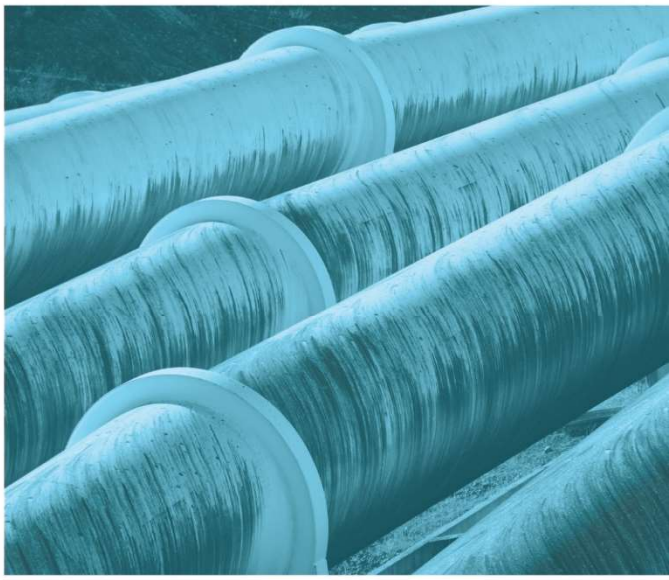



M4-M5 Link Mainline Tunnels

Construction Noise and Vibration Impact Statement - Northcote Operations

Prepared for Lendlease Samsung Bouygues Joint Venture
March 2019

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Report Number

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Client

Lendlease Samsung Bouygues Joint Venture

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14 March 2019

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14 March 2019

This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of the client and no responsibility will be taken for its use by other parties. The client may, at its discretion, use the report to inform regulators and the public.

Executive Summary

This CNVIS identifies and describes construction works associated with Northcote tunnel operations. The potential noise levels from the Site were assessed in accordance with relevant policies, standards, guidelines and the instrument of approval conditions.

Predicted noise levels at most receivers are compliant with NMLs throughout most periods, the exception being during the night period, where an exceedance of up to 4 dB has been identified (at R11). This is predominantly due to external truck movements. There are also six other residences where a 1 to 2 dB exceedance of NMLs is predicted during the night period. A 1 to 2 dB exceedance is classified in general terms by the EPA and DPE as negligible after all feasible and reasonable noise mitigation and management has been applied (refer to the NPfI (EPA 2017) and Voluntary Land Acquisition and Mitigation Policy (VLAMP) (DPE 2017)).

In accordance with RMS CNVG requirements, these predicted noise levels will be verified through noise measurement once 24 hour operations commence. Additional feasible and reasonable noise mitigation and management measures will be identified, where required. Possible noise mitigation and management measures have been presented in Section 9.

Maximum noise levels above the sleep disturbance screening criteria are predicted at three representative locations. However, predicted maximum noise levels at all receivers are below levels expected to cause awakenings of 60 to 65 dB L_{max} external (equating to 50 to 55 dB L_{max} internal) as referenced in the RNP (EPA 2011). Maximum noise level events will be managed during the night-time period in accordance with the site's Noise and Vibration Management Plan (NVMP).

In addition, Condition E88 of the CoA requires at receiver noise mitigation in the form of property treatment, which is to be offered to the land owners for habitable living spaces, or other mitigation or management measures as agreed by the occupier, to the residential properties identified in Appendix E of the Project Approval. Although the implementation of at receiver mitigation is principally an outcome of the approval conditions, some receivers identified within this CNVIS that exceed the NML's are all entitled to receive at-receiver treatments according to the Project Approval, which will assist in mitigating noise from the Site.

Vibration impacts from the operations phase of the project are considered very unlikely, except from tunnelling activity. Vibration impacts from tunnelling activity has been assessed in the project's Tunnelling CNVIS (EMM 2019)

Construction traffic noise on the local road network will be assessed in the project's haulage CNVIS.

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Tables

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1 Introduction

1.1 Context

This Construction Noise and Vibration Impact Statement (CNVIS) has been prepared to identify the noise and vibration impacts from a portion of Stage 1 of the WestConnex 3A – M4-M5 Link Mainline tunnels project (the Project). In addition, this CNVIS also responds to (as required) the various noise and vibration requirements detailed within the Minister's Conditions of Approval (CoA), the WestConnex M4-M5 Link Environmental Impact Statement (EIS), the revised environmental management measures (REMM) listed in the Submissions and Preferred Infrastructure Report (SPIR) and all applicable legislation.

1.2 Background and project description

An EIS (AECOM 2017) assessed the potential impacts of construction and operation of the project on noise and vibration, within Chapter 10.

The EIS identified the potential noise and vibration impacts during construction typically associated with noise intensive construction works. It concluded any potential impacts could be managed by standard mitigation and management measures.

The WestConnex M4-M5 Link project is being constructed in two stages (refer to Figure 1.1):

- Stage 1: (the Project and subject of this document): M4-M5 Link Mainline tunnels.
- Stage 2: Rozelle interchange.

Sydney Motorway Corporation (SMC) has engaged Lendlease Samsung Bouygues Joint Venture (LSBJV) to design and construct Stage 1 of the project (refer Figure 1.1). The key features of the Mainline tunnels project include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction;
- Connections of the mainline tunnels to the M4 East project, comprising:
  - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield;
  - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (which is currently being constructed as part of the M4 East project); and
  - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking;
- Connections of the mainline tunnels to the New M5 project, comprising:
  - A tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters;
  - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project); and

  - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking;

- Construction of tunnel stubs to provide for future underground connection of the mainline tunnels to the Rozelle interchange and Iron Cove Link;
- A motorway operations complex at St Peters (Campbell Road) (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets (the Campbell Road ventilation facility), offices, on-site storage and parking for employees;
- Tunnel ventilation systems, including ventilation supply and exhaust facilities, ventilation fans, ventilation outlets and ventilation tunnels;
- Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (which is currently being constructed as part of M4 East project) for use by the M4-M5 Link project;
- Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities;
- Water treatment would occur at the operational water treatment facility at the Campbell Road motorway operations complex (subject to future Modification);
- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage);
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems;
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities;
- Temporary construction ancillary facilities to facilitate construction of the project at the following locations:
  - Northcote Street civil and tunnel site (C3a), Haberfield;
  - Haberfield civil site (C2b), Haberfield;
  - Parramatta Road East civil site (C3b), Haberfield;
  - Parramatta Road West civil site (C1b), Ashfield;
  - Wattle Street civil and tunnel site (C1a), Haberfield;
  - Pyrmont Bridge Road tunnel site (C9), Camperdown/Annandale;
  - Campbell Road civil and tunnel site (C10), St Peters; and
  - White Bay civil site (C11), Rozelle.

An overview of the project footprint and ancillary facilities is presented in the Construction Environmental Management Plan (CEMP) and Site Environmental Management Plan (SEMP). Further detail of the project description is presented in Section 1.3 of the CEMP.

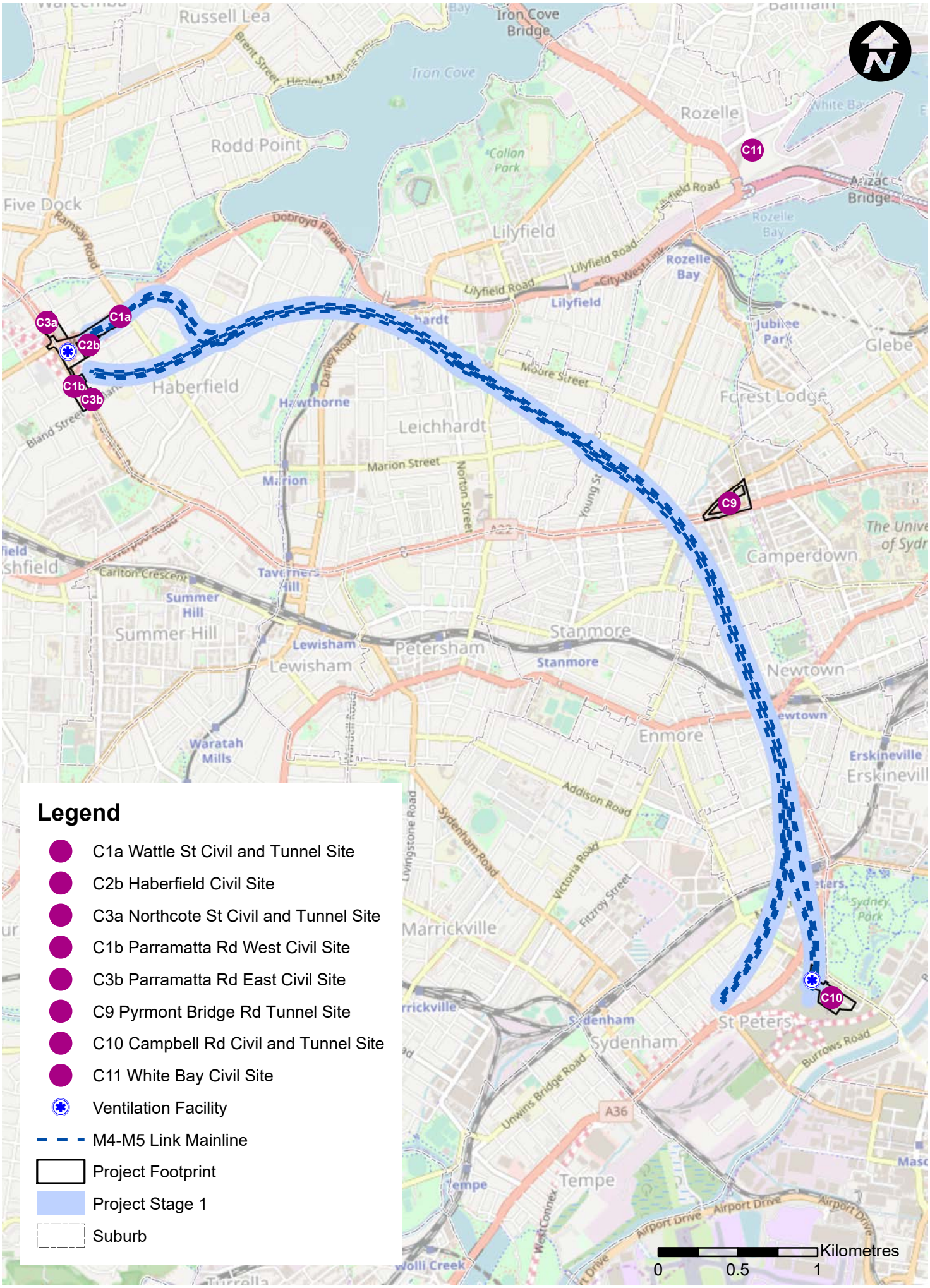


Figure 1-1 Overview of Stage 1 - M4-M5 Link Mainline Tunnels (the Project)

