommendations of the Construction Noise Strategy, it is recommended that a programme of noise and vibration monitoring be included in the construction schedule at the commencement of tunnelling works so that the actual levels experienced within the nearest affected receiver buildings can be measured and the construction activities and schedule be adjusted accordingly.

Groundborne noise and vibration is likely to be a significant factor in determining required construction methodologies and staging. It is important that contractors tendering for the works are made aware of any such restrictions so they can make allowances for the changed construction scheduling that may be required for these activities.

7.5 Mitigation Measures

With no mitigation measures in place, exceedances are predicted at numerous noise sensitive receiver locations for all stages of works. In accordance with ICNG, all feasible and reasonable mitigation measures are therefore required to be explored. The following section discusses potential mitigation measures for implementation.

The Construction Noise Strategy developed for the project and documented as part of the SPIR summarises feasible and reasonable mitigation measures relevant to the project. The suite of mitigation measures detailed therein are also considered relevant to the proposed CSSI modification works.

For information, noise mitigation measures for each major construction activity are discussed in the following sections.

7.5.1 General

In general, practices to reduce construction noise impacts may include;

- Adherence to the standard approved working hours for construction projects where possible
- Management of noise from construction work that might be undertaken outside the recommended standard hours following Section 2.3 of the ICNG
- The location of stationary plant (air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using natural screening by topography and intervening structures wherever possible to reduce noise impacts
- Using site sheds and other temporary structures or screens to limit noise exposure where possible
- The appropriate choice of low-noise construction equipment and/or methods
- Modifications to construction equipment or the construction methodology or program. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity, or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.
- A Community Consultation Strategy should be prepared for the project to outline methods for consultation with the community during construction including, but not limited to; advance notification of planned activities and expected disruption/effects, construction noise complaints handling procedures and effective monitoring of noise levels in and around potentially affected dwellings.

The above represents the best practical means of control. While the contractor will be able to achieve moderate reductions in noise and vibration, some impact is expected. A Construction Noise and Vibration Management Plan would be adopted for construction stages incorporating a program of noise monitoring at sensitive receivers, a community information program and a complaints hotline.

7.5.2 Construction noise and vibration management plan

For all construction works, the appointed contractor will be required to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan should include but not be limited to the following:

- Roles and responsibilities
- Noise sensitive receiver locations
- Predicted impacts

- Mitigation strategy
- Respite / scheduling
- Monitoring methodology
- Community engagement strategy.

Specific engineering methods for controlling construction noise and vibration impacts relevant to this study are discussed in the following sections.

7.5.3 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use.

7.5.4 Maximum equipment noise levels

The Transport for NSW (TfNSW) Construction Noise Strategy (CNS) [23] provides a framework for applying standard and additional mitigation measures for transport infrastructure construction projects including the maximum allowable noise levels for construction equipment. This will be an appropriate basis for determining screening measures necessary for machinery on site by the construction contractor.

7.5.5 Noise level reductions from mitigation

Indicative noise reduction for different noise mitigation measures relevant to construction activities for the project can be obtained from the guidance of AS2436 and BS5228.1.

7.5.6 Cumulative impacts

When considering mitigation measures and strategy, consideration should be given to cumulative impacts due to other developments occurring within the vicinity of the subject development site at the same time. Coordination between developments would be required to enable constructability including access requirements and traffic management. Where possible, as part of this coordination, construction phasing and implementation of respite should be coordinated between developments in order to minimise cumulative construction noise and vibration impacts.

8 Conclusion

Assessment has been undertaken of noise and vibration impacts associated with proposed modifications to the approved Sydney Metro scheme under the proposed Metro Martin Place development.

Information provided in the EIS / PIR documentation for the CSSI scheme have been used as the basis of assessment and comparison.

Assessment of construction noise and vibration has been undertaken for noise impact from the development to nearby receivers. Analysis has focussed on areas that constitute a modification to the approved scheme, however cumulative impacts have been assessed where relevant.

Mitigation measures provided in the Construction Noise Strategy have been identified as being relevant to the proposed modification works.

