Macquarie

Sydney Metro Martin Place Integrated Station Development

North Tower, SSD DA Stage 2: Acoustic Assessment Report

CSWSMP-MAC-SMN-NA-REP-999902

1 | 29 August 2018

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 247838

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Contents

1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) (SSD DA) submitted to the Minister for Planning (Minister) pursuant to Part 4 of *the Environmental Planning and Assessment Act 1979* (EP&A Act) on behalf of Macquarie Corporate Holdings Pty Limited (Macquarie), who is seeking to create a world class transport and employment precinct at Martin Place, Sydney.

The SSD DA seeks approval for the detailed design and construction of the **North Site** Over Station Development (OSD), located above and integrated with Metro Martin Place station (part of the NSW Government's approved Sydney Metro project). The northern entrance to Metro Martin Place station will front Hunter Street, Elizabeth Street and Castlereagh Street, with the North Site OSD situated above.

This application follows the approval granted by the Minister for a Concept Proposal (otherwise known as a Stage 1 SSD DA) for two OSD commercial towers above the northern and southern entrances of Metro Martin Place station (SSD 17_8351). The approved Concept Proposal establishes building envelopes, land uses, Gross Floor Areas (GFA) and Design Guidelines with which the detailed design (otherwise known as a Stage 2 SSD DA) must be consistent. This application does not seek approval for elements of the Metro Martin Place Precinct (the Precinct) which relate to the Sydney Metro City and Southwest project, which is subject to a separate Critical State Significant Infrastructure (CSSI) approval. These include:

- Demolition of buildings on the North Site and South Site;
- Construction of rail infrastructure, including station platforms and concourse areas;
- Ground level public domain works; and
- Station related elements in the podium of the North Tower.

However, this application does seek approval for OSD areas in the approved Metro Martin Place station structure, above and below ground level, which are classified as SSD as they relate principally to the OSD. These components are within the Sydney Metro CSSI approved station building that will contain some OSD elements not already approved by the CSSI Approval. Those elements include the end of trip facilities, office entries, office space and retail areas, along with other office/retail plant and back of house requirements that are associated with the proposed OSD and not the rail infrastructure.

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.

Context

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 and Southwest (Stage 2).

Stage 2 of Sydney Metro entails the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and onto 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 approved the Stage 2 (Chatswood to Sydenham) Sydney Metro application lodged by Transport for NSW (TfNSW) as a Critical State Significant Infrastructure (CSSI) project (reference SSI 15_7400). Work is well underway under this approval, including demolition of buildings at Martin Place.

The OSD development is subject to separate applications to be lodged under the relevant provisions of the EP&A Act. One approval is being sought for the North Site – this application – and one for the South Site via a separate application.

Site Description

The Metro Martin Place Precinct 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).

This application relates **only to the North Site**, being the city block bounded by Hunter Street, Castlereagh Street, Elizabeth Street, and Martin Place (refer to Figure 1).

The South Site (39 – 49 Martin Place) is the subject of a separate Stage 2 SSD DA.

Figure 1: Aerial Photo of the North and South Site of the Metro Martin Place Precinct

Background

Sydney Metro Stage 2 Approval (SSI 15_7400)

The Sydney Metro CSSI Approval approves the demolition of existing buildings at Martin Place, excavation and construction of the new station (above and below ground) along with construction of below and above ground structural and other components of the future OSD, although the fit-out and use of such areas are the subject of separate development approval processes.

On 22 March 2018, the Minister approved Modification 3 to the Sydney Metro CSSI Approval. This enabled the inclusion of Macquarie-owned land at 50 Martin Place and 9-19 Elizabeth Street within Metro Martin Place station, and other associated changes (including retention of the opening to the existing MLC pedestrian link).

Concept Proposal (SSD 17_8351)

On 22 March 2018, the Minister approved a Concept Proposal (SSD 17_8351) relating to Metro Martin Place Precinct. The Concept Proposal establishes the planning and development framework through which to assess the detailed Stage 2 SSD DAs.

Specifically, the Concept Proposal encompassed:

- Building envelopes for OSD towers on the North Site and South Site comprising:
  - 40+ storey building on the North Site (see Figure 2)
  - 28+ storey building on the South Site
  - Concept details to integrate the North Site with the existing and retained 50 Martin Place building (the former Government Savings Bank of NSW)
- Predominantly commercial land uses on both sites, comprising office, business and retail premises
- A maximum total GFA of 125,437m^2 across both sites
- Design Guidelines to guide the built form and design of the future development
- A framework for achieving design excellence
- Strategies for utilities and services provision, managing drainage and flooding, and achieving ecological sustainable development
- Conceptual OSD areas in the approved Metro Martin Place Metro station structure, above and below ground level[1]

[1] *Refers to those components within the Metro CSSI approved station envelope that will contain some OSD elements not approved in the CSSI consent. Those elements include the end of trip facilities, office entries, office space and retail areas, along with other office/retail plant and back of house requirements that are associated with the proposed OSD and not the rail infrastructure.*

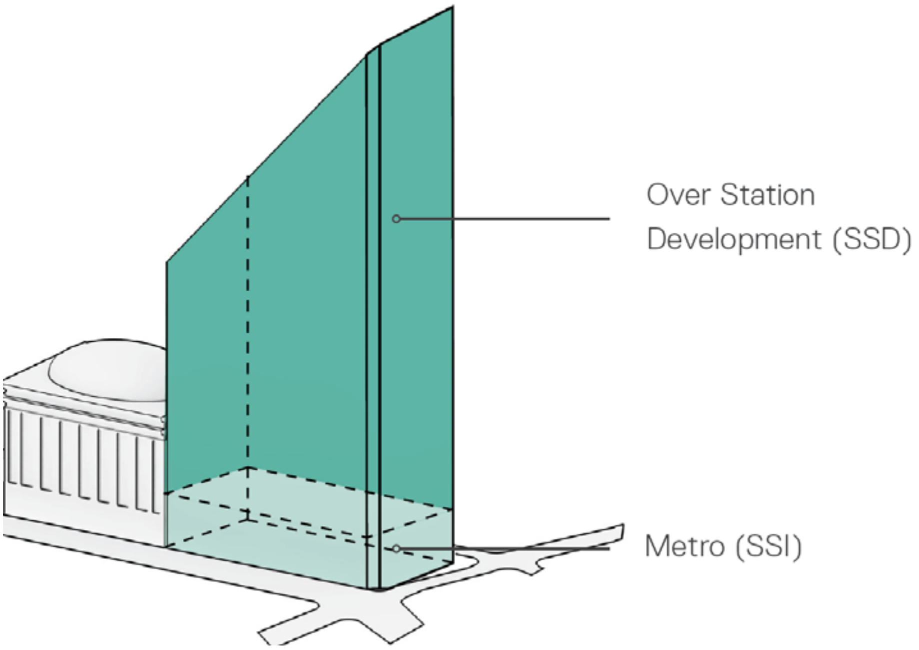


Figure 2: North Site Approved OSD Building Envelope

Planning Proposal (PP_2017_SYDNE_007_00) - Amendment to Sydney LEP 2012

The Planning Proposal (PP_2017_SYDNE_007_00) sought to amend the development standards applying to the Metro Martin Place Precinct through the inclusion of a site-specific provision in the Sydney Local Environmental Plan (LEP) 2012. This site-specific provision reduced the portion of the **South Site** that was subject to a 55 metre height limit from 25 metres from the boundary to Martin Place, to 8 metres, and applies the Hyde Park North Sun Access Plane to the remainder of the South Site, forming the height limit of the tower. It also permits a revised FSR of 22:1 on the South Site and 18.5:1 on the North Site. These amendments were gazetted within Sydney LEP 2012 (Amendment No. 46) on 8 June 2018 and reflect the new planning controls applying to the Precinct.

Overview of the Proposed Development

The subject application seeks approval for the detailed design, construction and operation of the North Tower. The proposal has been designed as a fully integrated station and OSD project that intends to be built and delivered as one development, in-time for the opening of Sydney Metro City and Southwest in 2024. This application seeks consent for the following:

- The design, construction and operation of a new 39 storey commercial OSD tower (plus rooftop plant) within the approved building envelope for the North Site, including office space and retail tenancies.
- Physical connections between the OSD podium and the existing 50 Martin Place building, to enable the use of the North Site as one integrated building.
- Vehicle loading areas within the basement levels.

- Extension and augmentation of physical infrastructure / utilities as required.
- Detailed design and delivery of ‘interface areas’ within both the approved station and Concept Proposal envelope that contain OSD-exclusive elements, such as end of trip facilities, office entries, office space and retail areas not associated with the rail infrastructure.