1.3 Scope of this CNVIS

The scope of this CNVIS is to assess potential noise impacts from 24/7 tunnelling activities at the Northcote ancillary facility at Haberfield. The site layout is shown in Figure 1.2. The proposed activities at this site assessed in this CNVIS include:

- tunnel excavation and ventilation;
- spoil handling inside an acoustic shed and haulage offsite;
- civil fit out (pavement, concreting works); and
- tunnel lining and support (concreting, shotcrete, deliveries).

The purpose of the CNVIS is to identify potential noise and vibration impacts and to develop feasible and reasonable noise management and mitigation measures where potential impacts are identified.

The site is an established tunnelling site for the WestConnex M4 East component of the project which will be handed over to the WestConnex M4-M5 Link project for continued tunnelling. The operation under the WestConnex M4-M5 Link project will be largely equivalent to the existing operation.

1.4 Environmental management systems overview

The environmental management system overview is described in Section 1.5 of the CEMP. Noise and vibration impacts are managed through the implementation of the Noise and Vibration Management Plan (NVMP) as required by CoA C4 b).

Figure 1.2 Site layout

2 Purpose and objectives

The key objective of the CNVIS is to ensure all CoA, REMM and licence/permit requirements relevant to noise and vibration are described, scheduled and assigned responsibility as outlined in:

- The EIS prepared for WestConnex M4-M5 Link;
- The submissions report prepared for WestConnex M4-M5 Link;
- Conditions of Approval granted to the project on 17 April 2018;
- Roads and Maritime specifications G36;
- The Project's Environmental Protection Licence (EPL); and
- All relevant legislation and other requirements described in Section 3 of this Plan.

3 Environmental requirements

3.1 Legislation

This CNVIS has been prepared in accordance with:

- Environmental Planning and Assessment Act 1979; and
- Protection of the Environment Operations Act 1997 (POEO Act).

3.2 Guidelines

The following guidelines apply to project related construction noise and vibration:

- *NSW Industrial Noise Policy* (INP) 2000*,* Environmental Protection Authority[1];
- *NSW Interim Construction Noise Guideline* (ICNG) 2009, Department of Environment and Climate Change;
- *NSW Road Noise Policy,* Department of Environment 2011, Climate Change and Water;
- *NSW Assessing Vibration – a technical guideline* (AVTG) 2006, Department of Environment and Conservation;
- *NSW Noise Criteria Guideline* (NCG) 2015, Roads and Maritime Services;
- *NSW Noise Mitigation Guideline* (NMG) 2015, Roads and Maritime Services;
- *Construction noise and vibration guideline* (CNVG) 2016, Roads and Maritime Services;
- Australian Standard AS/NZS 2107:2000 *'Acoustics - Recommended design sound levels and reverberation times for building interiors'*;
- Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration;
- Australian Standard AS 2187.2 *'Explosives - Storage and use - Part 2 Use of explosives'*;
- Australian Standard AS2436-1981 *'Guide to Noise Control on Construction, Maintenance and Demolition Sites'*;
- British Standard BS 6472-2008, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*;
- British Standard 7385: Part 2-1993 *'Evaluation and measurement of vibration in buildings'*;
- German Standard DIN4150-1999 *'Structural vibration Part 3: Effects of vibration on Structures'*;
- *Construction Noise Strategy 7TP-ST-157/2.0* (CNS) 2012, Transport for NSW; and
- *Environmental Noise Management Manual* (ENMM) 2001, Roads and Traffic Authority.

[1] This document has since been superseded by the NSW Noise Policy for Industry (NPfI) 2017. However, the INP remains the relevant policy in accordance with the project's Instrument of Approval and NPfI transitional requirements.

3.3 Conditions of approval

The CoA relevant to this CNVIS are listed in Table 3.1.

Table 3.1 Conditions of Approval for construction noise and vibration

Condition	Key requirement
Land Use Survey	
E66	A detailed land use survey must be undertaken to confirm sensitive receivers (including critical working areas such as operating theatres and precision laboratories) potentially exposed to construction noise and vibration, construction ground-borne noise and operational noise. The survey may be undertaken on a progressive basis but must be undertaken in any one area prior to the commencement of works which generate construction or operational noise, vibration or ground-borne noise in that area. The results of the survey must be included in the Construction Noise and Vibration Management Sub-plan.
Noise Assessments	
E67	All noise and vibration assessment, management and mitigation required by this approval must consider the cumulative noise impacts of approved CSSI and SSI projects. This includes using ambient and background levels which do not include other WestConnex M4 East and New M5 (SSI 6307 and SSI 6788) projects. This condition applies to all works and operation.
Works Hours	
E68	Works must be undertaken during the following hours: a) 7:00 am to 6:00 pm Mondays to Fridays, inclusive; b) 8:00 am to 1:00 pm Saturdays; and c) at no time on Sundays or public holidays.
E69	Notwithstanding **Condition E68**, works may be undertaken between 1:00 pm to 6:00 pm on Saturday.
E70	Notwithstanding **Conditions E68** and **E69** the following works are permitted to be undertaken 24 hours a day, seven days a week: a) tunnelling activities excluding cut and cover tunnelling; b) haulage of spoil and delivery of material; c) works within an acoustic shed; and d) (d) tunnel fit out works. Other surface works associated with tunnelling must only be undertaken in accordance with the requirements of **Condition E73**.
Construction Noise and Vibration – General	
E79	Construction Noise and Vibration Impact Statements must be prepared for construction ancillary facility(s) before any works that result in noise and vibration impacts commence, and include specific mitigation measures identified through consultation with affected sensitive receivers. The Statements must supplement the Construction Noise and Vibration Management Sub-plan or Site Establishment Management Plan(s) and are to be implemented for the duration of the works. The Construction Noise and Vibration Impact Statement for the White Bay Civil Site (C11) must be prepared in consultation with the Port Authority of NSW and NSW Heritage Council.

Table 3.1 Conditions of Approval for construction noise and vibration

Condition	Key requirement
E80	Noise generating works in the vicinity of potentially-affected community, religious, educational institutions and noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) resulting in noise levels above the NMLs must not be timetabled within sensitive periods, unless other reasonable arrangements with the affected institutions are made at no cost to the affected institution.
E81	Mitigation measures must be implemented with the aim of achieving the following construction noise management levels and vibration criteria: a) construction 'Noise affected' noise management levels established using the *Interim Construction Noise Guideline* (DECC, 2009); b) vibration criteria established using the *Assessing vibration: a technical guideline* (DEC 2006) (for human exposure); c) Australian Standard AS 2187.2 - 2006 "*Explosives - Storage and Use - Use of Explosives*"; d) BS 7385 Part 2-1993 "*Evaluation and measurement for vibration in buildings Part 2*" as they are "applicable to Australian conditions"; and e) the vibration limits set out in the *German Standard DIN 4150-3: Structural Vibration- effects of vibration on structures* (for structural damage). Any works identified as exceeding the noise management levels and/or vibration criteria must be managed in accordance with the **Construction Noise and Vibration Management Sub-plan.** *Note: The Interim Construction Noise Guideline identifies 'particularly annoying' activities that require the addition of 5 dB(A) to the predicted level before comparing to the construction Noise Management Level.*
Construction Noise Mitigation – Acoustic Sheds	
E86	All acoustic sheds must be erected as soon as site establishment works at the facilities are completed and before undertaking any works which are required to be conducted within the sheds.

