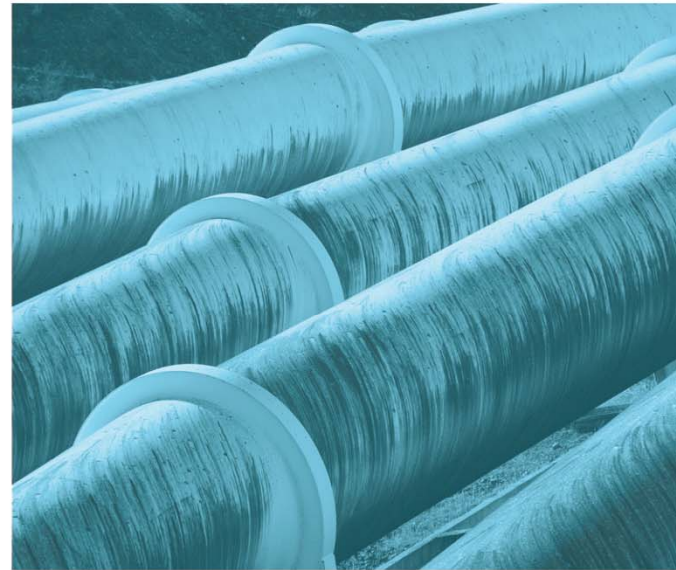




M4-M5 Mainline Link Tunnels

Construction Noise and Vibration Impact Statement - Wattle Street
civil and tunnelling site

Prepared for Lendlease Samsung Bouygues Joint Venture
February 2019



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Construction Noise and Vibration Impact Statement - Wattle Street civil and tunnelling site

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Client

Lendlease Samsung Bouygues Joint Venture

Date

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Version

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Prepared by



Carl Fokkema

Associate

21 February 2019

Approved by



Najah Ishac

Director

21 February 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.

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Executive Summary

EMM has prepared a Construction Noise and Vibration Impact Statement (CNVIS) for works proposed at the Wattle Street civil and tunnelling site (the Site) for the M4-M5 Link Mainline Tunnels project. Activities at the Site are principally associated with tunnelling support activities comprising ventilation, spoil handling, loading, haulage and concrete deliveries and lowering of Wattle Street ramps utilising road profilers during the day following completion of tunnelling activities.

The potential noise levels from the Site were assessed in accordance with relevant policies, standards, guidelines and the instrument of approval conditions.

The existing environment in the vicinity of the Site comprises residential and non-residential receivers as identified in the M4-M5 Link EIS. The study area was divided up into Noise Catchment Areas (NCA's) and background noise monitoring conducted at representative receiver locations. The NMLs for the project are based on measured background noise levels as described in the EIS in the absence of construction noise from each stage of the WestConnex project. Therefore, adhering to NMLs as far as practicable would also assist in minimising cumulative noise impacts from the project.

The primary document in NSW for assessing construction noise is the EPA's Interim Construction Noise Guideline (ICNG). Noise from construction sites is inevitable, but the aim of the ICNG "is to protect the majority of residences and other sensitive land uses from noise pollution most of the time". It is inherent for some construction projects to exceed noise management levels provided in the ICNG. However, where this is the case, all feasible and reasonable noise mitigation and management measures must be implemented.

The CNVIS has considered the $L_{Aeq,15min}$ (average noise level as per ICNG) and $L_{A1,1min}$ or L_{Amax} (eg maxima events) potential noise impacts from activities at the Site. Noise levels have been predicted to exceed the NMLs for certain scenarios and at some residential and non-residential receivers for standard and Out of Hours (OOH) periods. A review of the results confirms predicted levels that are consistent or lower than those reported in the EIS. Condition E88 of the Approval requires at receiver noise mitigation in the form of property treatment 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 Approval and shown in Table 3.1. Although the implementation of at receiver mitigation is principally an outcome of the approval conditions, the receivers identified within this CNVIS that exceed the NML's are all indicated to receive at-receiver treatments which will assist in mitigating noise from the Site.

The assessment has also indicated potential for exceedance of sleep disturbance 'screening criterion' at night. However, the predicted levels are less than the existing L_{Amax} and L_{A1} noise levels that the residential receivers were exposed to from traffic on Wattle Street and typically less than the equivalent external facade level of 60-65 dB(A) as referenced in the NSW, Road Noise Policy (RNP).