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 4.22 of the EP&A Act a Concept 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 the site are to be the subject of subsequent DAs. This SSD DA represents a detailed proposal and follows the approval of a Concept Proposal on the site under Section 4.22 of the EP&A Act.

Submitted separately to this SSD DA is a SSD DA for the South Site (Stage 2 South Site SSD DA). A Stage 1 Amending SSD DA to the Concept Proposal (Stage 1 Amending DA) has also been submitted that has the effect of aligning the approved South Site envelope with the new planning controls established for the South Site (achieved through the site specific amendment to the Sydney LEP 2012).

Figure 3 below is a diagrammatic representation of the suite of key planning applications undertaken or proposed by Macquarie and their relationship to the subject application (the subject of this report).

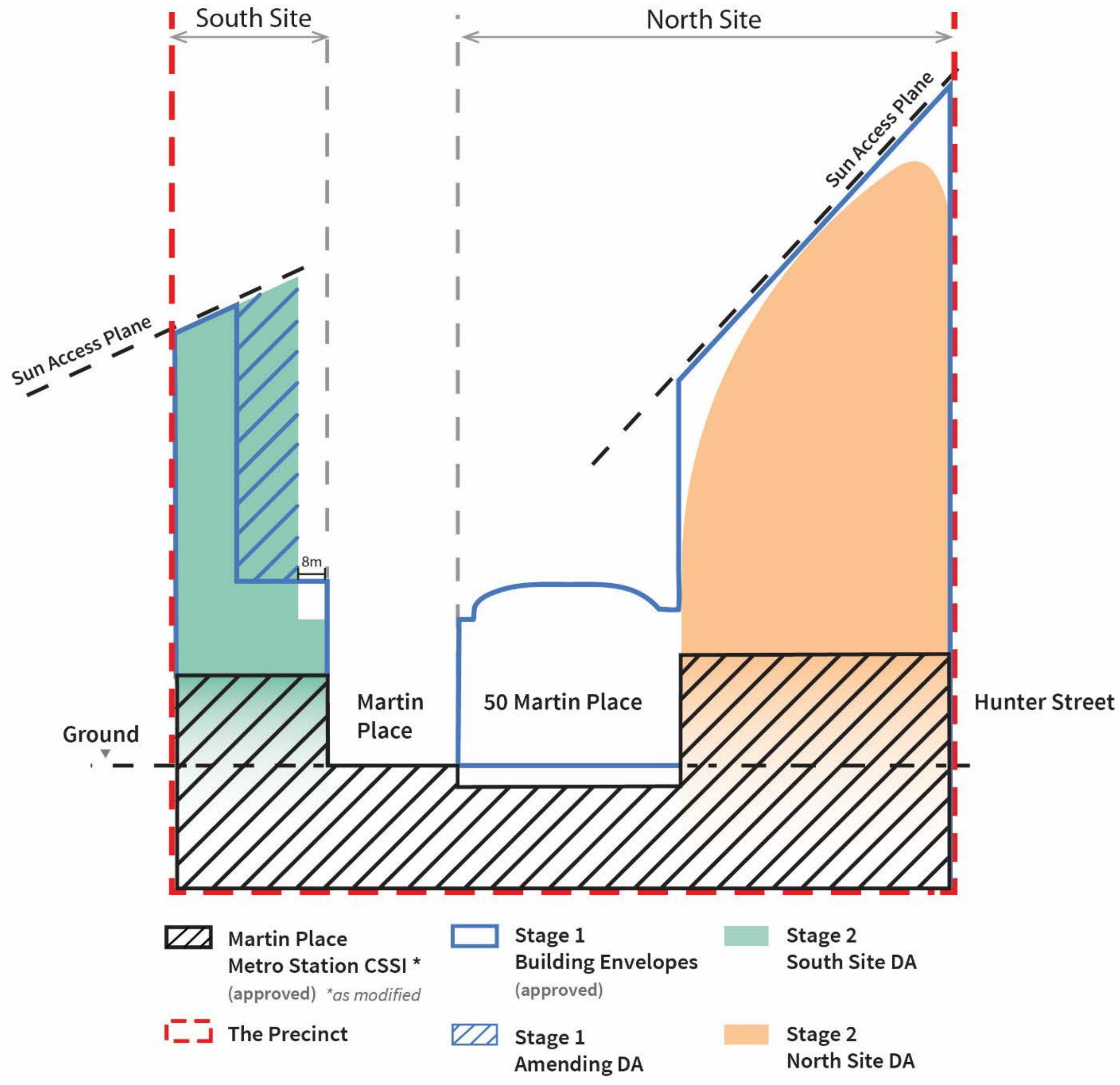


Figure 3: Relationship of key planning applications to the Stage 2 North Site DA (this application)

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 follows:

The EIS must include all relevant plans, architectural drawings, diagrams and relevant documentation required under Schedule 1 of the EP&A Regulation 2000. Provide these as part of the EIS rather than as separate documents.

In addition, the EIS must include the following:

- Noise and vibration report (operation).

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

The relevant policies and guidelines for construction and operational noise and vibration have been addressed in this report and are summarised in the list of references in Section 11.

Furthermore, Condition B15 of the Development consent, Section 4.38 of the Environmental Planning and Assessment Act 1979, states:

- B15. Future Development Application(s) for construction of new buildings shall be accompanied by a noise and vibration impact assessment that identifies and provides a quantitative assessment of the main noise generating sources and activities during operation, including consideration of noise and vibration impacts associated with commercial development. above a train station. Details are to be provided outlining any mitigations measures to ensure the amenity of future sensitive land uses on the site or the neighbouring residential areas is protected during the operation of the development.

This report has been prepared to address the above condition.

2 Executive summary

This report provides an assessment of noise and vibration impacts associated with the construction and operation of the Metro Martin Place Integrated Station Development, specifically the North Tower.

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 (EIS) and subsequent Submissions and Preferred Infrastructure Report (SPIR) for the Sydney Metro project.

In accordance with SEARs 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.

Control of operational noise and vibration emissions from the development will be readily achieved via standard engineering solutions. Detailed assessment of operational noise emissions will be conducted as design develops. Preliminary design solutions are provided at this stage.

Detailed assessment of operational noise emissions from the project will be conducted as design develops. Control of operational noise and vibration emissions from the development will be readily achieved via standard engineering solutions. Preliminary design solutions are provided.

Assessment of noise and vibration impacts 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. Indicative glazing build-ups are provided for the different levels of the OSD to control external noise intrusion.

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 arising from the OSD 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 construction noise assessment undertaken as part of the EIS for the Sydney Metro scheme. Noise and vibration impacts are expected during all stages of construction works, including OSD construction works. Recommendations are provided to manage and mitigate noise and vibration impacts.

3 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.

3.1 Noise Sensitive Receiver Locations

The area surrounding Metro Martin Place Precinct 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.