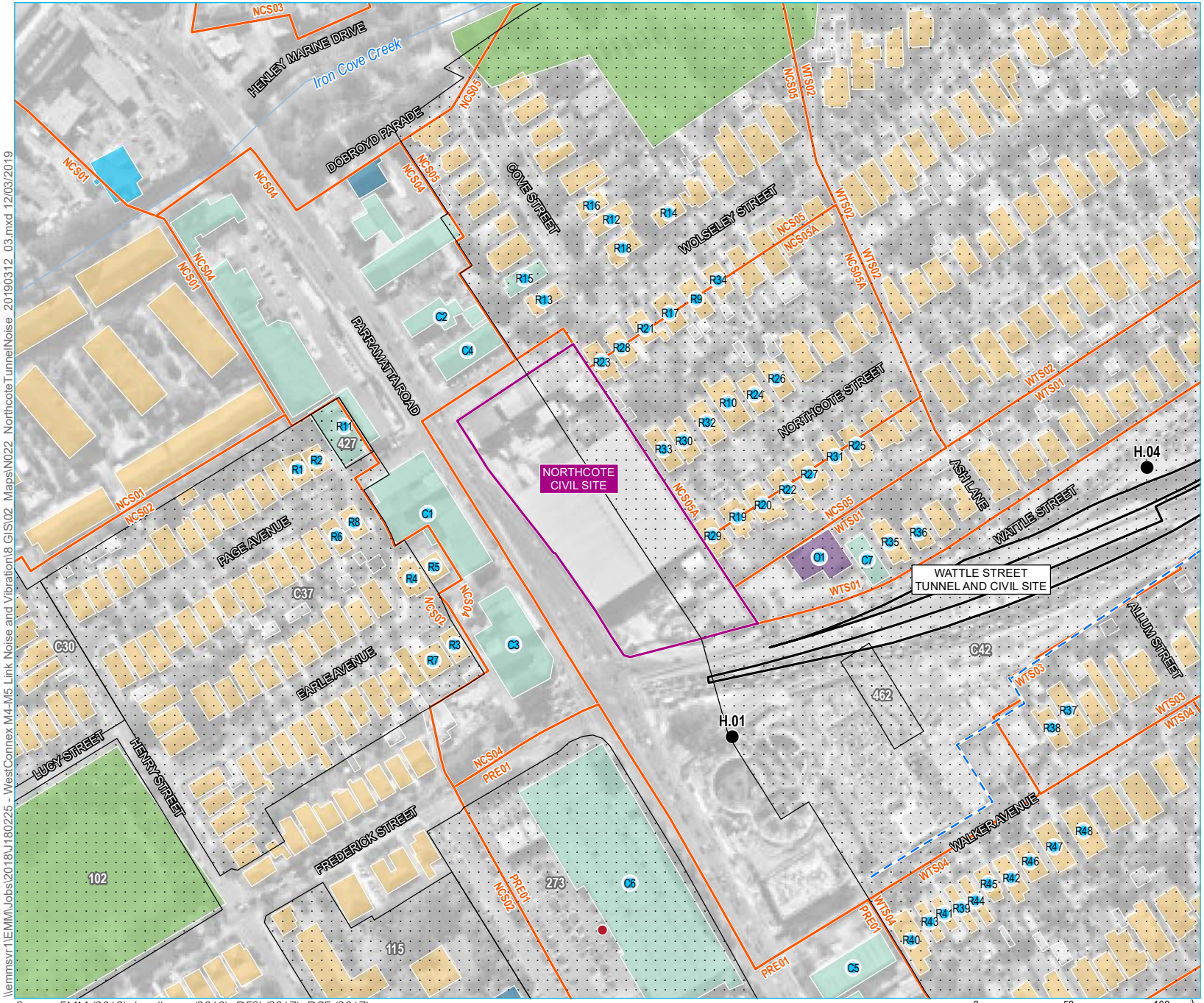
4 Existing environment

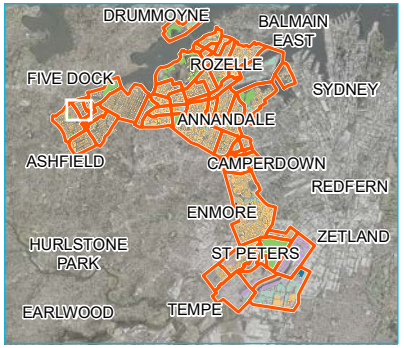
4.1 Noise and vibration sensitive receivers

A detailed land use survey has been undertaken to address E66 of the CoA. The outcomes of the land use survey have been incorporated into this CNVIS. A visual representation of the survey is provided in the NVMP. For the purpose of this assessment, receivers potentially sensitive to noise have been categorised as:

- residential dwellings;
- commercial, retail and industrial properties; and
- other, including:
    - education institutions;
    - childcare centres;
    - medical (hospital wards or other uses including medical centres);
    - places of worship;
    - outdoor open areas (passive and active recreation);
    - aged care;
    - hotel;
    - theatre/auditorium;
    - public building; and
    - recording studio.

The sensitive receivers in proximity to the site is shown in Figure 4.1. Heritage items of importance where vibration emission needs to be considered are also shown.





KEY

- Noise logger location
- Receiver location and ID
- Heritage item identified in EIS
- Watercourse / drainage line
- M4 East noise wall (existing)
- Noise catchment boundary
- Heritage item (local environmental plan)

Noise receiver

- Commercial
- Residential
- Other (cafe / bar)
- Other (childcare)
- Other (outdoor active)
- Other (place of worship)

Source: EMM (2019); LendLease (2018); DFSI (2017); DPE (2017)

0 50 100 m

GDA 1994 MGA Zone 56

N

Noise catchment areas, receivers and baseline monitoring locations

M4-M5 Link Mainline Tunnels

Construction noise and vibration impact statement, Northcote Tunnel Site

Figure 4.1

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4.2 Noise catchment areas

The areas surrounding the Project have been divided into Noise Catchment Areas (NCAs). NCAs group individual sensitive receivers by common traits such as existing noise environment and location in relation to the works. The NCAs have been based on those established in the M4-East EIS, with some modifications to allow for site specific characteristics identified during the detailed assessment and delivery phase.

The noise catchment areas of relevance to this CNVIS are shown in and are explained in Table 4.1.

Table 4.1 Nearest residential noise and vibration sensitive receivers

NCA	Description
NCS01	West of Parramatta Rd and north of Knocklayde St, consisting of predominantly residential receivers and some commercial premises.
NCS02	West of Parramatta Rd, south of Kncoklayde St and north of Richmond Ave, consisting of predominantly residential receivers and some commercial premises.
NCS04	Follows the alignment of Parramatta Rd, south of Iron Cove Creek and north of Frederick St, consisting of commercial premises.
NCS05	East of Parramatta Rd, north of Wolseley St, south of Iron Cove Creek and west of Ash Lane, consisting of residential premises.
NCS05A	East of the ancillary site, south of Wolseley St and north of Wattle St, consisting of residential premises.
PRE01	Follows the alignment of Parramatta Rd, south of Frederick St, consisting of commercial receivers.
WTS01	Row of houses along the north side of Wattle St, consisting of predominantly residential receivers and a place of worship.
WTS02	North of Wattle St, and east of Ash Lane, consisting of predominantly residential receivers and some commercial premises.
WTS03	Row of houses to the south of Wattle St, along Walker Ave, west of Ramsay St, consisting of residential premises.
WTS04	Houses to the south of Walker Ave, east of Parramatta Rd, west of Allum St and north of Alt St, consisting of residential premises.

4.3 Background noise levels

This CNVIS has adopted background noise levels documented in the M4 East EIS which are presented in Table 4.2 for each relevant NCA.

Table 4.2 Rating background levels

NCA	Rating background levels (RBLs)		
	Day	Evening	Night
NCS01	47	46	40
NCS02	47	46	40
NCS05	45	45	42
NCS05A	41	43	37

Table 4.2 Rating background levels

NCA	Rating background levels (RBLs)		
	Day	Evening	Night
WTS01	56	53	43
WTS02	41	41	37
WTS03	41	41	37
WTS04	45	45	39

1. Based on long-term noise logging conducted by SLR Consulting on behalf of WDA in October 2015
2. NCS04 and PRE01 consist of only commercial properties and hence RBLs are not presented

5 Construction noise criteria

5.1 Interim Construction Noise Guideline

The ICNG provides guidelines for the assessment and management of noise from construction works.

Table 5.1 is an extract from the ICNG and provides construction NMLs for residential receivers for both recommended standard construction hours and outside of these periods.

It is noted that the CoA allows extended standard hours of construction during 1pm to 6pm on Saturdays which deviates slightly from ICNG recommended standard hours.

Table 5.1 ICNG residential noise management levels

Time of day	Management level $L_{Aeq,15\ minute}$	How to apply
Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 6:00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq,15 minute 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 75 dB	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; and – if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

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 5.2 summarises noise management levels for non-residential land uses as defined in the ICNG.

Table 5.2 ICNG noise management levels at other land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB (when in use)
Offices, retail outlets	External noise level 70 dB (when in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use)
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)
Places of worship	Internal noise level 45 dB (when in use)
Active recreation areas	External noise level 65 dB (when in use)
Passive recreation areas	External noise level 60 dB (when in use)

Source: ICNG (DECC, 2009)

The ICNG provides further guidance for construction noise levels at commercial and industrial premises as follows:

> Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories. The external noise levels should be assessed at the most-affected occupied point of the premises:
>
> Industrial premises: external $L_{Aeq\ (15\ min)}$ 75 dB(A)
>
> offices, retail outlets: external $L_{Aeq\ (15\ min)}$ 70 dB(A)
>
> other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.
>
> Examples of other noise-sensitive businesses are theatres and child care centres. The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels (Standards Australia 2000).
>
> The proponent should assess construction noise levels for the project, and consult with occupants of commercial and industrial premises prior to lodging an application where required.

During construction, the proponent should regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.

5.2 Sleep disturbance at residences

The Site will operate during the night-time period (10pm to 7am). Therefore, the assessment of potential sleep disturbance at residences is required in accordance with the INP application notes. Sleep disturbance is defined as both awakenings and disturbance to sleep stages.

The INP application notes suggests that an $L_{A1(1min)}$ or L_{Amax} level of RBL plus 15 dB is a suitable screening criterion for sleep disturbance for the night-time period. This applies at the most affected façade of a building.

A detailed maximum noise level event assessment is required if the screening criteria is exceeded. Further guidance in regard to potential impact on sleep is provided in the NSW Road Noise Policy (RNP) (DECCW 2011). The RNP calls

upon a number of studies that have been conducted into the effect of maximum noise levels on sleep, and provides the following factors that are key in assessing the extent of impacts on sleep:

- how often high noise events would occur;
- the distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the project;
- whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods); and
- current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night.