The construction scenarios presented in this report are considered representative of typical or worst case. The CNVIS provides methods on how noise can be managed and mitigated in Section 9.

The potential for cumulative noise impacts from the project with other components of the WestConnex project (ie M4 East) have been considered. However, a review of the Site project timeframes confirms that impacts would be unlikely to occur. The next closest site associated with the M4-M5 Link Mainline Tunnels is the Parramatta Road East and West (PREW) which is located more than 250m from the Wattle Street site and would not contribute to cumulative noise levels for the Wattle Street receivers.

Detailed assessment of ground vibration from excavation and tunnelling activities is addressed in the M4-M5 Mainline Link Tunnels Tunnelling CNVIS.

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1 Introduction

1.1 Context

This Construction Noise and Vibration Impact Statement (CNVIS) have 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) (AECOM 2017), 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:

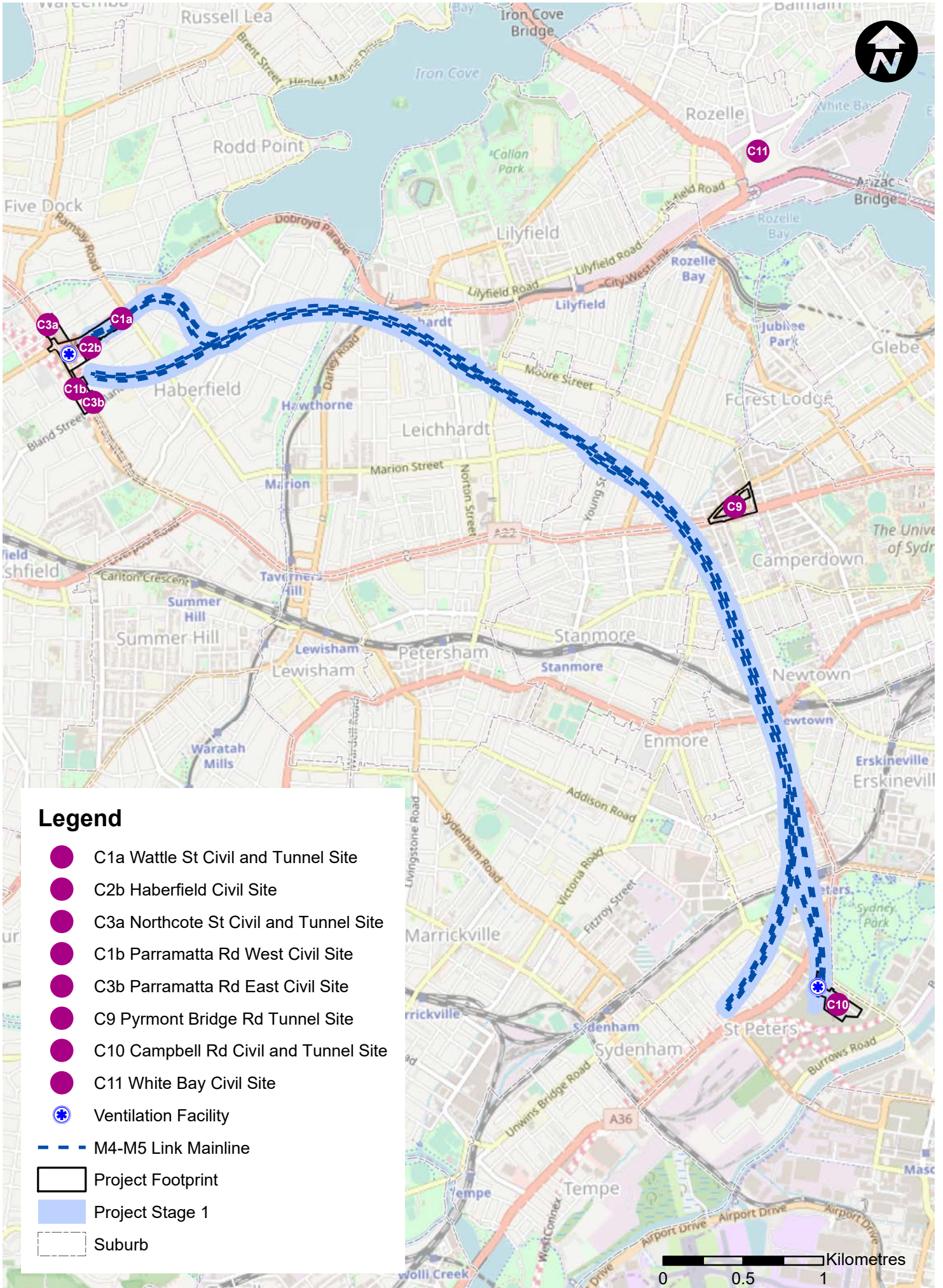
- Stage 1 (the Project and subject of this document): M4-M5 Link Mainline tunnels;
- Stage 2: Rozelle interchange.