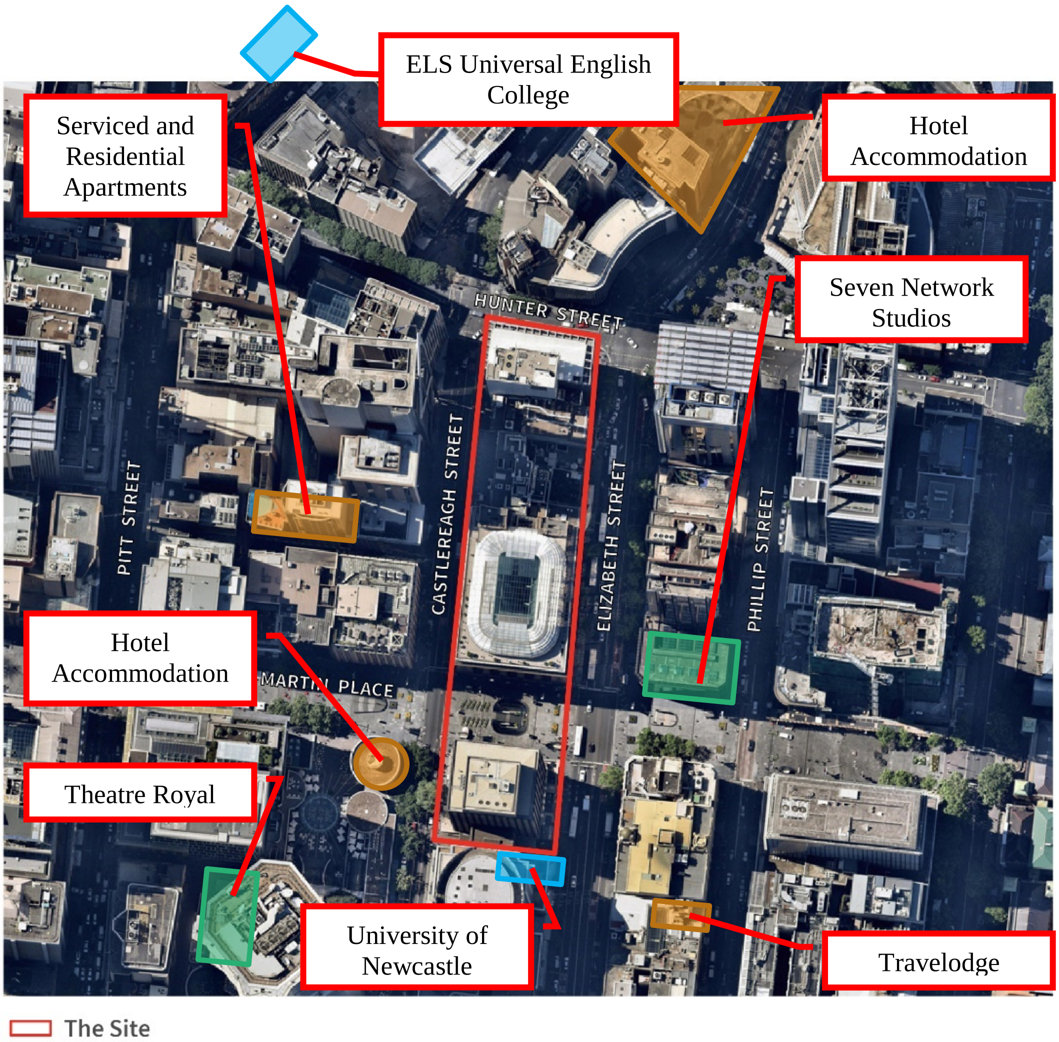


Figure 4: Proposed development site

3.2 Noise Survey

3.2.1 Noise Measurement Locations

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

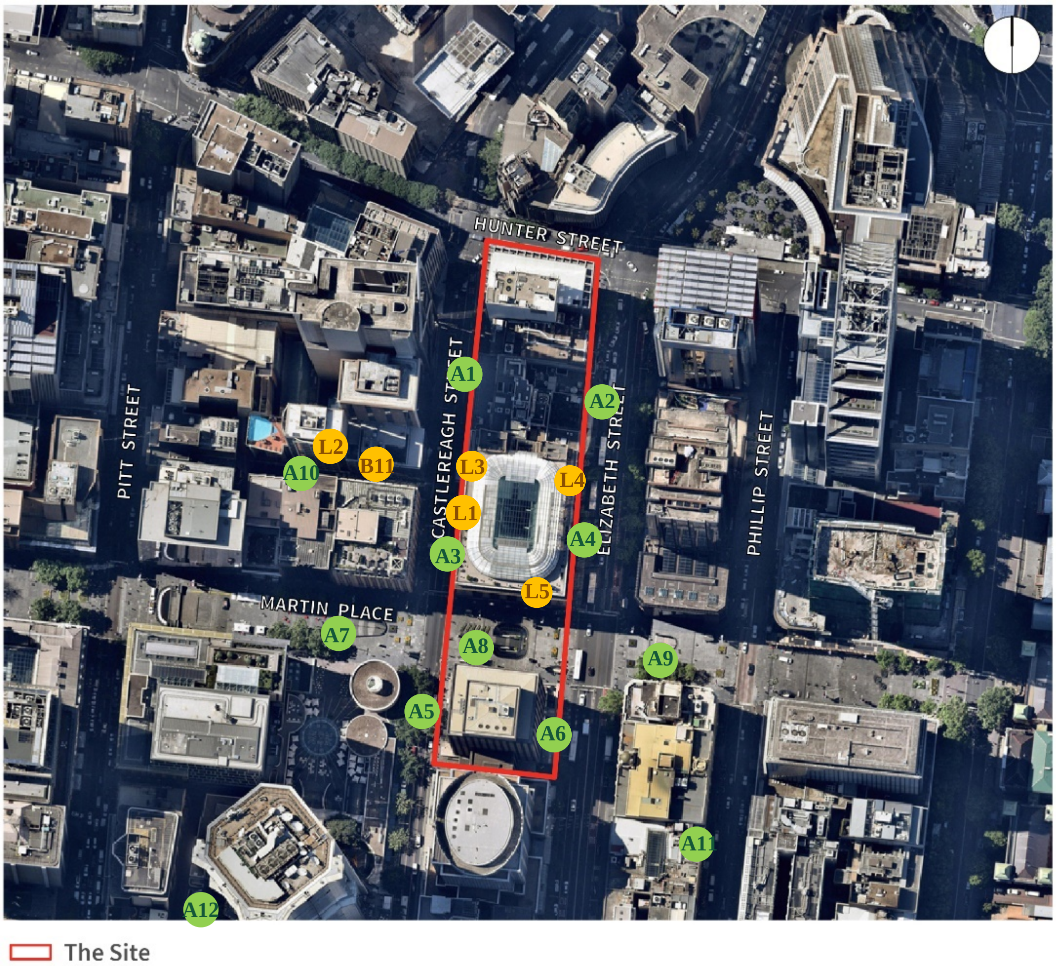


Figure 5: Noise measurement locations

Unattended
Attended

3.2.2 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 Martin Place Station Integrated Station Development 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 Street and Elizabeth Street 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.

3.2.3 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.

3.3 Vibration Survey

3.3.1 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 ESL 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.

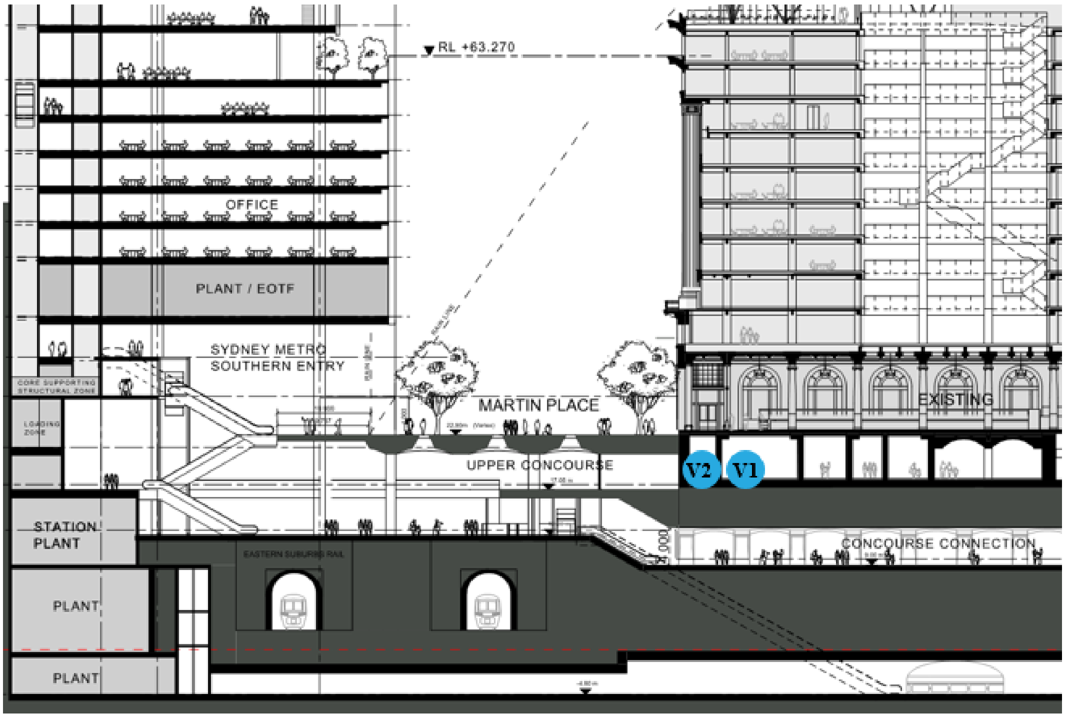


Figure 6: Vibration survey measurement locations

Unattended

3.3.2 Vibration Measurement Results

Measured vibration levels from the survey are presented in Figure 7 as acceleration to inform assessment against target criteria discussed in Section 4.4.4. Assessment results are included in Section 6.3.1.2.