The RNP also quotes the following internal noise levels with respect to potential sleep disturbance:

- maximum internal noise levels (L_{max}) below 50 to 55 dBA are unlikely to awaken people from sleep; and
- one or two noise events per night, with maximum internal noise levels (L_{max}) of 65 to 70 dBA, are not likely to affect health and wellbeing significantly.

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade of a residential building of standard construction including a partially open window will reduce external noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB L_{Amax} calculated at the facade of a residence are unlikely to cause sleep disturbance affects.

5.3 Project specific NMLs - residential

In accordance with the ICNG and based on the RBLs presented in Table 4.2, Table 5.3 presents the project specific construction noise affected NMLs applicable to residential premises during the proposed work hours. As per the ICNG, these apply to ground floor locations. The highly noise affected NML also applies to all residential receivers during standard hours.

Table 5.3 Project-specific NMLs at residential locations

NCA	Residential NML $L_{Aeq,15mins}$				Sleep Disturbance L_{Amax}	
	Day (S)	Day (O)	Evening	Night	Screening	Max
NCS01	57	52	51	45	55	65
NCS02	57	52	51	45	55	65
NCS05	55	50	50	47	57	65
NCS05A	51	46	48	42	52	65
WTS01	66	61	58	48	58	65
WTS02	51	46	46	42	52	65
WTS03	51	46	46	42	52	65
WTS04	55	50	50	44	54	65

5.4 Project specific NMLs - non-residential

Table 5.4 presents the project specific construction NMLs applicable to non-residential land uses as defined in the NSW ICNG and AS2107.

Table 5.4 Project specific NMLs at non-residential land uses

Land use	Noise management level (when in use), $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB
Offices, retail outlets	External noise level 70 dB
Classrooms at schools and other educational institutions	Internal noise level 45 dB
Hospital wards and operating theatres	Internal noise level 45 dB
Places of worship	Internal noise level 45 dB
Active recreation areas	External noise level 65 dB
Passive recreation areas	External noise level 60 dB
Child care centres[1]	External noise level 65 dB
Aged care[1]	External noise level 65 dB (7am to 10pm) 60 dB (10pm to 7am)
Hotels[1]	External noise level 65 dB (7am to 10pm) 60 dB (10pm to 7am)
Theatre/auditorium[1]	External noise level 45 dB
Recording studio[1]	External noise level 45 dB
Public building[1]	Determined on site specific basis

Notes:

1. NML based on AS2017 recommend maximum internal noise level and the premise that windows and doors for such development would typically remain closed, providing 20 dB of outdoor to indoor construction noise level reduction.
2. Notwithstanding NMLs in this table, Condition E80 states “Noise generating works in the vicinity of potentially-affected community, religious, educational institutions and noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) resulting in noise levels above the NMLs must not be timetabled within sensitive periods, unless other reasonable arrangements with the affected institutions are made at no cost to the affected institution

6 Construction vibration criteria

6.1 Overview

Vibration criteria adopted for the works are consistent with those established in the EIS and in accordance with the Instrument of Approval (SSI 7485). Condition E81 of SSI 7485 states that mitigation measures must be implemented with the aim of achieving the following vibration criteria:

- vibration criteria established using the Assessing vibration: a technical guideline (DEC 2006) (for human exposure);
- Australian Standard AS 2187.2 - 2006 “Explosives - Storage and Use - Use of Explosives”;
- BS 7385 Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2” as they are “applicable to Australian conditions”; and
- the vibration limits set out in the German Standard DIN 4150-3: Structural Vibration- effects of vibration on structures (for structural damage).

It is noted that blasting is not part of the scope for works relevant to this CNVIS.

6.2 Human comfort – Assessing vibration: a technical guideline (DEC)

Environmental Noise Management – Assessing Vibration: a technical guideline (DEC 2006) is based on guidelines contained in BS 6472 – 2008, Evaluation of human exposure to vibration in buildings (1 to 80Hz).

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 6.1.

Table 6.1 Examples of types of vibration (from Table 2.1 of the guideline)

Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	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. Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby 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 these would be assessed against impulsive vibration criteria.

Intermittent vibration is representative of activities such as impact hammering, vibratory rolling or general excavation work (such as an excavator tracking) and, as such, is most relevant to this assessment.

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted RMS (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate VDV the following formula (refer *section 2.4.1* of the guideline) was used:

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

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

The Acceptable Vibration Dose Values (VDV) for intermittent vibration are reproduced in Table 6.2.

Table 6.2 Acceptable vibration dose values (VDV) for intermittent vibration ($m/s^{1.75}$)

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical Areas	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

Notes:

1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am.
2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The Guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

6.3 Structural vibration criteria

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels that have potential to cause damage to the main structure.

6.3.1 Australian Standard AS 2187.2 - 2006

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 "*Explosives - Storage and Use - Use of Explosives*" recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2*" be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 6.3 and graphically in Figure 6.1.

Table 6.3 Transient vibration guide values - minimal risk of cosmetic damage

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

Notes: Source: BS 7385 Part 2-1993

The standard states that the guide values in Table 6.3 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 6.3 may need to be reduced by up to 50%.

Sheet piling activities (for example) are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may therefore be appropriate to reduce the transient values by 50%.

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz. The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 5.3, and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 6.3 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Figure 6.1.

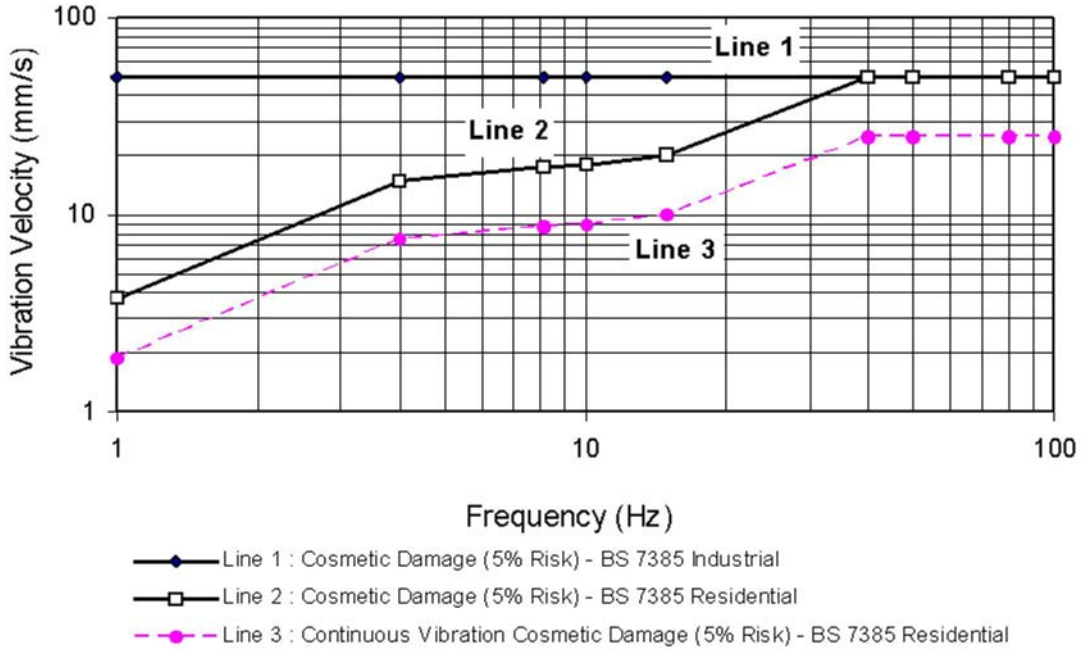


Figure 6.1 Graph of transient vibration guide values for cosmetic damage

It is noteworthy that extra to the guide values nominated in Table 6.3, the standard states that:

> "Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."

Also that:

> "A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."

A vibration screening criterion of 15 mm/s is recommended for structures surrounding the site for vibration inducing construction. This should be reduced to 7.5mm/s (by 50%) if the vibration activity is continuous and has the potential to cause resonance effects in surrounding structures (eg sheet piling).

6.3.2 German Standard DIN 4150-3:1999

The German Standard DIN 4150 - Part 3: 1999, provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 6.4 and shown graphically in Figure 6.2.

For residential and commercial type structures, the standard recommends safe limits as low as 5mm/s and 20mm/s respectively. These limits increase with frequency values above 10Hz. The operational frequency of construction plant typically ranges between 10Hz to 30Hz, and hence according to DIN4150, the safe vibration guide limit range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings, the limit is as low as 20 mm/s, while for heritage or sensitive structures the lower limit is 3 mm/s.

Table 6.4 Structural damage guideline values of vibration velocity – DIN4150

Line*	Type of Structure	Vibration Velocity in mm/s			
		At Foundation at a Frequency of		Plane of Floor of Uppermost Storey	
		1Hz to 10Hz	10Hz to 50 Hz	50Hz to 100Hz	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	5 to 20	15
3	Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Notes:

1. "Line*" refers to curves in Figure 1 of DIN4150
2. For frequencies above 100Hz the higher values in the 50Hz to 100Hz column should be used

These levels are "safe limits", for which damage due to vibration effects is unlikely to occur. "Damage" is defined in DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Should such damage be observed without vibration levels exceeding the "safe limits" then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur.