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 subterranean connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield;
 - Entry and exit ramp within the existing cut and cover structure between the mainline tunnels and the Wattle Street interchange at Haberfield (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 subterranean 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;
- Fit out (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 (subject to future Modification);
 - 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.



Legend

- C1a Wattle St Civil and Tunnel Site
- C2b Haberfield Civil Site
- C3a Northcote St Civil and Tunnel Site
- C1b Parramatta Rd West Civil Site
- C3b Parramatta Rd East Civil Site
- C9 Pymont Bridge Rd Tunnel Site
- C10 Campbell Rd Civil and Tunnel Site
- C11 White Bay Civil Site
- ★ Ventilation Facility
- M4-M5 Link Mainline
- ▭ Project Footprint
- Project Stage 1
- ▭ Suburb

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 and vibration impacts from the construction phase of Wattle Street tunnelling support comprising ventilation, spoil handling, loading, haulage and concrete deliveries and ramp lowering activities utilising road profiler, and to develop feasible and reasonable noise management and mitigation measures where impacts are identified.

The civil and tunnel support site would be located above and below ground along Wattle Street at Haberfield between Parramatta Road and Ramsay Street. This construction would use land above ground that is currently being used as a construction zone for the M4 East project. In addition, the entry and exit ramps and cut-and-cover structures being built by the M4 East project would be used to support tunnelling; including stockpiling, loading and removal of spoil and ventilation.

Road headers would be launched from this site to excavate the tunnels that would connect the Wattle Street interchange entry and exit ramps with the M4-M5 Link mainline tunnels. Tunnelling would commence from the end of the cut and cover structure, approximately 100m from the Wattle Street ramp portals. Assessment of tunnelling activities including operation of road headers and associated noise and vibration assessment is addressed in detail within the Tunnelling CNVIS for the M4-M5 Link Mainline Tunnels and has not been considered further in this CNVIS.

Key construction activities to be carried out at and supported by the Wattle Street civil and tunnel support site would include:

- establishment of site offices, amenities and temporary infrastructure, including temporary fencing;
- establishment of temporary noise attenuation measures identified in Figure 4.1;
- completion of excavation and stabilisation works in the dive structures and cut-and-cover structures (that are being built as part of the M4 East project);
- delivery, lay down and storage of materials, including precast concrete;
- excavation, as well as stockpiling and reloading of excavated material and spoil haulage from tunnelling activities;
- provision of temporary ventilation systems to support tunnelling activities;
- civil ramp and tunnel fit out works (including pavement and drainage works);
- installation of mechanical and electrical services within the ramps and tunnels;
- civil works to integrate the tunnels with the surface road network at the Wattle Street interchange;
- finishing works including asphaltting, lighting, line marking and signage installation;
- operation of a water treatment plant;
- rehabilitation and landscaping to be consistent with the M4 East Urban Design and Landscape Plan; and,
- demobilisation.