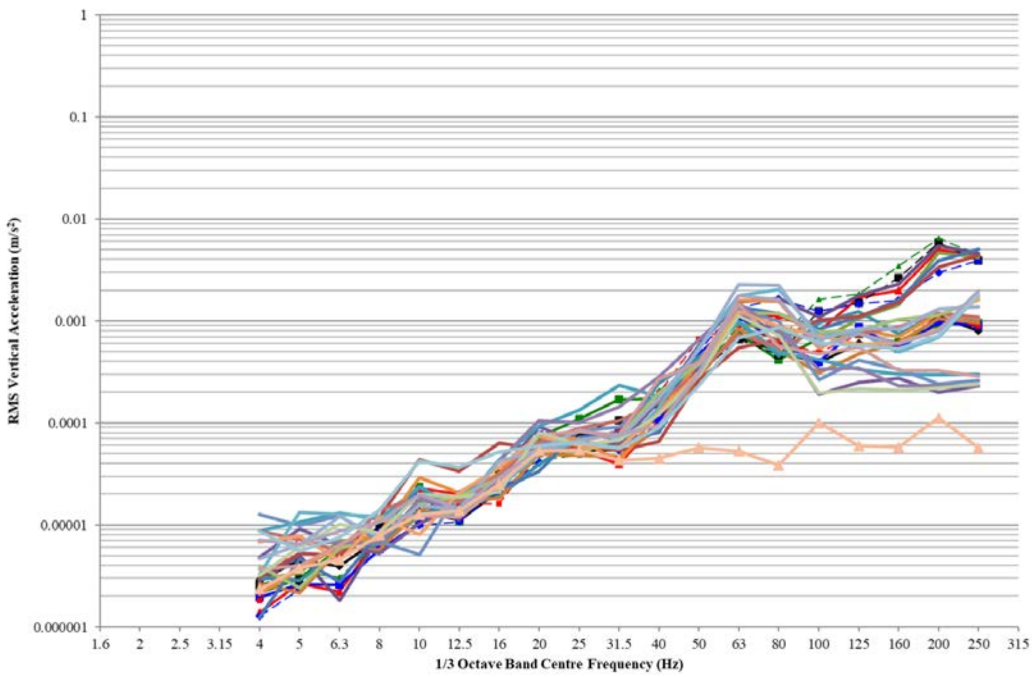


Figure 7: Measured train vibration levels, lower basement – 50 Martin Place

4 Assessment criteria

4.1 Assessment Requirements

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

4.2 Operational Noise Criteria

4.2.1 Environmental Noise

4.2.2 Industrial Noise

Noise emission from the Project has been assessed in accordance with the NSW *Industrial Noise Policy* (INP) [2], 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.

4.2.2.1 Intrusive Noise Criteria

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

- $L_{Aeq,15minute}$ ≤ 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 North Tower noise goals.

4.2.2.2 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)

Type of receiver	Indicative Noise Amenity Area	Time of day[1]	Recommended $L_{Aeq(Period)}$ noise level	
			Acceptable	**Recommended maximum**
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45

Type of receiver	**Indicative Noise Amenity Area**	**Time of day**[1]	**Recommended $L_{Aeq(Period)}$ noise level**	
			Acceptable	**Recommended maximum**
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
	Urban/Industrial Interface - for existing situations only	Day	65	70
		Evening	55	60
		Night	50	55
School classrooms - internal	All	Noisiest 1 hour period when in use	35	40
Hospital ward	All	Noisiest 1 hour period		
- internal			35	40
- 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 20 dB higher is considered appropriate (i.e. for educational facilities 40+20=60dBA). This is based on the assumption that glazing elements in the CBD would provide at least 20 dB attenuation.

4.2.2.3 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.

4.2.2.4 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

Time Period	**Intrusive Criteria $dBL_{Aeq(15min)}$**	**Amenity Criteria $dBL_{Aeq(Period)}$**			
	Residential Receivers		**Commercial Receivers**	**Educational Receivers**	**Places of Worship**
Day (7am – 6pm)	66	56			
Evening (6pm – 10pm)	61	52	65	60[1,2]	60[1]
Night (10pm – 7am)	57	53			

[1] External noise levels have been derived assuming a minimum 20 dB reduction via the façade as per the EIS.

[2] Note 10 of the INP states that in the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 $dBL_{Aeq(1hr)}$.

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

4.2.2.5 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

4.2.2.6 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 s’

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

Receiver type	**Limiting criterion, dB(A)**
Residential	61
Commercial	70
Educational	65
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.

4.2.3 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, an 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 are also typically adopted by local Councils for applicable development. The criteria are 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.”*

4.2.4 Road Traffic Noise

The NSW Road Noise Policy (RNP) [3] 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.

4.2.5 External Noise Intrusion

4.2.6 Airborne Noise

AS 2107:2016 [4] 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 is 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.

4.2.6.1 Groundborne Noise

Guidance for groundborne noise levels from railways is provided in Interim Guidance for Applicants [5], and more recently in the NSW Infrastructure SEPP

(ISEPP) [6]. 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 [7].

Clause 87 of the ISEPP 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 ISEPP – 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 project are as follows:

- Open plan office areas: 45 dB $L_{Amax,slow}$

4.3 Construction Noise Criteria

The following sections summarise recommended construction noise targets for the proposed North Tower OSD.

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 8.

4.3.1 Airborne Construction Noise Targets

4.3.1.1 External Receivers

The NSW *Interim Construction Noise Guideline* (ICNG) [8] 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 below.

Table 7: Construction noise management levels at residential receivers

Time of day	**Management level** [1] **$L_{Aeq\ (15\ min)}$**	**How to apply**
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ 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.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • 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.

Time of day	Management level 1 $L_{Aeq\ (15\ min)}$	How to apply
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 *of the ICNG.*
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.		

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 prior to commencement of construction.

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			

4.3.2 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.

4.4 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.

Note the CSSI approval (separate to this SSDA) is the approval instrument applicable to all in-ground works including utilities, tunnelling, piling, excavation, and construction works and any resultant vibration impacts on existing rail tunnels and structures. However, the North Tower structure is integrated with the Metro Martin Place station structure, as detailed in the separate structural engineering statement, therefore sections 4.4.2 and 4.4.3 are included for context and shall be relevant to any tower works which will potentially have vibration impacts on the in-ground works.

4.4.1 Structural Damage

4.4.1.1 Definition

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard BS 7385-2 [9] and/or German Standard DIN4150-3 [10]. British Standard 7385-1 [11], 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 . 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.

4.4.1.2 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	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

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
	commercial type buildings				

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%.

4.4.1.3 German Standard

German Standard DIN 4150-3 [12] 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

4.4.1.4 CSSI PIR Vibration Screening Criteria

The CSSI EIS and PIR documentation adopts the following line-wide 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.

4.4.2 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.

4.4.3 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 4.4.1, the following sections discuss further criteria relevant to rail tunnels.

4.4.3.1 Vulnerability of Ground-related Structures and Services

BS5228-2:2009 [13] 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.

4.4.3.2 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.

4.4.4 Human Exposure

Potential vibration disturbance to human occupants of buildings is made in accordance with the NSW DEC ‘*Assessing Vibration; a technical guideline*’ [14]. The criteria outlined in the guideline is based on the British Standard BS 6472-1 [15]. 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

5 Operational Acoustic Assessment

5.1 Operational Noise Sources

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

- Mechanical plant and equipment
- Electrical plant and equipment
- Licensed premises

5.2 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 design the most stringent noise criteria as presented in Section 4.2.1 have been adopted as the governing criteria for environmental noise emission. Basically, it has been assumed that all mechanical plant apart from emergency equipment such as smoke exhaust fans, generators and stair pressurisation fans, will operate 24 hours.

This section addresses primary acoustic attenuation measures only. The detailed mechanical systems noise control strategies will be developed as the design progresses.

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.

5.2.1 Attenuators

Indicative attenuator sizes for the different equipment items within the development are presented in the Table 16 below. These have determined based on the current equipment selections and current level of detail for plantroom layouts.

The sizes and specific acoustic performance for the attenuators will be verified with detailed design calculations as the design progresses. The purpose at this stage is to inform preliminary spatial allowances.

Refer to Mechanical drawings for the specific locations.