As indicated by the guide levels from DIN 4150 in Figure 6.2, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the "point source" nature of vibration from plant causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

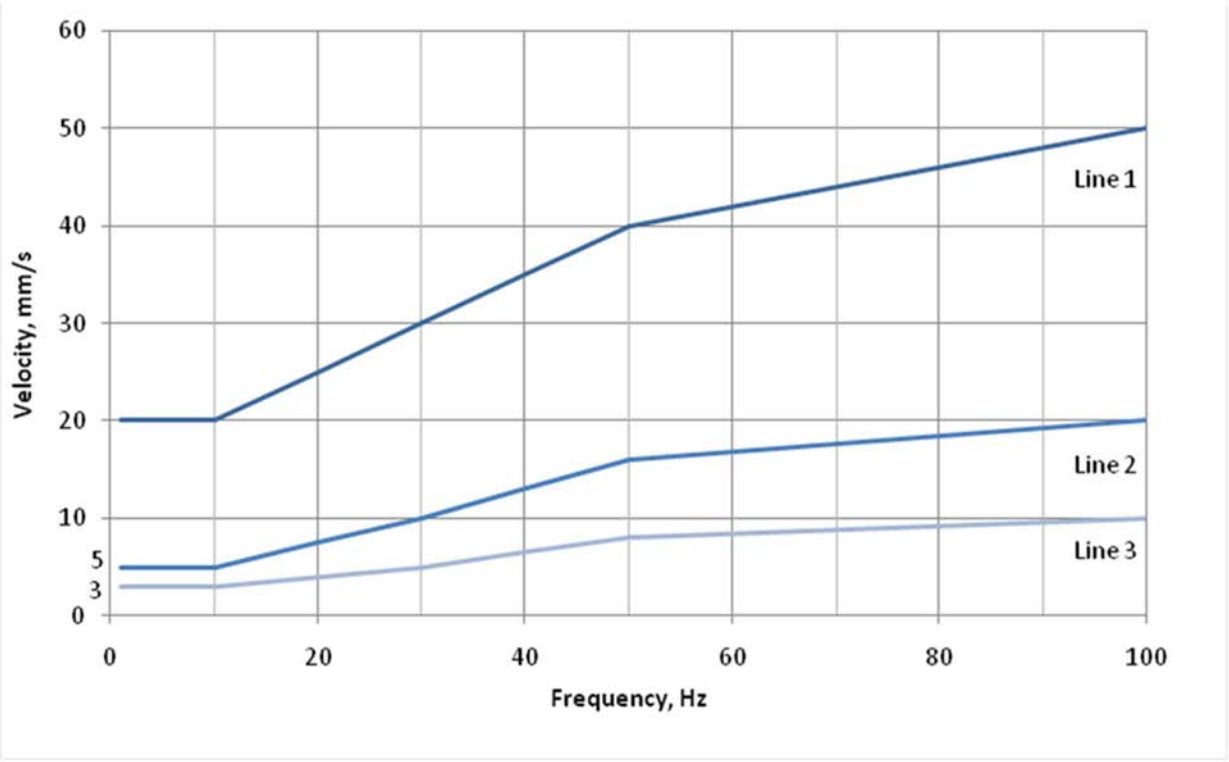


Figure 6.2 DIN4150 structural damage guideline values of vibration velocity

6.3.3 Project specific structural vibration criteria

Condition E81 requires that BS7385-2 and DIN4150-3 are both satisfied. DIN4150-3 is more conservative and provides more information for the assessment of heritage structures. If DIN4150-3 limits are satisfied, the limits in BS7385-2 will also be satisfied.

DIN4150-3 has therefore been adopted as the structural vibration criteria for the project.

7 Construction noise assessment

7.1 Assessment method

The following sections outline the modelling method and key assumptions adopted to assess noise levels from 24 hour / 7 day a week operation of the site in accordance with the ICNG (EPA 2009) and CNVG (RMS 2015) requirements.

A detailed summary of equipment, including periods of operation and sound power levels is presented Appendix B.

7.1.1 Equipment included in assessment

For all periods, the following activity was assessed:

- spoil haul trucks and concrete trucks entering site from Parramatta Road and exiting onto Wattle Street;
- light vehicles and deliveries entering site from Wattle Street entrance; and
- plant and equipment within the site compound and acoustic shed working at full capacity as described in Section 7.1.3 and Section 7.1.5.

7.1.2 External haul truck and concrete truck movements

The following assumptions have been made in reference to truck movements on-site:

- truck ingress and egress routes as described above and as shown in Figure 7.1
- concrete trucks were modelled with a sound power level of 108 dBA travelling at 10 km/h; and
- spoil haul trucks were modelled with a sound power level of 105 dBA travelling at 10 km/h.

7.1.3 Inside the acoustic shed

The following assumptions have been made in reference to construction activities occurring inside the acoustic shed in a worst-case 15 minute period:

- The equipment generating noise in the shed consists of:
  - two 24t front end loaders (FELs);
  - five 38t articulated dump trucks (ADT);
  - one road concrete agitator; and
  - five truck and dogs for spoil haulage.
- A worst case reverberant sound pressure level of 86 L_{Aeq} dB has been adopted inside the acoustic shed. This is based on all plant and equipment listed (total sound power level of 119 dBA) above operating in the shed at one time continuously over a 15-minute assessment period. This provides a conservative representation of noise levels inside the shed.

7.1.4 Construction ventilation noise

Noise associated with ventilation for the tunnelling construction activities consists of four axial fans at the location depicted on Figure 7.1 each with a sound power level of 89 dBA inclusive of silencers. The fans are elevated on a steel structure and will be housed within a shed, with the ventilation openings facing away from residences. All ducting extended to the cut and cover will be enclosed to minimise noise breakout.

7.1.5 Other noise generating site activities

Other noise generating activities and equipment on-site included in modelling consists of:

- a compressor (Ingersoll Rand R110i – A8.5 or similar) with a sound power level of 98 dBA, $L_{Aeq,15min}$;
- a water treatment plant with pumps generating a sound power level of 78 dBA, $L_{Aeq,15min}$;
- a franna crane working near the workshops with a sound power level of 99 dBA, $L_{Aeq,15min}$; and
- noise generated from the workshop with a nominal worst-case sound power level of 107 dBA, $L_{Aeq,15min.}$

The location of this equipment is shown on Figure 7.1

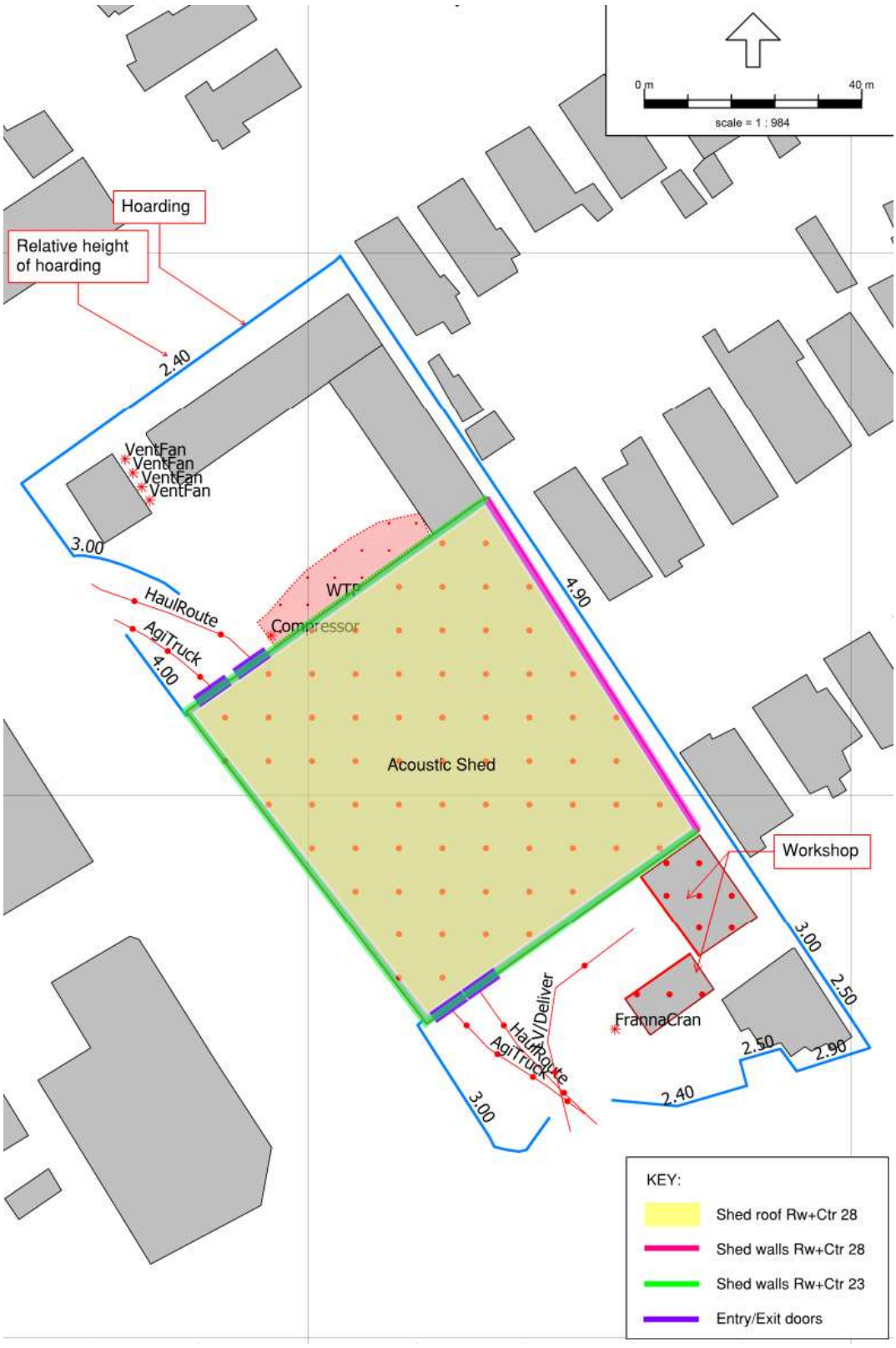


Figure 7.1 Modelled noise source locations

7.2 Site specific noise mitigation

The following mitigation will require implementation on site to achieve compliance with noise management levels:

1. an acoustic shed over the tunnel shaft and spoil handling sites;
2. ventilation fans and ducting to be contained in an acoustic structure including in-duct fan silencing; and
3. hoardings around the site.