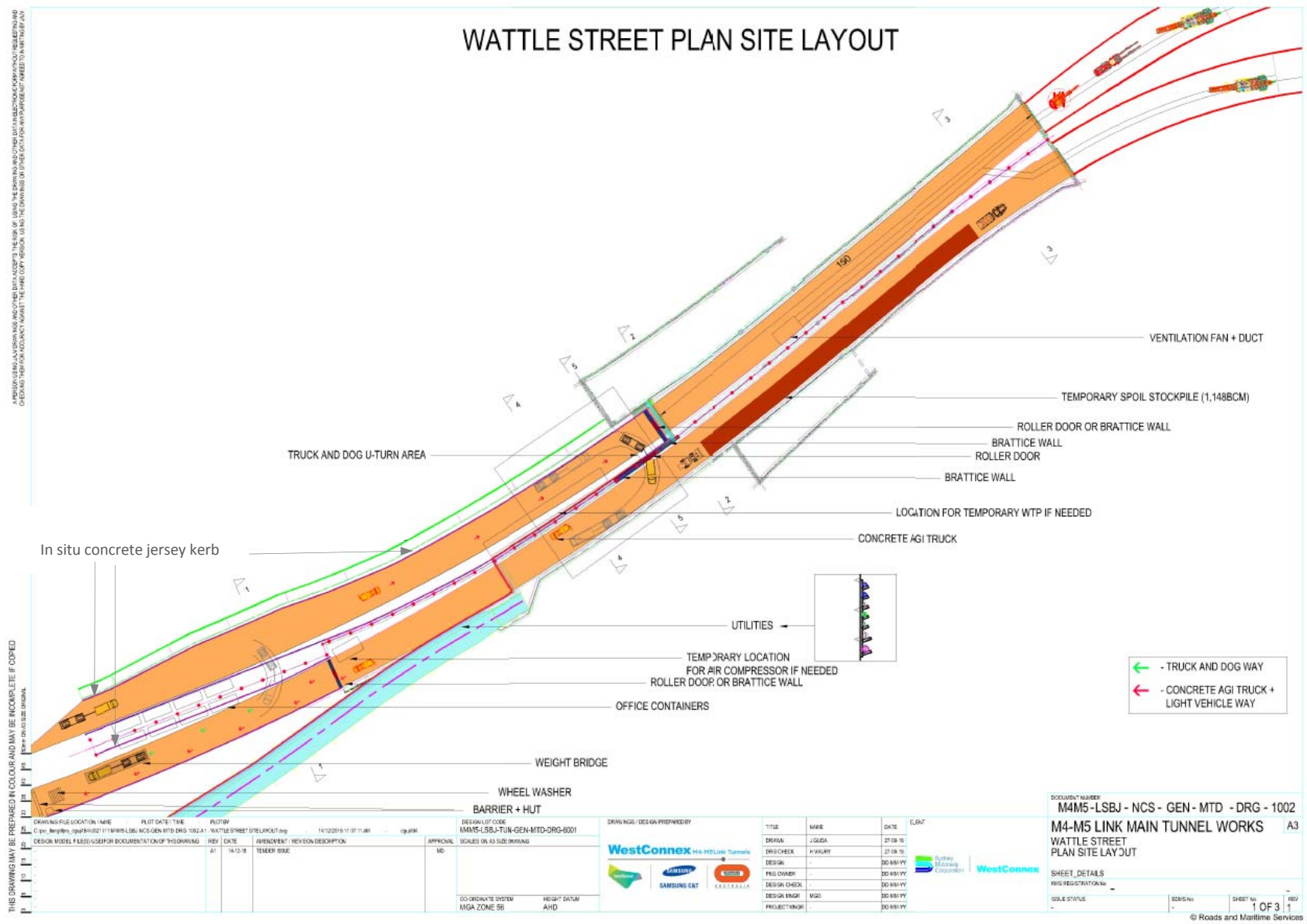


Figure 1.2 Wattle Street civil and tunnel site layout

Works at this site would also be supported by the facilities at the Parramatta Road East and West civil sites.

The Wattle Street interchange entry and exit ramps that will be constructed as part of the M4 East project would be used for spoil removal. Heavy vehicles would enter the site via the eastbound entry ramp, be loaded with spoil underground within the tunnels, and then exit the site to Wattle Street via the westbound exit ramp.

Spoil handling at this site would occur 24 hours a day, seven days a week.

A review of WestConnex M4 East Construction Noise and Vibration Management Plan (M4 East CNVMP) confirms finishing works for the M4 East are forecast to be completed by Quarter 1 2019 (Section 5.1 of the M4 East CNVMP). The Project works are forecast to commence in Quarter 2 2019, accordingly there is no overlap and cumulative noise has not been considered further.