Table 16: Indicative attenuator requirements

Level	Equipment	Attenuator Length – Air Path Location
L39	CT-N-39-01	600 mm - intake

Level	Equipment	Attenuator Length – Air Path Location
	CT-N-39-02	600 mm – intake
	CT-N-39-03	600 mm – intake
	CT-N-39-04	600 mm - intake
	CT-N-39-05	600 mm - intake
L38	SEF-N-38-01	900 mm - discharge
	SEF-N-38-02	900 mm - discharge
	TEF-N-38-01	600 mm - discharge
	KEF-N-38-01	1200 mm - discharge
	TGEF-N-38-01	600 mm - discharge
L28	RAF-N-28-01	2100 mm – discharge and intake
	RAF-N-28-02	2100 mm – discharge and intake
	TGEF-N-28-01	1500 mm – discharge
	TGEF-N-28-02	1200 mm – discharge
	TGEF-N-28-03	1200 mm – discharge
	SEF-N-28-01	1500 mm – discharge
	SEF-N-28-02	1500 mm - discharge
	SPF-N-28-01	1500 mm – discharge
	SPF-N-28-02	2100 mm – discharge
	OAF-N-28-01	3000 mm - intake
	OAF-N-28-02	3000 mm - intake
	TEF-N-28-01	2100 mm – discharge
	TEF-N-28-02	2100 mm – discharge
	GEF-N-28-01	2100 mm – discharge
	AHU-N-28-01	1500 mm - supply
	AHU-N-28-02	1500 mm - supply
	AHU-N-28-03	1500 mm - supply
	AHU-N-28-04	1500 mm - supply
	AHU-N-28-05	1500 mm - supply
	AHU-N-28-06	1500 mm - supply
L15	RAF-N-15-01	3000 mm – discharge and intake
	RAF-N-15-02	3000 mm – discharge and intake
	SPF-N-15-01	2100 mm – intake
	SEF-N-15-01	1500 mm - discharge
	SEF-N-15-02	1500 mm - discharge
	AHU-N-15-01	2400 mm – supply
	AHU-N-15-02	2400 mm – supply
	AHU-N-15-03	2400 mm – supply

Level	Equipment	Attenuator Length – Air Path Location
	AHU-N-15-04	2400 mm – supply
	AHU-N-15-05	2400 mm – supply
	AHU-N-15-06	2400 mm – supply
	AHU-N-15-07	2400 mm – supply
	AHU-N-15-08	2400 mm – supply
	AHU-N-15-09	2400 mm – supply
	AHU-N-15-10	2400 mm – supply
	AHU-N-15-11	2400 mm – supply
	TEF-N-15-01	1200 mm – discharge
	TGEF-N-15-01	1200 mm – discharge
	TGEF-N-15-02	1200 mm – discharge
	TGEF-N-15-03	1200 mm – discharge
	KEF-N-15-02	1200 mm – discharge
L6	AHU-N-06-01	1200 mm – intake 3000 mm - discharge
	AHU-N-06-02	600 mm – intake 1200 mm - discharge
	AHU-N-06-03/04	900 mm – intake 1800 mm - discharge
	GEF-N-06-01	2100 mm – intake 2400 mm - discharge
	OAF-N-06-01	1800 mm – intake 3000 mm - discharge
	SEF-N-06-01	3000 mm – intake and discharge
	Carpark Exhaust Fan	3000 mm – intake and discharge
L5	KEF-N-05-01 to 04	1500 mm – intake 1800 mm - discharge
L3	GEF-N-03-01	900 mm – intake 1500 mm - discharge
	GEF-N-03-02	600 mm – intake 2100 mm – discharge
L1	AHU-N-01-01	1500 mm - intake
	AHU-N-01-02	1500 mm - intake
	GEF-N-01-01	3000 mm - intake
	GEF-N-01-02	3000 mm - discharge
	SPF-N-01-01	3000 mm – intake 1200 mm - discharge
	OAF-N-01-01	1500 mm – discharge and intake
GF	OAF-N-G-01	1500 mm – discharge and intake

Level	Equipment	Attenuator Length – Air Path Location
	SAF-N-00-01	2100 mm – discharge and intake
	SAF-N-00-02	2100 mm – discharge and intake
	SAF-N-00-03	2100 mm – discharge and intake
LG	GEF-N-LG-01	2400 mm – intake 1500 mm – discharge
	GEF-N-LG-02	2400 mm – intake 1500 mm – discharge
	SEF-N-LG-01	3000 mm – intake 3000 mm – discharge
	SEF-N-LG-02	3000 mm – intake 3000 mm – discharge
B1	TEF-N-B1-01	1500 mm – discharge and intake
	GEF-N-B1-01	1500 mm – discharge and intake
	OAF-N-B1-01	1500 mm – discharge and intake
B2	TEF-N-B2-01	1500 mm – discharge and intake
B3	GEF-N-B3-01	1500 mm – discharge and intake

5.2.2 Acoustic Louvres

Indicative acoustic louvre requirements are listed in Table 17 below. Refer to Mechanical drawings for the specific locations.

Table 17: Indicative acoustic louvre requirements

Level	Acoustic Louvre Depth – Air Path Location
L38	600 mm - intake
L28	600 mm - intake
L28 – electrical room	300 mm – intake
L15	600 mm - intake
L6 – chillers and pumps	600 mm - intake
L5/6 – cooling towers	600 mm - exhaust
L5	300 mm - exhaust
L4	300 mm - intake
L3	300 mm - exhaust

5.2.3 Sound Absorption within Plantrooms

It is recommended that sound absorbing finishes are installed within plantrooms to control reverberant noise levels. It is recommended this to be 50 mm thickness sound absorbing finish, with a minimum density of 32 kg/m3.

5.2.4 Ductwork Acoustic Cladding

Acoustic external duct cladding should be provided for ductwork in all plant rooms between the attenuator and where the duct leaves the plant room. To minimise the need for external duct cladding, attenuators should be installed in ductwork as close to the exit of the plantroom as possible. This requirement is to be superimposed on top of the requirements for internal insulation for acoustic and thermal purposes.

In addition to this, external duct cladding is also required for ducts traversing office areas on **Level 15**.

5.2.5 Equipment Enclosures

It is recommended that enclosures are provided for the following equipment items:

Table 18: Equipment enclosures

Location	Equipment	Minimum enclosure
L28	OAF-N-28-01	1x13 mm fire rated plasterboard (or equivalent)
	OAF-N-28-02	
L38	SEF-N-38-01	
	SEF-N-38-01	

5.2.6 Internal Duct Lining

Internal duct lining should be installed as follows:

Equipment on Levels 15 and 28:

Table 19: Internal duct lining requirements for equipment in L15 and L28

Location	Requirement
L15 plantroom supply ducts	50 mm lining
L28 plantroom supply ducts	50 mm lining
L28 OAF intake plenum	25 mm lining

Equipment in lower levels:

Table 20: Internal duct lining requirements for equipment in L15 and L28

Level	Equipment	Air path location	Requirement
L1	L1_N_AHU01	Inlet	- Minimum 1m of internally lined ductwork with 50mm acoustic lining
		Outlet	- Minimum 10m of internally lined ductwork with 50mm acoustic lining

Level	Equipment	Air path location	Requirement
	L1_N_AHU02	Inlet	- Minimum 1m of internally lined ductwork with 50mm acoustic lining
		Outlet	- Minimum 5m of internally lined ductwork with 50mm acoustic lining
	L1_N_GEF01/02	Inlet	- Minimum 2m of internally lined ductwork with 50mm acoustic lining
		Outlet	- Minimum 1m of internally lined ductwork with 50mm acoustic lining
L6	AHU-N-06-01	Outlet	- Minimum 5m of internally lined ductwork with 50mm acoustic lining
	AHU-N-06-03/04	Outlet	- Minimum 3m of internally lined ductwork with 50mm acoustic lining
	GEF-N-06-01	Inlet	- Minimum 2m of internally lined ductwork with 50mm acoustic lining
	KEF-N-05-01 to 04	Outlet	- Minimum 4m of internally lined ductwork with 50mm acoustic lining
	OAF-N-06-01	Outlet	- Minimum 4m of internally lined ductwork with 50mm acoustic lining

5.3 Electrical Plant and Equipment

5.3.1 Generators

Typical generator installations are specified to include proscriptive performance requirements for each component of the generator and installation - noise level for generator, insertion loss for gen set, noise level at flue exhaust, etc.

The recommended design approach for generators is to provide and overall performance specification, which includes specific noise levels to be achieved at a specific distance outside the generator room:

- The following are the recommended performance criteria:65 dB(A) at 1 m from each generator room air intake louvre
- 65 dB(A) at 1 m from each generator air discharge louvre
- 65 dB(A) at 1 m from each flue exhaust opening
- NR 50 / 55 dB(A) within open office areas above & below

In lieu of factory acoustic tests, we require that the generator supplier demonstrates upon completion that they have achieve the above noise criteria by providing measurements as part of the commissioning process. Further, substantiation must be provided during the equipment submission and shop drawing process that the acoustic criteria will be achieved. The supplier should provide:

- Sound power levels for generator engine, radiator, and flue exhaust
- Acoustic performance of flue exhaust mufflers
- Acoustic performance of air intake & discharge attenuators
- Acoustic performance of sound absorptive room lining
- Shop drawings showing configuration of plasterboard lining, sound absorptive lining, generator, attenuators, and louvres
- Shop drawings of floating floor
- Calculations demonstrating compliance with acoustic criteria

5.3.1.1 Noise Control Measures

Ultimately, the generator supplier should be responsible for detailed noise control measures, however the following are general measures to be included in the design

General

- The generator room should be lined with sound absorbing finishes. It is recommended this to be 50 mm thickness sound absorbing finish, with a minimum density of 32 kg/m^3.
- Primary and secondary mufflers should be provided on the generator flue exhaust.
- Anti-vibration mounts - should be used to support the generator sets. These should be open (i.e. unhoused) springs, usually with a static deflection ≥ 50 mm. They should include in-series 'noise stop pads' of neoprene or similar.