7.2.1 Acoustic shed construction

The following wall and roof specifications have been referenced from M4-East project drawing number 00-A601 Revision A (dated 27/11/2015).

i Walls

The following construction is indicative of the east shed wall:

- outer skin of 0.48 mm sheet steel;
- minimum 55 mm cavity insulation with perforated foil facing inwards;
- 10 kg/m^2 wave bar acoustic membranes fixed either side of girts; and
- inner skin of 0.42 mm sheet steel.

The following construction is indicative of all other shed walls:

- outer skin of 0.48 mm sheet steel;
- 55 mm internal insulation lining walls with perforated foil facing inwards; and
- 10 kg/m^2 wave bar acoustic membrane fixed to inside girts.

The minimum required sound transmission loss of this wall is presented in Table 7.1. This table also presents the anticipated reduction in performance due to detailing leaks at junctions.

Table 7.1 Minimum sound transmission loss of shed walls

Shed wall	Description	Octave band centre frequency, minimum transmission loss, dB							Rw + Ctr
		63	125	250	500	1k	2k	4k	
North east wall	In principle performance	11	14	26	38	40	44	53	28
	With shed leakage	6	9	21	31	31	33	35	-
All other walls	In principle performance	6	12	16	21	27	30	40	23
	With shed leakage	1	7	11	14	18	22	32	-

ii Roof

The following construction is indicative of the shed roof:

- outer skin of 0.48 mm sheet steel;
- 10kg/m^2 wave bar acoustic membrane fixed to purlins/rafters;
- 55 mm internal insulation lining walls with perforated foil facing inwards; and
- inner skin of 0.42 mm sheet steel.

The minimum required sound transmission loss of the roof is presented in Table 7.2.

Table 7.2 Minimum sound transmission loss of shed roof

Element	Octave band centre frequency, minimum transmission loss, dB						
	63	125	250	500	1k	2k	4k
Shed roof	6	9	21	31	31	33	35

iii Internal reverberation control

The shed roof and all walls will be internally lined with insulation to control reverberation noise build-up and breakout through the open doors. A minimum 90% surface area needs to be covered with a material with minimum absorption coefficient as presented in Table 7.3.

Table 7.3 Minimum sound absorption coefficient of internal insulation

Element	Octave band centre frequency, minimum absorption coefficient					
	125	250	500	1k	2k	NRC
Shed roof and walls (at least 90% coverage)	0.3	1.0	1.0	1.0	0.9	1.0

7.2.2 Noise hoarding

The proposed location and height of site hoardings for both scenarios is shown in Figure 7.1.

All hoarding with a height of 3 m or less should comprise a single sheet of 17mm plywood or equivalent providing a minimum Rw of 22.

All hoarding of greater than 3m height should comprise either two sheets of 17 mm plywood with sheet joins opposed, double stacked shipping containers or equivalent providing a minimum Rw of 28.

7.2.3 Construction ventilation noise mitigation

Four axial fans as shown in Figure 7.1 will be used to provide supply air to the construction works underground. The fans are contained in an acoustic shed with attenuators fitted to supply air inlet. The sound power level of the enclosure breakout and the supply air inlet in total should not exceed a sound power level of 89 dBA. .

7.3 Noise predictions

Noise emissions from the site were modelled using Bruel & Kjær proprietary modelling software, Predictor. Predictor allows prediction under the ISO9613-2 "*Acoustics – Attenuation of Sound during Propagation Outdoors – general method"* algorithm. This algorithm is accepted by the EPA. Features which affect the predicted noise level that are considered in the noise modelling include:

- equipment sound power levels and locations;
- screening from structures;
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

For all scenarios, it has been assumed that all plant and equipment operate simultaneously. This is considered to be a conservative representation of a typical worst case scenario.

7.3.1 Summary of results

Noise level predictions to the nearest representative sensitive receivers to the site are provided in Appendix C. This subset of receivers has the highest predicted noise levels of all residential receivers in the immediate NCAs. Therefore, predicted noise levels at other residential receivers within the immediate NCAs will be equal to or less than those presented in Appendix C.

Predictions for each period, as well as L_{max} predictions for assessing sleep disturbance, are presented with comparison to relevant NMLs as outlined in Section 5. The noise level predictions are based on operational noise sources outlined in Section 7.1 and with noise mitigation applied as outlined in Section 7.2.

In summary, noise level predictions comply at most of the assessed sensitive receiver locations for the worst case operational scenario. The exceptions to this are described below.

Predicted noise levels at most receivers are compliant with NMLs throughout most periods, the exception being during the night period, where an exceedance of up to 4 dB has been identified (at R11), predominantly due to truck movements. There are also six other residences where a 1 to 2 dB exceedance of NMLs is predicted during the night period. A 1 to 2 dB exceedance is classified in general terms by the EPA and DPE as negligible after all feasible and reasonable noise mitigation and management has been applied (refer to the NPfI (EPA 2017) and Voluntary Land Acquisition and Mitigation Policy (VLAMP) (DPE 2017)).

A noise level of 44 dB is predicted at the place of worship to the east of the site (6-12 Wattle Street) during the day time with site at maximum capacity. The NML for places of worship in Table 5.4 specifies an internal level of 45dB. A typical building facade partially including windows would provide a transmission loss of at least 10dB. Accounting for this, an external level of 44dB at the façade, and therefore a likely internal noise level of 34 dB, is predicted to satisfy this requirement.

Consultation on proposed works and mitigation measures will be undertaken with receivers identified to have exceedances of NMLs outside standard construction hours (ie 'affected sensitive receivers'), where no other consultation or at receiver mitigation strategies are implemented.

7.3.2 Sleep disturbance

Sleep disturbance impacts from onsite trucking movements has been assessed at residential receivers. The predicted maximum noise levels at the nearest representative receivers are provided in Appendix C and apply to the upper most floor.

Maximum noise levels above the sleep disturbance screening criteria are predicted at three representative locations.

However, predicted maximum noise levels at all receivers are below levels expected to cause awakenings of 60 to 65 dB L_{max} external (equating to 50 to 55 dB L_{max} internal) as referenced in the RNP (EPA 2011).

Maximum noise level events will be managed during the night-time period in accordance with the Noise and Vibration Management Plan (NVMP).

7.3.3 Road traffic noise

Road traffic noise impacts due to increased truck movements on public roads generated by 24/7 tunnelling activities will be assessed in the project's haulage CNVIS.

8 Construction vibration assessment

No vibration impacts from the operational phase of the site are expected, except from tunnelling activity. Vibration impacts from tunnelling have been assessed in the Tunnelling CNVIS (EMM 2019).

9 Noise mitigation and management

9.1 General

The EPA's NSW ICNG requires that construction noise levels are assessed against NMLs.

Noise levels above NMLs have been predicted with the incorporation of noise mitigation measures. It is not uncommon for construction projects to exceed NMLs. For this reason, they are not considered as noise criteria, but as a trigger for all feasible and reasonable noise mitigation and management to be considered, once exceeded.

Noise mitigation and management for the site that has been described in detail in Section 7.2. Other mitigation and management measures that can be implemented on site are provided in the following sections.

9.2 Work practices

Work practice methods include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;
- regular identification of noisy activities and adoption of improvement techniques;
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents;
- develop routes for the delivery of materials and parking of vehicles to minimise noise;
- where possible, avoid the use of equipment that generates impulsive noise;
- minimise the movement of materials and plant and unnecessary metal-on-metal contact;
- minimise truck movements; and
- schedule respite periods for intensive works as determined through consultation with potentially affected neighbours (e.g. a daily respite period for a minimum of one hour at midday).

9.3 Plant and equipment

Additional measures for plant and equipment include:

- where possible, choose quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks;
- operate plant and equipment in the quietest and most efficient manner; and
- regularly inspect and maintain plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

9.4 Quantifying noise reductions

Approximate noise reductions provided by some of these measures are provided in Table 9.1.

Table 9.1 Relative effectiveness of various forms of noise control

Noise control	Nominal noise reduction possible, in total A-weighted sound pressure level, dB
Increase source to receiver distance[1]	approximately 6 dB for each doubling of distance
Reduce equipment operating times or turn off idling machinery[2]	approximately 3 dB per halving of operating time
Operating training on quiet operation[2]	Up to 3 to 5 dB
Screening (eg noise barrier)[1]	normally 5dB to 10 dB, maximum 15 dB
Enclosure (eg shed/building)[1]	normally 15 dB to 25 dB, maximum 50 dB
Silencing (eg exhaust mufflers) [1]	normally 5 dB to 10 dB, maximum 20 dB

Notes:

1. Sourced from AS2436-2010
2. Based on EMM's measurement experience at construction and mining sites

9.5 Additional noise mitigation measures – Construction Noise and Vibration Guideline

In many instances, impacts from construction noise and vibration are unavoidable where works are undertaken in relatively close proximity to surrounding receivers. The CNVG includes a list of additional mitigation measures which aim to manage the potential noise impacts. Additional mitigation measures from the CNVG that have been adopted for the project are summarised in Table 9.2.