The assessment has been undertaken based on information available at the time of writing the report and will need to be updated as the design progresses.

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Appendix A

Acoustic Terminology

Absorption Coefficient, α

The amount of sound absorbed by a sample is characterised by the absorption coefficient, α. A perfect absorber (e.g. a sufficiently large opening in a room) from which no sound is reflected has an absorption coefficient of 1.00. There are two common methods for measuring sound absorption coefficients of a material.

One, the impedance tube method, is useful for readily obtaining results and only requires a small sample to be tested, but is limited in that it can only measure the normal-incidence absorption coefficient – i.e. the absorption coefficient for a single angle with sound propagating perpendicular to the material.

The other method, the reverberation chamber method, requires more extensive tests and a larger (~10 m²) sample size, but obtains the random-incidence absorption coefficient- i.e. the effective absorption coefficient of the material averaged over all angles. The random-incidence absorption coefficient is required for detailed room acoustic calculations.
Note that the reverberation chamber method can legitimately measure coefficients greater than 1.0 due to “edge effects” such as diffraction or scattering from the edges of the sample. These edge effects are reduced by using a barrier around the sample or by using a larger sample.

Weighted absorption coefficient (αw)

The weighted absorption coefficient, defined in ISO 11654 is a frequency-weighted single number absorption coefficient used to categorise the overall absorption effectiveness of a material.
Descriptors are used to indicate if the material absorbs strongly at high (“H”), mid (“M”) and/or low (“L”) frequencies – e.g. a material may be rated as αw 0.85(LH), which indicates that it strongly absorbs at both low and high frequencies.
The weighted-absorption coefficient is also used to assign materials into five absorption classes (materials with very low absorption are not assigned a class): Class A has the highest absorption, with Class E having the lowest absorption.

Noise-reduction Coefficient (NRC)

The noise reduction coefficient (NRC) is the (arithmetical) average of the sound-absorption coefficients of a material at 250Hz, 500Hz, 1kHz and 2kHz. It is intended for use a single-number index of the sound absorbing efficiency of a material.

Ambient Noise Level

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

Background Noise Level

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

Assessment Background Level (ABL)

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

Rating Background Level (RBL / minLA90,1hour)

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

Decibel

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

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

dB(A)

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

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

Some typical dB(A) levels are shown below.

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

L1

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

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

L10

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

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

L90

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

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

Leq

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

Leq is often used as the “average” level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB LAeq. Often the measurement duration is quoted, thus LAeq,15 min represents the dB(A) weighted energy-average level of a 15 minute measurement.

Lmax

The Lmax statistical level can be used to describe the “absolute maximum” level of a sound or vibration level that varies with time.
Mathematically, Lmax is the highest value recorded during the measurement period. As an example, 94 dB LAmax is a highest value of 94 dB(A) during the measurement period.
Since Lmax is often caused by an instantaneous event, Lmax levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as “pitch”. Sounds towards the lower end of the human hearing frequency range are perceived as “bass” or “low-pitched” and sounds with a higher frequency are perceived as “treble” or “high pitched”.

Impact Sound Pressure Level

The technical parameter used to determine impact sound isolation of floors is the impact sound pressure level, Li.