Level 28 generator room

Based on a sound pressure level of 111 dB(A) at 1 m from each generator on Level 28 (as per current equipment selection) the following is recommended:

- Minimum 3000 mm long attenuators should be provided for the air intake and air discharge louvres.
- The construction of the generator room floor should comprise the following as a minimum:

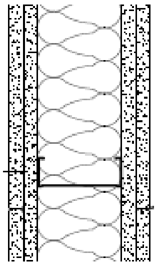
  180mm concrete slab + 100mm cavity with 50mm insulation (33kg/m^3) + 2x13 fire rated plasterboard (10.5kg/m^2 each) on resilient clips, with no penetrations.

- The construction of the generator room ceiling should comprise the following:

  130mm concrete slab + 150mm cavity with 100mm insulation (33kg/m^3) + 3x13 fire rated plasterboard (10.5kg/m^2 each) on resilient clips, with no penetrations.

The generator internal walls and external walls should achieve an R_w 50 as minimum. Options to meet this are presented in Table 21 below. Note that any glazed elements used for architectural purposes for the external envelope of the generator rooms will be separate to the acoustic performance requirements.

Table 21: Generator room wall constructions

Wall Build-up		
DRYWALL		2 x 13 mm high-density plasterboard 64 mm stud 2 x 13 mm high-density plasterboard 50 mm absorptive quilt in cavity
MASONRY		190 mm hollow block (270 kg/m2) full height OR 140 mm solid blocks (260 kg/m2) full height

Level 15 generator room

Based on a sound pressure level of 103 dB(A) at 1 m from the generator (as per current equipment selection) the following is recommended:

- Minimum 3000 mm long attenuators should be provided for the air intake and air discharge louvre.
- The construction of the generator room floor should comprise the following as a minimum:

  180mm concrete slab + 100mm cavity with 50mm insulation (33kg/m^3) + 1x13 fire rated plasterboard (10.5kg/m^2 each) on resilient clips, with no penetrations.
- The construction of the generator room ceiling should comprise the following:

  130mm concrete slab + 150mm cavity with 100mm insulation (33kg/m^3) + 1x13 fire rated plasterboard (10.5kg/m^2 each) on resilient clips, with no penetrations

- The generator room internal walls should achieve an R_w 50. Refer to Table 21 above for construction options:

5.3.2 Transformer Room on Level 28

Refer to Section 4.1.1.2 for acoustic louvre requirements for this room.

5.4 Plantroom Noise Breakout

A mechanical noise breakout assessment has been undertaken based on the current mechanical design. Acoustic louvre requirements have been presented in Section 4.1.1.2.

The sound insulation performance requirement for other areas of the façade of the plantrooms is follows:

Table 22: Acoustic performance of plantroom façade (solid areas)

Acoustic Performance	Indicative Construction
Rw 40	Insulated façade panel (e.g. Kingspan KS1000AWP) + 50 mm cavity + 6.78 mm laminated glass

5.5 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 4.2.3 will be required.

6 Noise and Vibration Impact upon Development

6.1 Noise and Vibration Sources

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

- Environmental noise (including 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.

6.2 Road Traffic Noise

Measured road traffic noise levels presented in Section 3.2 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.

Calculations have been carried out to determine potential noise intrusion into the development. Indicative glazing solutions to achieve recommended internal noise levels are provided in Table 23.

Table 23: Indicative glazing selections to address road traffic noise intrusion

Level	Façade Acoustic Performance	Indicative Glazing Selection
GL - L2 retail, reception and café areas	$R_w + C_{tr}$ 39	10 mm float/ 12mm cavity /16.8 mm laminate
GL – L4 lift lobbies	$R_w + C_{tr}$ 35	10 mm float / 12mm cavity / 8.8 mm laminate
L3 – L4 Flexible Space	Rw + Ctr 55	17.5 mm laminate / 250mm air gap / 21.5 mm laminate or 10/12/12 DGU / 300mm cavity / 10.78mm laminated glass
L5 – L14 offices and lift lobbies	Rw + Ctr 32	6 mm float / 12mm cavity / 8.8 mm laminate
L16 – L27 offices and lift lobbies	Rw + Ctr 32	6 mm float / 12mm cavity / 8.8 mm laminate

Level	Façade Acoustic Performance	Indicative Glazing Selection
L29 – L35 offices and lift lobbies	Rw + Ctr 27	6 mm float / 12mm cavity / 6 mm float
L36 lift lobby	Rw + Ctr 33	6 mm float / 12 mm cavity / 10 mm float
L36 – L37 offices	Rw + Ctr 33	6 mm float / 12 mm cavity / 10 mm float

6.3 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 and the future proposed Sydney Metro tunnels that traverse the site.

6.3.1 Eastern Suburbs Rail Line (existing)

6.3.1.1 Vibration

The Assessing Vibration Technical Guideline notes that, as a screening method, the overall unweighted RMS acceleration could be assessed against the preferred values (i.e. the criteria presented in Table 14 of this report). This represents a conservative approach to demonstrating compliance or the need to use the more precise approach using appropriate frequency weightings. It is noted that the measured acceleration presented in Figure 7 falls below the most stringent vibration criteria for the development.

6.3.1.2 Groundborne Noise

With reference to Figure 8, 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 24 for 20Hz and above and are presented as decibel units for the purpose of groundborne noise predictions.

Table 24: 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 24, the predicted reverberant sound pressure level radiated into the worst affected sensitive location in the North Site OSD development is in the order of 30 dBA. Compliance is therefore demonstrated against the lowest limit of 35 dBA. It is noted that this is based on the maximum spectrum from a typical "1 in 20" train event and is therefore considered conservative.

6.3.2 Sydney Metro (future)

6.3.2.1 Groundborne Noise

Figure 8 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 Sydney Metro line to commercial and other sensitive receivers.

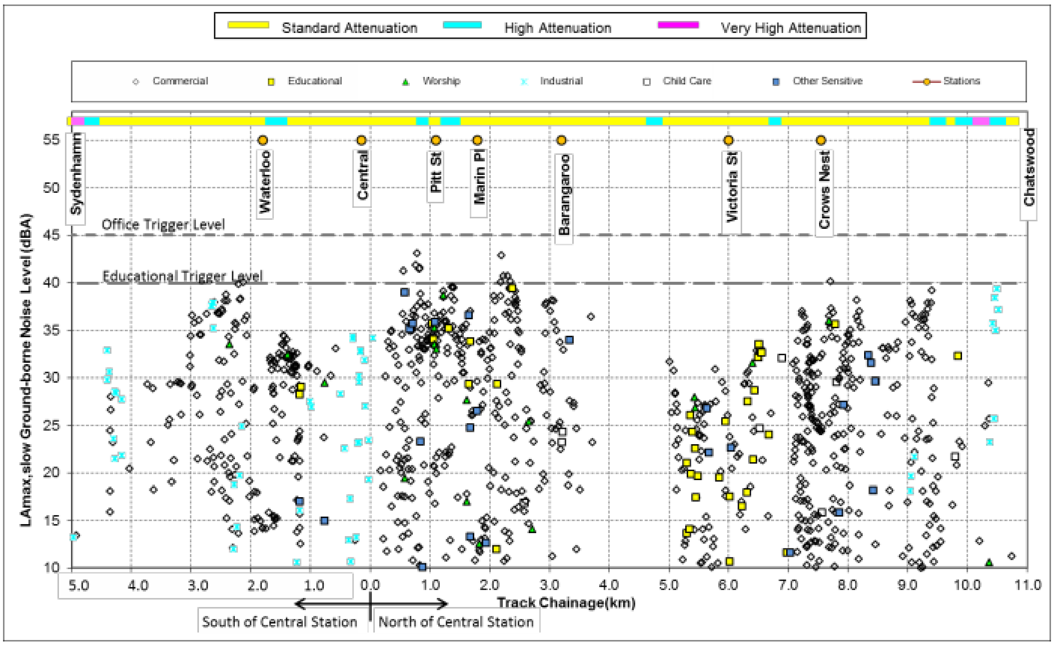


Figure 8: Predicted groundborne noise levels for commercial and other sensitive receivers.