Table 9.2 CNVG additional noise mitigation measures

ID	Name	Description
N	Notification (letterbox drop or equivalent)	Advanced warning of works and potential disruptions can assist in reducing the impact to the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of seven calendar days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.
SN	Specific notifications	Specific notifications are letterbox drops (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification should provide additional information to that covered in the general notifications and be targeted at highly affected receivers.
RO	Respite offers	Respite Offers should be considered and or adopted where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed three hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.
R1	Respite period 1	Out of hours construction conducted during the OOHW period 1 (Monday to Friday 6pm to 10pm, Saturday 7am to 8am and 1pm to 10pm, Sunday/Public Holiday 8am to 6pm) shall be limited to no more than three consecutive evenings per week except where there is a duration respite. For night work these periods of work should be separated by not less than one week and no more than six evenings per month.

Table 9.2 CNVG additional noise mitigation measures

ID	Name	Description
R2	Respite period 2	Night time construction in OOHW period 2 (Monday to Friday 10pm to 7am, Saturday 10pm to 8am, Sunday/Public Holiday 6pm to 7am) shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and six nights per month. Where possible, high noise generating works shall be completed before 11pm.
AA	Alternative accommodation	Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels (refer to Tables C1-C3 of the CNVG). The specifics of the offer will be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
DR	Duration respite	Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified that it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite.
V	Verification	Refer to Appendix F of the CNVG for more details about verification of noise and vibration levels as part of routine checks of noise levels or following reasonable complaints. This verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

The level of additional mitigation is then assigned based on the impact classification (ie predicted noise level above NML) and the list of measures in Table 9.3.

Table 9.3 Additional mitigation measures matrix – airborne construction noise

Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			**Additional mitigation measures**	
Perception	**dBA above RBL**	**dBA above NML**	**Type**	**Mitigation levels**
All hours				
75 dBA or greater			N, V, RO	HA
Standard hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Hol (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly audible	10 to 20	<10	-	NML
Moderately intrusive	20 to 30	10 to 20	N, V	NML + 10
Highly intrusive	>30	> 20	N, V	NML + 20
OOHW Period 1: Mon – Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)				
Noticeable	5 to 10	<5	-	NML
Clearly audible	10 to 20	5 to 15	N, R1, DR	NML +5
Moderately intrusive	20 to 30	15 to 25	V, N, R1, DR	NML + 15
Highly intrusive	>30	>25	V, N, SN, R2, DR	NML + 25
OOHW period 2: Mon - Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Hol (6pm – 7am)				
Noticeable	5 to 10	<5	N	NML
Clearly audible	10 to 20	5 to 15	V, N, R2, DR	NML + 5

Table 9.3 Additional mitigation measures matrix – airborne construction noise

Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			Additional mitigation measures	
Perception	**dBA above RBL**	**dBA above NML**	**Type**	**Mitigation levels**
Moderately intrusive	20 to 30	15 to 25	V, N, SN, R2, DR	NML + 15
Highly intrusive	>30	>25	AA, V, N, SN, R2, DR	NML + 25

Note:

1. The following abbreviations are used: Alternative Accommodation (AA), Respite Period 1 (R1), Verification (V), Specific Notifications (SN), Notification drops (N), Respite Period 2 (R2), Negotiated Respite (NR), Highly Affected (HA), Respite Offer (RO), Duration Respite (DR).

Noise level exceedances of up to 4 dB have been predicted at residential receivers which place the predicted noise level in the noticeable category. In accordance with the RMS CVNG, noise levels at these properties (identified in Appendix C) will be verified via noise measurement.

Consultation on proposed works and mitigation measures will be undertaken with receivers identified to have exceedances of NMLs (ie 'affected sensitive receivers'), where no other consultation or at receiver mitigation strategies are implemented.

9.6 Community consultation and complaints handling

Community consultation and complaints handling will be undertaken in accordance with the project's Community Communication Strategy (CCS).

10 Conclusion

This CNVIS identifies and describes construction works associated with Northcote tunnel operations. The potential noise levels from the Site were assessed in accordance with relevant policies, standards, guidelines and the instrument of approval conditions.

Predicted noise levels at most receivers are compliant with NMLs throughout most periods, the exception being during the night period, where an exceedance of up to 4 dB has been identified (at R11). This is predominantly due to external truck movements. There are also six other residences where a 1 to 2 dB exceedance of NMLs is predicted during the night period. A 1 to 2 dB exceedance is classified in general terms by the EPA and DPE as negligible after all feasible and reasonable noise mitigation and management has been applied (refer to the NPfI (EPA 2017) and Voluntary Land Acquisition and Mitigation Policy (VLAMP) (DPE 2017)).

In accordance with RMS CNVG requirements, these predicted noise levels will be verified through noise measurement once 24 hour operations commence. Additional feasible and reasonable noise mitigation and management measures will be identified, where required. Possible noise mitigation and management measures have been presented in Section 9.

Maximum noise levels above the sleep disturbance screening criteria are predicted at three representative locations. However, predicted maximum noise levels at all receivers are below levels expected to cause awakenings of 60 to 65 dB L_{max} external (equating to 50 to 55 dB L_{max} internal) as referenced in the RNP (EPA 2011). Maximum noise level events will be managed during the night-time period in accordance with the site's Noise and Vibration Management Plan (NVMP).

In addition, Condition E88 of the CoA requires at receiver noise mitigation in the form of property treatment, which is to be offered to the land owners for habitable living spaces, or other mitigation or management measures as agreed by the occupier, to the residential properties identified in Appendix E of the Project Approval. Although the implementation of at receiver mitigation is principally an outcome of the approval conditions, some receivers identified within this CNVIS that exceed the NML's are all entitled to receive at-receiver treatments according to the Project Approval, which will assist in mitigating noise from the Site.

Vibration impacts from the operations phase of the project are considered very unlikely, except from tunnelling activity. Vibration impacts from tunnelling activity has been assessed in the project's Tunnelling CNVIS (EMM 2019)

Construction traffic noise on the local road network will be assessed in the project's haulage CNVIS.

Appendix A

Acoustic glossary

Several technical terms are discussed in this report. These are explained in Table A.1.

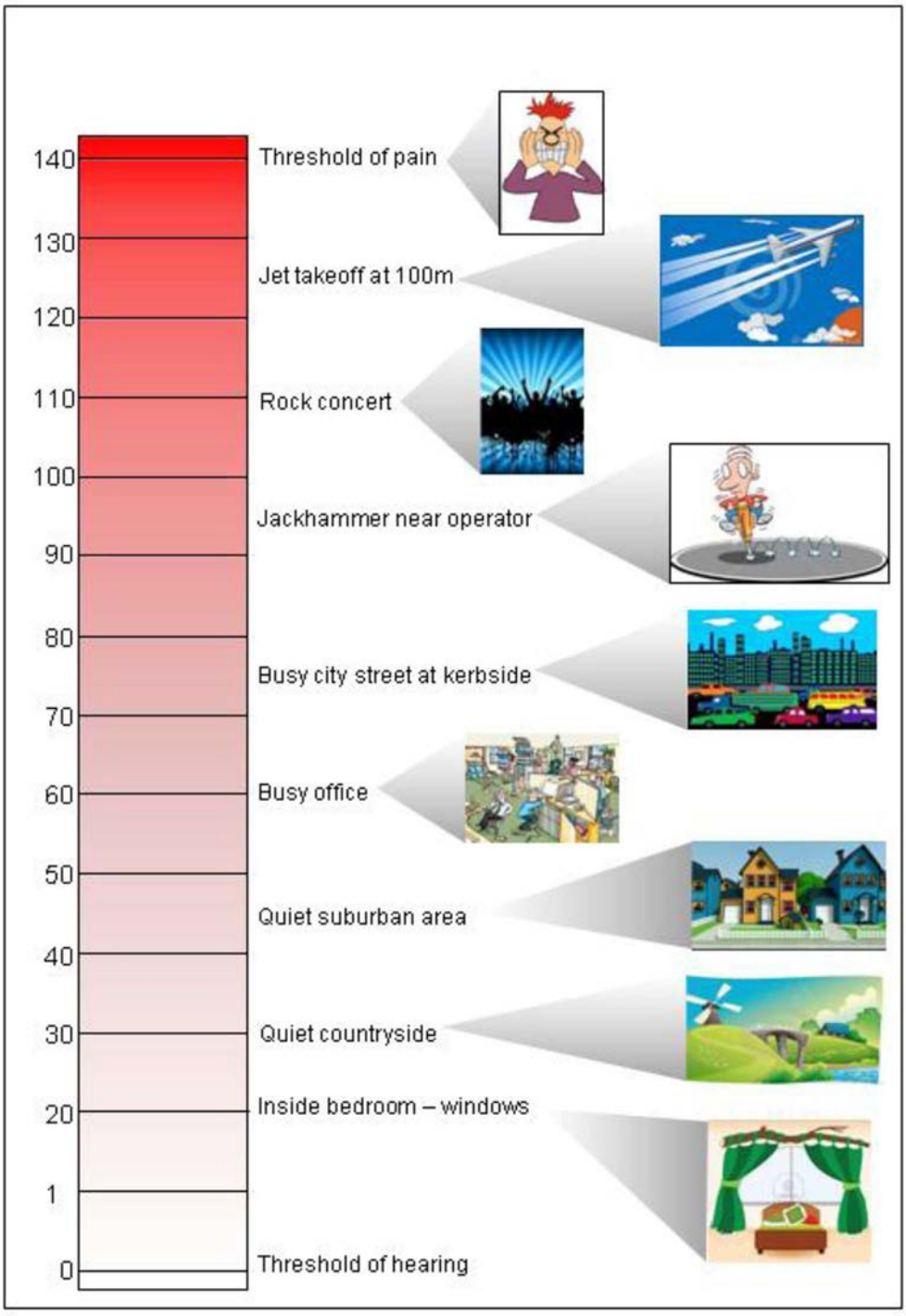
Table A.1 Glossary of Acoustic Terms

Term	Description
dB	Noise is measured in units called decibel (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_{A1}	The 'A-weighted' noise level which is exceeded 1% of the time.
L_{A10}	The 'A-weighted' noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise level.
L_{A90}	Commonly referred to as the background noise level. The 'A-weighted' noise level exceeded 90% of the time.
L_{Aeq}	The energy average noise from a source. This is the equivalent continuous 'A-weighted' sound pressure level over a given period. The $L_{Aeq,15min}$ descriptor refers to an L_{Aeq} noise level measured over a 15-minute period.
$L_{Aeq,1hour}$[1]	This is the equivalent continuous 'A-weighted' sound pressure level over an hour period. The $L_{Aeq,1hour}$ descriptor refers to an L_{Aeq} noise level measured over a 1-hour period.
L_{Amin}	The minimum 'A-weighted' noise level received during a measuring interval.
L_{Amax}	The maximum root mean squared 'A-weighted' sound pressure level (or maximum noise level) received during a measuring interval.
L_{Ceq}	This is the equivalent continuous 'C-weighted' sound pressure level over a given period. The $L_{Ceq,15min}$ descriptor refers to an L_{Ceq} noise level measured over a 15-minute period. C-weighting can be used to measure low frequency noise.