The assessment of noise impacts from heavy vehicles for spoil haulage on the existing road network (not onsite) for reuse or dumping offsite is addressed in a separate Spoil Haulage CNVIS.

Operational noise and vibration measures do not fall within the scope of this CNVIS.

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 Construction Noise and Vibration Management Plan (CNVMP) as required by CoA C4 (b).

2 Purpose and objectives

2.1 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 Authority¹;
- *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;
- *NSW Noise Mitigation Guideline (NMG) 2015*, Roads and Maritime;
- *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 ancillary facility construction noise and vibration are listed in Table 3.1.

Table 3.1 Conditions of Approval for construction and vibration

Condition	Key requirement
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) tunnel fit out works. Other surface works associated with tunnelling must only be undertaken in accordance with the requirements of Condition E73 .
Highly Noise Intensive Works	
E72	Except as permitted by an EPL, highly noise intensive works that result in an exceedance of the applicable NML at the same receiver must only be undertaken: (a) between the hours of 8:00 am to 6:00 pm Monday to Friday; (b) between the hours of 8:00 am to 1:00 pm Saturday; and (c) in continuous blocks not exceeding three (3) hours each with a minimum respite from those activities and works of not less than one (1) hour between each block. For the purposes of this condition, 'continuous' includes any period during which there is less than a one (1) hour respite between ceasing and recommencing any of the work that are the subject of this condition.
Variation to work hours	
E73	Notwithstanding Conditions E68 to E72 works may be undertaken outside the hours specified under those conditions in the following circumstances: (a) for the delivery of materials required by the NSW Police Force or other authority for safety reasons; or (b) where it is required in an emergency to avoid injury or the loss of life, to avoid damage or loss of property or to prevent environmental harm; or (c) where different construction hours are permitted or required under an EPL in force in respect of the CSSI; or (d) works approved under an Out-of-Hours Work Protocol for works not subject to an EPL as required by Condition E77 ; or (e) construction that causes $L_{Aeq(15\text{ minute})}$ noise levels:

Table 3.1 Conditions of Approval for construction and vibration

Condition	Key requirement
	<p>(i) no more than 5 dB(A) above the rating background level at any residence in accordance with the <i>Interim Construction Noise Guideline</i> (DECC, 2009), and</p> <p>(ii) no more than the 'Noise affected' noise management levels specified in Table 3 of the <i>Interim Construction Noise Guideline</i> (DECC, 2009) at other sensitive land uses, and</p> <p>(iii) continuous or impulsive vibration values, measured at the most affected residence are no more than the maximum values for human exposure to vibration, specified in Table 2.2 of <i>Assessing Vibration: a technical guideline</i> (DEC, 2006), and</p> <p>(iv) intermittent vibration values measured at the most affected residence are no more than the maximum values for human exposure to vibration, specified in Table 2.4 of <i>Assessing Vibration: a technical guideline</i> (DEC, 2006).</p> <p><i>Note: Section 5.24(1)(e) of the EP&A Act requires that an EPL be substantially consistent with this approval. For example, an EPL cannot authorise spoil movements at the Darley Road construction ancillary facility outside of the hours specified in Conditions E68 and E69. Out of Hours Works considered under Conditions E73(c) and (d) must be justified and include an assessment of mitigation measures.</i></p>
Out-of-Hours Work Scheduling and Respite	
E75	<p>Out-of-hours works that are regulated by an EPL as per Condition E73(c) or through the Out of-Hours Work Protocol as per Condition E77 include:</p> <p>(a) works which could result in a high risk to construction personnel or public safety, based on a risk assessment carried out in accordance with AS/NZS ISO 31000:2009 "Risk Management – Principles and Guidelines"; or</p> <p>(b) where the relevant road network operator has advised the Proponent in writing that carrying out the works and activities could result in a high risk to road network operational performance; or</p> <p>(c) where the relevant utility service operator has advised the Proponent in writing that carrying out the works and activities could result in a high risk to the operation and integrity of the utility network; or</p> <p>(d) where the TfNSW Transport Management Centre (or other road authority) has advised the Proponent in writing that a road occupancy licence is required and will not be issued for the works or activities during the hours specified in Condition E68 and Condition E69; or</p> <p>(e) where Sydney Trains (or other rail authority) has advised the Proponent in writing that a Rail Possession is required. NSW Government 49 Department of Planning and Environment Conditions of Approval for WestConnex M4-M5 Link SSI 7485</p> <p><i>Note: Other out-of-hours works can be undertaken with the approval of an EPL, or through the project's Out-of-Hours Work Protocol for works not subject to a EPL.</i></p>
E76	<p>In order to undertake out-of-hours work described in Condition E75, the Proponent must identify appropriate respite periods for the out-of-hours works in consultation with the community at each affected location. This consultation must include (but not be limited to) providing the community with:</p> <p>(a) a schedule of likely out-of-hours work for a period no less than three (3) months;</p> <p>(b) the potential works, location and duration;</p> <p>(c) the noise characteristics and likely noise levels of the works; and</p> <p>(d) likely mitigation and management measures.</p> <p>The outcomes of the community consultation, the identified respite periods and the scheduling of the likely out-of-hour works must be provided to the AA, EPA and the Secretary.</p>
Out-of-Hours Work Protocol – Works not subject to an EPL	
E77	<p>An Out-of-Hours Work Protocol must be prepared to identify a process for the consideration, management and approval of works which are outside the hours defined in Conditions E68 and E69, and that are not subject to an EPL. The Protocol must be approved by the Secretary prior to commencement of the works. The Protocol must be prepared in consultation with the EPA and AA. The Protocol must:</p>