From the data presented, predicted groundborne noise levels are generally below 40 dB$L_{Amax,slow}$. There are four instances where predicted groundborne noise levels are 41-43 dB$L_{Amax,slow}$. These predicted levels are within internal groundborne noise targets for office areas summarised in Section 4.2.6.1.

Using input source vibration information provided in Technical Paper 2: Noise and Vibration [1] calculations have been made to predict potential ground-borne noise impacts from the future Sydney Metro line to the North Site OSD. It should be noted that these predictions are preliminary based on the level of design detail at this stage of the project. More detailed assessment may be required as design progresses.

Currently, Level 3 represents the nearest potentially affected noise-sensitive receiver location to rail vibration source and also has the most stringent assessment criterion. As such, predictions of ground-borne noise are focussed on this location.

6.3.2.2 Recommendations

Based on the above analysis, it is not anticipated that ground-borne noise and vibration due to the proposed rail tunnels will be an issue for the office areas in the proposed development.

7 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.*

7.1 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.

8 Construction Noise and Vibration Assessment

The following sections summarise the prediction of construction noise and vibration from the development 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 Sydney Metro Martin Place Station Integrated Station Development may be constructed.

Reference has also been made to the EIS and PIR documentation for the project as the basis 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, a detailed assessment and an appropriate construction noise and vibration management plan will be developed for the project.

8.1 Noise Catchment Areas

To enable assessment, receiver locations have been grouped into noise catchment areas (NCAs) around the proposed construction works. For direct comparison, these areas assessed have been derived in alignment with the NCAs utilised in the Sydney Metro SPIR Construction Noise and Vibration Report [16]

Table 26 summarises receiver types within each catchment area. An aerial image of the proposed construction site and surrounding NCAs is also provided in Figure 9 for reference.

Table 25: 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
NCA – D	Studio	Studio receivers to the east, between Hunter Street and Martin Place. Channel 7.

Noise Catchment Areas	Type of receiver	Location
	Commercial	Commercial receivers to the east, between Hunter Street and Martin Place.
	Residential	Residential receivers east of site
	Place of Worship	St Stephens church
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

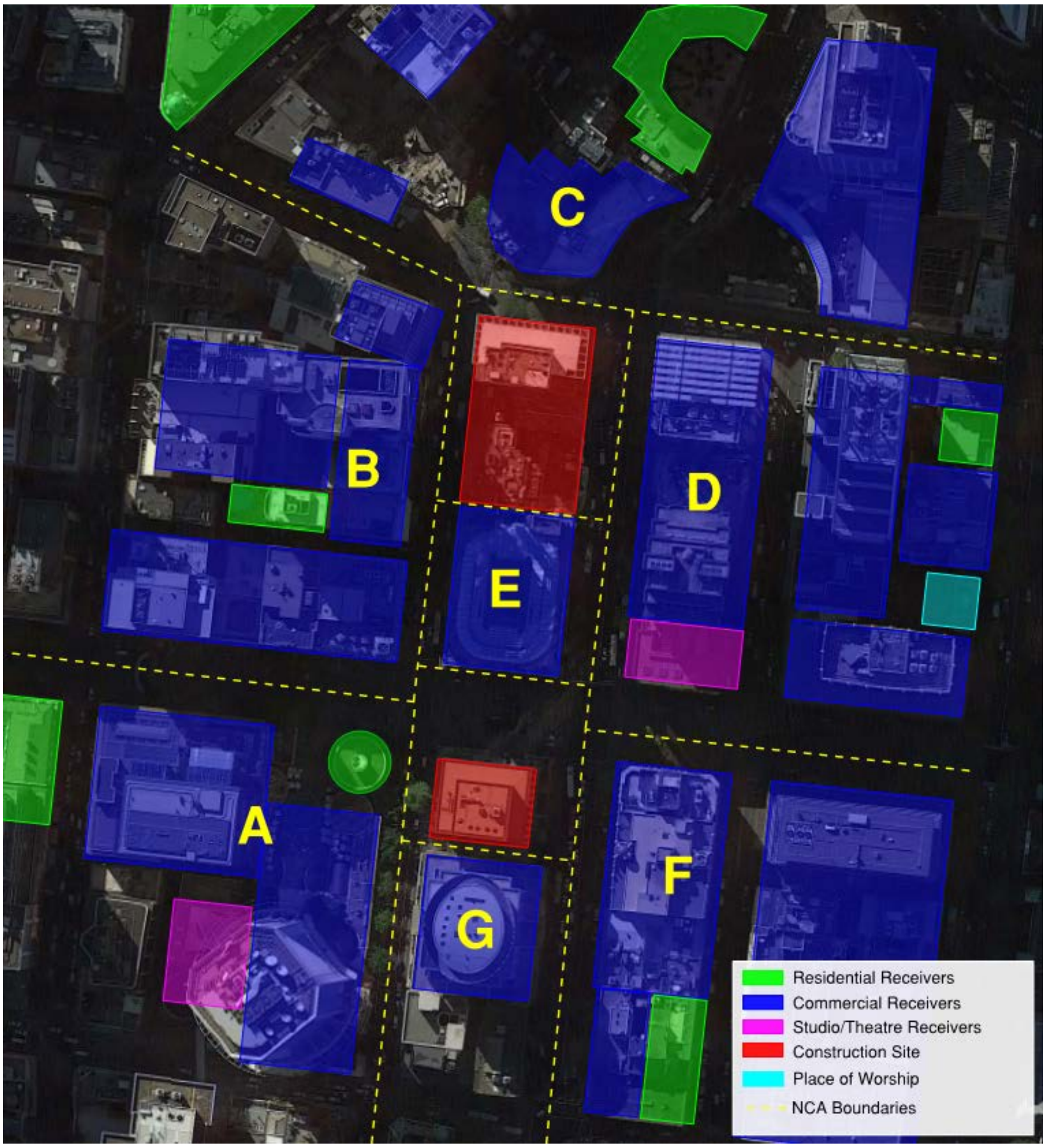


Figure 9: Aerial image of noise catchment areas

8.2 Proposal

In general, the Project incorporates the same locations and methodologies for construction as summarised in the EIS and CSSI PIR for the Sydney Metro project. A general description of the construction scenarios and anticipated timeframes is provided therein and is provided in

Table 26: 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

Sequence	Stage	Description	Duration
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 the Sydney Metro project are well quantified in the Sydney Metro EIS and SPIR and will therefore not be discussed further in this report. This assessment will instead be concentrated on the cumulative impacts from all works associated with Metro Martin Place station and both North and South Site OSDs.

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.

8.2.1 Construction Hours

It is anticipated that most works will be undertaken during standard construction hours, however an assessment is made against all assessment period criteria for completeness.

8.3 Airborne Construction Noise Assessment

8.3.1 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 28 summarises equipment and associated sound power levels used in prediction of airborne construction noise. Table 27: 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

Equipment	Maximum SWL (dBA)	Max SPL @ 7m (dBA)
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

8.3.2 Predicted Noise Levels

8.3.3 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 at varying heights using the ISO 9613:1996 [17] prediction methodology in order to ascertain likely impacts during various stages of construction of the OSD towers. To illustrate this, Figure 10 provides an axonometric view of the model showing a typical grid noise map.

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.