It is useful to have an appreciation of decibel (dB), the unit of noise measurement. Table A.2 gives an indication as to what an average person perceives about changes in noise levels in the environment. Examples of common noise levels are provided in Figure A.1.

Table A.2 Perceived Change in Noise

Change in sound pressure level (dB)	Perceived change in noise
up to 2	not perceptible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times (or quarter) as loud



Source: Noise Measurement Manual (DEHP 2013).

Figure A.1 Common noise levels

Appendix B

Equipment list and sound power levels

Table B.1 Equipment list and sound power levels

Location	Equipment	Number of units/frequency			Sound Power Level (dBA)	
		Day	Evening	Night	Leq_{15min}	L_{max}
General worksite	Light Vehicle	10 per hour	5 per hour	5 per hour	89	-
	Water treatment plant pumps	2	2	2	78	-
	Road truck (deliveries)	4 per hour	-	-	105	-
	Water cart	4 per hour	4 per hour	-	104	-
	Compressor (inside semi-enclosed shed)	2	2	2	98	-
	Franna crane	1	1	-	99	106
Workshops (2)	Handtools	1	1	1	107	-
	Compressor	2	2	2	78	-
	Franna crane	1	1	1	93	106
Inside acoustic shed	Moxie	20 per hour	20 per hour	20 per hour	110	-
	Truck & dog	20 per hour	20 per hour	20 per hour	105	117
	Front-end loader	2	2	2	98	-
	Concrete truck	4 per hour	4 per hour	4 per hour	108	117
Ventilation fan shed	Ventilation fan (with silencer)	4	4	4	89	-

Appendix C

Predicted noise levels

Table C.1 Predicted noise levels

ID	Address	NCA	Land use	Day NML	Predicted noise levels ($L_{Aeq,15min}$) - Day	Day (OOH) NML	Predicted noise levels ($L_{Aeq,15min}$) - Day (OOH)	Evening NML	Predicted noise levels ($L_{Aeq,15min}$) - Evening	Night NML	Predicted noise levels ($L_{Aeq,15min}$) - Night	Sleep disturbance screening criteria	Predicted noise levels (L_{max}) - Night
C1	530 PARRAMATTA ROAD, ASHFIELD NSW 2131	NCS02	Commercial	70	54	70	54	70	54	70	54	-	-
R1	26 PAGE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	43	52	43	51	43	45	42	55	47
R2	28 PAGE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	43	52	43	51	43	45	42	55	49
R3	21 EARLE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	45	52	45	51	45	45	44	55	48
R4	22 EARLE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	42	52	42	51	42	45	42	55	47
R5	24 EARLE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	46	52	46	51	46	45	45	55	53
R6	25 PAGE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	42	52	42	51	42	45	42	55	49
R7	19 EARLE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	45	52	45	51	45	45	44	55	48
R8	27 PAGE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	42	52	42	51	42	45	42	55	49
R9	13 WOLSELEY STREET, HABERFIELD NSW 2045	NCS02	Residential	57	38	52	38	51	38	45	37	55	44
R10	12 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS02	Residential	57	42	52	42	51	42	45	41	55	46
R11	30 PAGE AVENUE, ASHFIELD NSW 2131	NCS02	Residential	57	49	52	49	51	49	45	49	55	60
C2	273 PARRAMATTA ROAD, HABERFIELD NSW 2045	NCS04	Commercial	70	42	70	42	70	42	70	42	-	-
C3	512 PARRAMATTA ROAD, ASHFIELD NSW 2131	NCS04	Commercial	70	52	70	52	70	52	70	51	-	-
C4	271-319 PARRAMATTA ROAD, HABERFIELD NSW 2045	NCS04	Commercial	70	48	70	48	70	48	70	48	-	-
R12	3 COVE STREET, HABERFIELD NSW 2045	NCS05	Residential	55	39	50	39	50	39	47	39	57	48
R13	2 COVE STREET, HABERFIELD NSW 2045	NCS05	Residential	55	41	50	41	50	41	47	41	57	53
R14	2 WOLSELEY STREET, HABERFIELD NSW 2045	NCS05	Residential	55	39	50	39	50	39	47	38	57	47
R15	4 COVE STREET, HABERFIELD NSW 2045	NCS05	Residential	55	39	50	39	50	39	47	38	57	46
R16	5 COVE STREET, HABERFIELD NSW 2045	NCS05	Residential	55	39	50	39	50	39	47	38	57	48
R17	11 WOLSELEY STREET, HABERFIELD NSW 2045	NCS05	Residential	55	42	50	42	50	42	47	41	57	49
R18	1 COVE STREET, HABERFIELD NSW 2045	NCS05	Residential	55	40	50	40	50	40	47	40	57	48
R19	7 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	44	46	44	46	44	42	43	52	45
R20	9 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	44	46	44	46	44	42	43	52	48
R21	9 WOLSELEY STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	43	46	43	46	43	42	42	52	48
R22	11 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	44	46	44	46	44	42	42	52	50
R23	5 WOLSELEY STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	44	46	44	46	44	42	43	52	47
R24	16 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	41	46	41	46	41	42	40	52	44
R25	17 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	41	46	41	46	41	42	40	52	45
R26	18 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	40	46	40	46	40	42	40	52	43
R27	13 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	43	46	43	46	43	42	42	52	47
R28	7 WOLSELEY STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	42	46	42	46	42	42	42	52	48
R29	5 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	45	46	45	46	45	42	44	52	49
R30	8 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	44	46	44	46	44	42	43	52	48

Table C.1 Predicted noise levels

ID	Address	NCA	Land use	Day NML	Predicted noise levels ($L_{Aeq,15min}$) - Day	Day (OOH) NML	Predicted noise levels ($L_{Aeq,15min}$) - Day (OOH)	Evening NML	Predicted noise levels ($L_{Aeq,15min}$) - Evening	Night NML	Predicted noise levels ($L_{Aeq,15min}$) - Night	Sleep disturbance screening criteria	Predicted noise levels (L_{max}) - Night
R31	15 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	42	46	42	46	42	42	41	52	47
R32	10 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	42	46	42	46	42	42	42	52	48
R33	6 NORTHCOTE STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	44	46	44	46	44	42	44	52	45
R34	15 WOLSELEY STREET, HABERFIELD NSW 2045	NCS05A	Residential	51	40	46	40	46	40	42	39	52	47
C5	215-217 PARRAMATTA ROAD, HABERFIELD NSW 2045	PRE01	Commercial	70	46	70	46	70	46	70	44	-	-
C6	476-500 PARRAMATTA ROAD, ASHFIELD NSW 2131	PRE01	Commercial	70	51	70	51	70	51	70	49	-	-
C7	16 WATTLE STREET, HABERFIELD NSW 2045	WTS01	Commercial	70	37	70	37	70	37	70	36	-	-
R35	18 WATTLE STREET, HABERFIELD NSW 2045	WTS01	Residential	66	39	61	39	58	39	48	39	58	43
O1	6-12 WATTLE STREET, HABERFIELD NSW 2045	WTS01	Place of worship	55	45	55	45	55	45	55	44	-	-
R36	20 WATTLE STREET, HABERFIELD NSW 2045	WTS01	Residential	66	38	61	38	58	38	48	37	58	45
R37	26 WALKER AVENUE, HABERFIELD NSW 2045	WTS03	Residential	51	35	46	35	46	35	42	34	52	41
R38	24 WALKER AVENUE, HABERFIELD NSW 2045	WTS03	Residential	51	44	46	44	46	44	42	42	52	54
R39	7 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	45	50	45	50	45	44	44	54	54
R40	3 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	46	50	46	50	46	44	45	54	55
R41	5A WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	46	50	46	50	46	44	44	54	54
R42	11 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	44	50	44	50	44	44	42	54	53
R43	5 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	46	50	46	50	46	44	44	54	54
R44	7A WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	45	50	45	50	45	44	43	54	54
R45	9 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	44	50	44	50	44	44	42	54	53
R46	13 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	44	50	44	50	44	44	42	54	53
R47	17 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	44	50	44	50	44	44	42	54	51
R48	19 WALKER AVENUE, HABERFIELD NSW 2045	WTS04	Residential	55	44	50	44	50	44	44	41	54	52

Note: 1. Yellow shading indicates an exceedance of NML by 1-2dB, red shading indicates an exceedance of NML by greater than 2dB