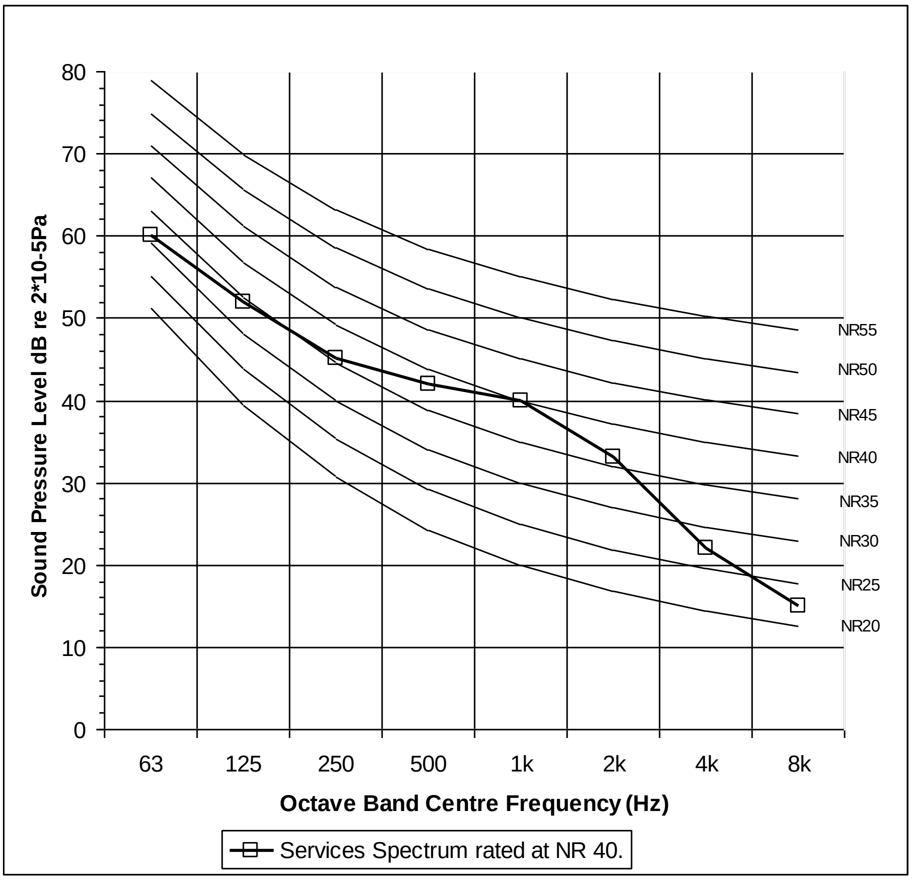
In the laboratory, the weighted normalised impact sound pressure level, Ln,w, is used to represent the impact sound isolation as a single figure.

On site, the weighted normalised apparent impact sound pressure level, L’n,w, and the weighted standardised apparent impact sound pressure level, L’n,Tw, are used to represent the impact sound isolation of a floor as a single figure.

These single weighted values are determined by comparing the spectral impact sound pressure levels (as defined in ISO 140-6 & ISO 140-7) with reference values outlined in AS/NZS ISO 717.2.

Noise Rating (NR) Curves

Noise rating (NR) curves are a set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The NR value of a noise is obtained by plotting the octave band spectrum on the set of standard curves. The highest value curve which is reached by the spectrum is the NR value. Shown below is a plant noise spectrum that is equivalent to NR 40.



Peak Particle Velocity (PPV)

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

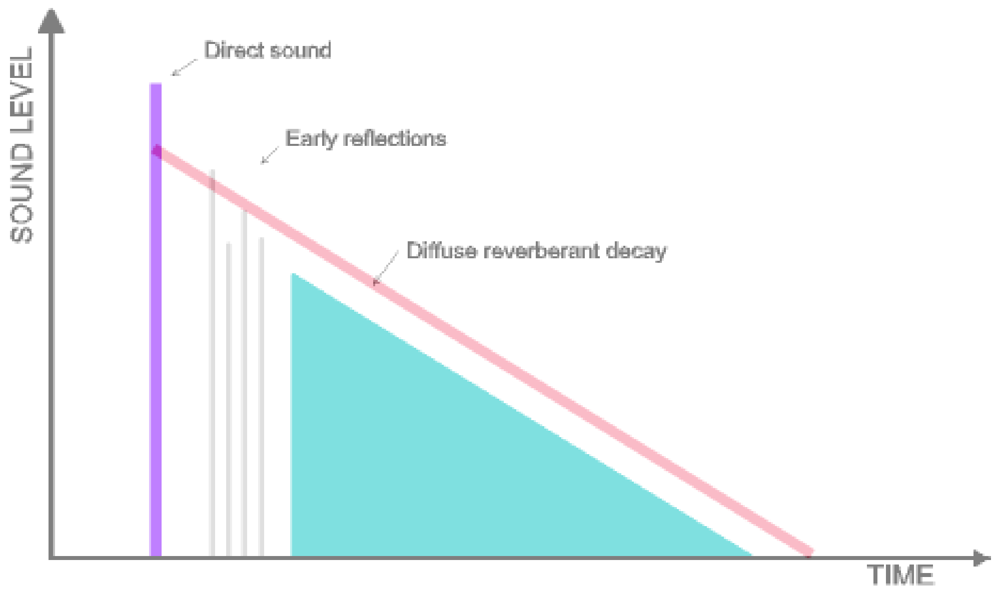
PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the Lmax or Lmax,spec index.