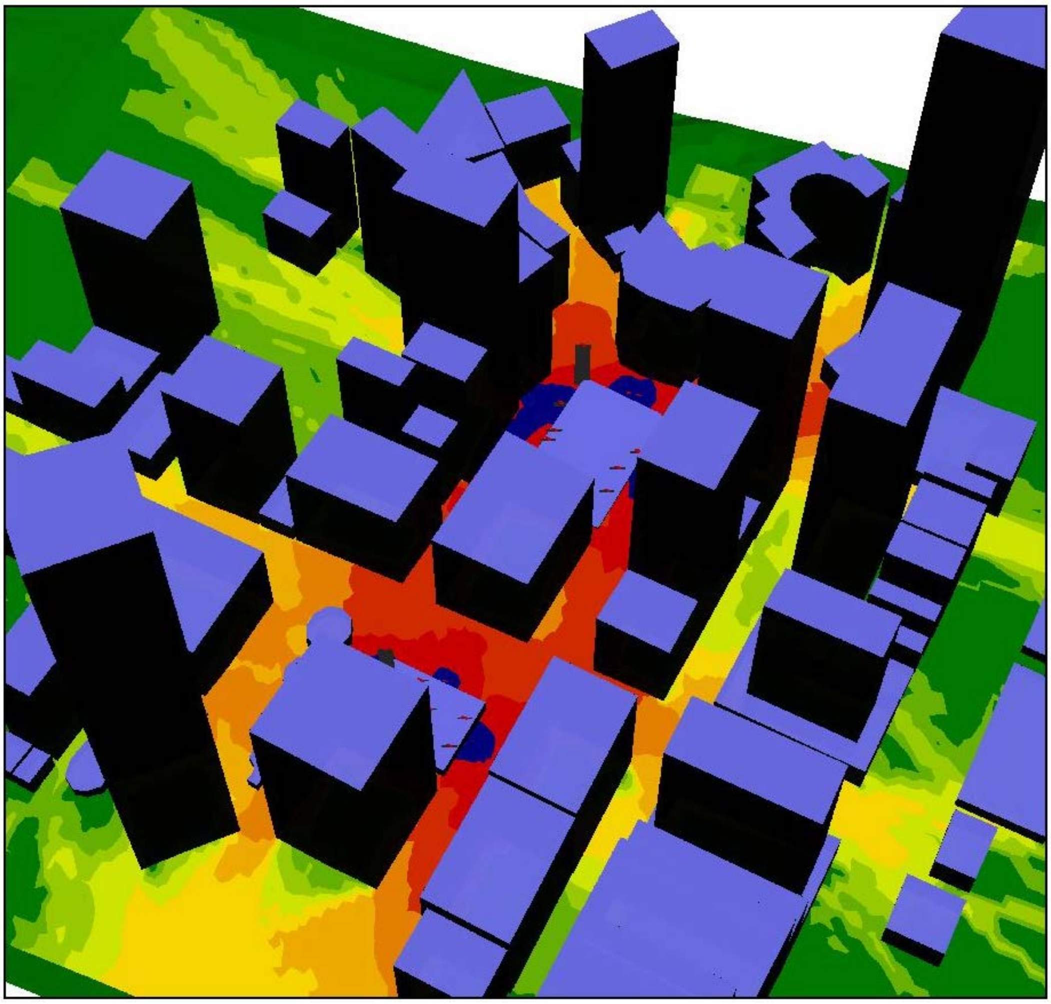


Figure 10: Grid noise map illustrating noise impacts due to construction

A summary of predicted worst case airborne noise exceedances at the nearest affected external receivers is given in Table 29 Results have been grouped by noise catchment area as per Section 8.1. A discussion of results is provided below the table.

Table 28: 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
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 Metro Martin Place construction works, noise impacts have been focused around the noisiest items of plant with the greatest potential to adversely impact nearby receivers. Sydney 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.

8.4 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.

8.5 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.

8.5.1 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. Whilst moderate reductions in noise and vibration will be achieved during construction, 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.

8.5.2 Construction Noise and Vibration Management Plan

For all construction works, a detailed Construction Noise and Vibration Management Plan (CNVMP) will be prepared. 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.

8.5.3 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.

8.5.4 Maximum Equipment Noise Levels

The Sydney Metro Construction Noise Strategy (CNS) [18] 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 during construction.

8.5.5 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.

8.5.6 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.

9 Agency consultations

Consultation has been undertaken on this SSD DA Stage 2 proposal with Sydney Metro and other relevant agencies as detailed in the Stakeholder and Community Engagement Summary Report, prepared by Ethos Urban.

10 Conclusion

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

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

Noise and vibration survey data has been used to quantify the existing environment.

In lieu of specific approval conditions, assessment criteria have been selected based on relevant state and national guidelines and legislation and as commensurate with SSDA applications of this nature.

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.

Recommendations are made of the requirements appropriate to achieve assessment criteria. These have been based on similar developments of this type and scale.

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.

All potential noise and vibration impacts of the project as described in this report have been mitigated through design and the construction methodology to minimise the impact on the city. These mitigations measures are in full accordance with industry standards, guidelines and legislation.

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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 m^2) 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.

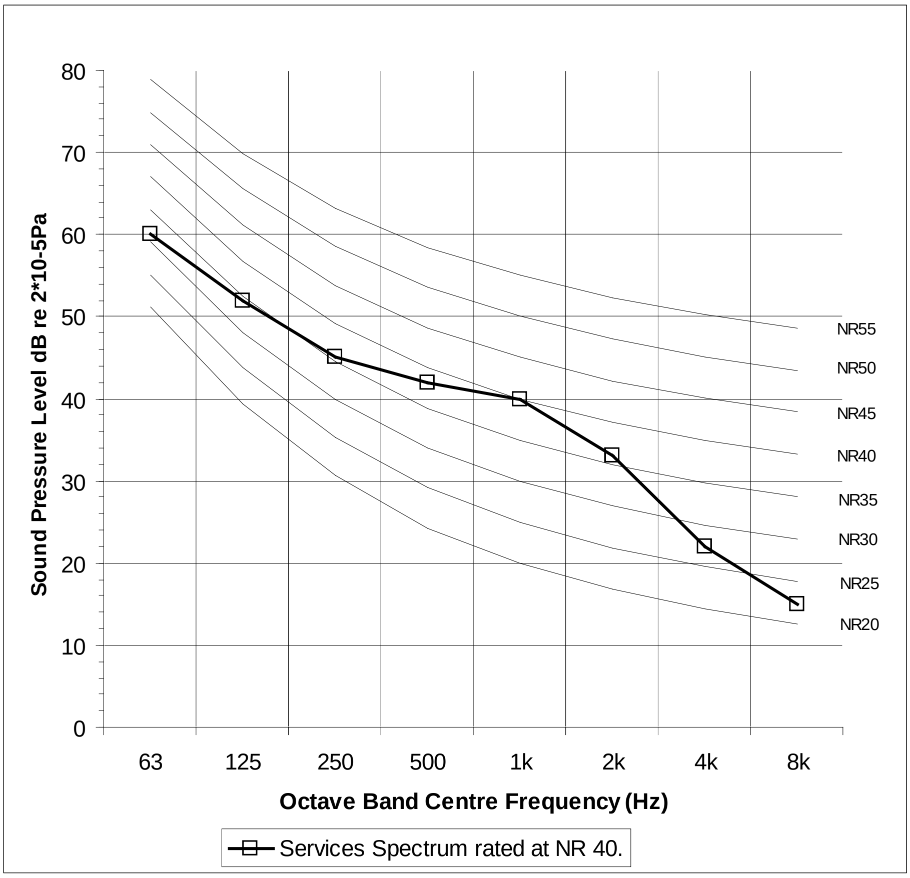
In the laboratory, the weighted normalised impact sound pressure level, Ln,w, is used to represent the impact sound isolation as a single figure.

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.

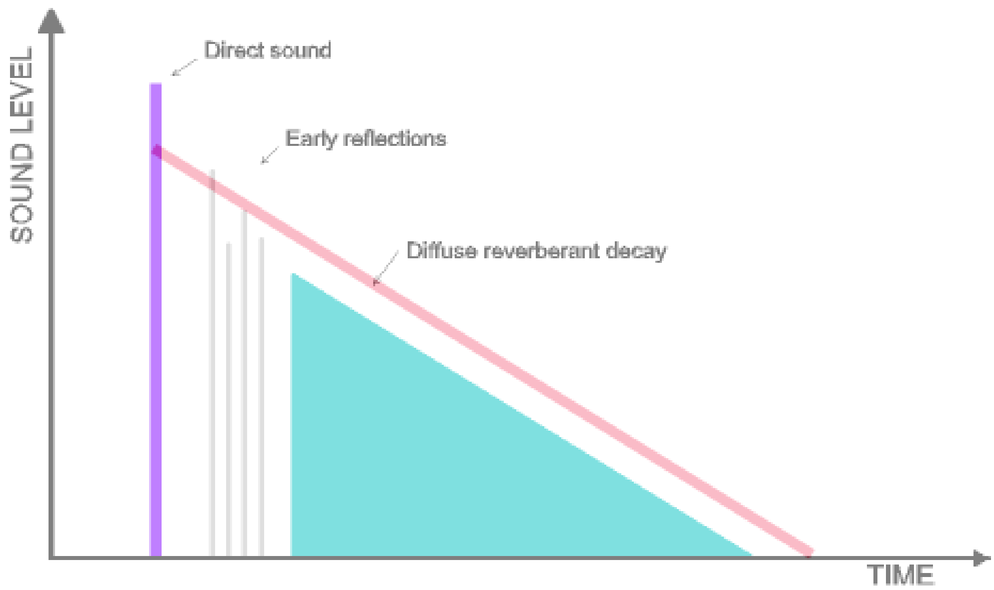
PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the Lmax or Lmax,spec index.

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.