Reverberation Time (T60)

The time, in seconds, taken for a sound within a space to decay by 60 dB after the sound source has stopped is denoted at the reverberation time. The RT is an important indicator of the subjective acoustic within an auditorium. A large RT subjectively corresponds to an acoustically ‘live’ or ‘boomy’ space, while a small RT subjectively corresponds to an acoustically ‘dead’ or ‘flat’ space.

Examples of typical design reverberation times are provided below:

Mid-frequency Reverberation Time, s	Example
< 0.1	Anechoic
0.1 – 0.4	Call centres
0.4 – 0.6	Library
0.6 – 0.8	Offices / board rooms
0.8 – 1.0	Small auditorium for speech
1.0 – 1.2	Music studios
1.2 – 1.5	Chamber music venues
1.5 – 2.0	Orchestral music venues
2.0 – 3.0	Church
3.0 – 8.0	Cathedral



Sound Level Difference (D)

Sound level difference is used to quantify the sound insulation between two spaces, and is equal to the difference in sound level between the two rooms at a particular frequency (e.g. if the sound level in the source room is 100 dB and the sound level in the adjacent room is 75 dB, the sound level difference is 25 dB). The weighted sound level difference, Dw, (as defined in AS/NZS ISO 717.1) is commonly used to provide a single-number descriptor to describe the overall performance of a partition across a wider frequency range.

The terms used to describe the airborne sound insulation rating of a building element when tested on-site are the weighted normalised level difference (Dn,w), which corrects the measured sound level difference to a reference absorption area in the receiving room, or the weighted standardized level difference (DnT,w), which corrects the measurements to a reference reverberation time in the receiving room.
These single numbers are determined by comparing the spectral sound insulation test results (as defined in ISO 140-4) with reference values, as outlined in AS/NZS ISO 717.1.

Sound Power and Sound Pressure

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

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, Rw, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. Rw values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'w) ratings.

Speech Transmission Index (STI)

STI is a technical index, predictable and measurable using specialised equipment, for assessing speech and vocal intelligibility. STI takes into account the signal/noise ratio of the speech signal and the reverberation of the receiving environment. The higher the value of STI, the higher the expected speech intelligibility.

STI ratings are assigned subjective categories, as follows:

STI Range	Subjective Category
< 0.3	Bad
0.3 – 0.45	Poor
0.45 – 0.6	Fair

STI Range	Subjective Category
0.6 – 0.75	Good
0.8 – 1.0	Excellent

Spectrum Adaptation Terms (C and Ctr)

The terms C and Ctr are spectrum adaptation terms (in dB) that are added to the Rw or Dw value of a partition in order to determine the overall sound insulation rating of a partition for various conditions. The overall performance of the partition is quoted as the sum of the Rw value and the spectrum adaptation terms, e.g. Dw + C 55 dB; Rw + Ctr 60 dB.

C is a spectrum adaptation term used to measure the performance of a partition for medium to high-frequency noise sources, such as speech.

Ctr is a spectrum adaptation term used to measure the performance of a partition for low-frequency noise sources such as traffic noise.

The values of C and Ctr are dependent on the construction of the partition. Because C and Ctr are (usually) negative quantities, they typically increase the Rw requirement of a partition (eg if Ctr is -6 dB, an Rw of 56 dB is required to achieve a rating of Rw + Ctr 50 dB).

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.