Table 3.1 Conditions of Approval for construction and vibration

Condition	Key requirement
	<p>(a) provide a process for the consideration of out-of-hours works against the relevant noise and vibration criteria, including the determination of low and high-risk activities;</p> <p>(b) provide a process for the identification of mitigation measures for residual impacts, including respite periods in consultation with the community at each affected location, consistent with the requirements of Condition E76;</p> <p>(c) identify procedures to facilitate the coordination of out-of-hours works approved by an EPL to ensure appropriate respite is provided; (d) identify an approval process that considers the risk of activities, proposed mitigation, management, and coordination, including where:</p> <ul style="list-style-type: none"> i) low risk activities can be approved by the ER in consultation with the AA, and ii) high risk activities that are approved by the Secretary; and <p>(e) identify Department, EPA and community notification arrangements for approved out of hours works, which maybe detailed in the Communication Strategy.</p>
Out-of-Hours Works – Utility Coordination and Respite	
E78	<p>All works undertaken for the delivery of the CSSI, including those undertaken by third parties, must be coordinated to ensure respite periods are provided. The Proponent must:</p> <p>(a) reschedule any works to provide respite to impacted noise sensitive receivers so that the respite is achieved in accordance with Condition E76; or</p> <p>(b) consider the provision of alternative respite or mitigation to impacted noise sensitive receivers; and</p> <p>(c) provide documentary evidence to the AA in support of any decision made by the Proponent in relation to respite or mitigation.</p>
E79	<p>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.</p>
E80	<p>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.</p>
Construction Noise and Vibration – General	
E79	<p>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.</p>
E80	<p>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.</p>

Table 3.1 Conditions of Approval for construction and vibration

Condition	Key requirement
E81	<p>Mitigation measures must be implemented with the aim of achieving the following construction noise management levels and vibration criteria:</p> <p>(a) construction ‘Noise affected’ noise management levels established using the <i>Interim Construction Noise Guideline</i> (DECC, 2009);</p> <p>(b) vibration criteria established using the <i>Assessing vibration: a technical guideline</i> (DEC, 2006) (for human exposure);</p> <p>(c) Australian Standard AS 2187.2 - 2006 “<i>Explosives - Storage and Use - Use of Explosives</i>”;</p> <p>(d) BS 7385 Part 2-1993 “<i>Evaluation and measurement for vibration in buildings Part 2</i>” as they are “applicable to Australian conditions”; and</p> <p>(e) the vibration limits set out in the <i>German Standard DIN 4150-3: Structural Vibration- effects of vibration on structures</i> (for structural damage).</p> <p>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.</p> <p><i>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.</i></p>
E82	<p>Mitigation measures must be applied when the following residential ground-borne noise levels are exceeded:</p> <p>(a) evening (6:00 pm to 10:00 pm) — internal LAeq(15 minute): 40 dB(A); and</p> <p>(b) night (10:00 pm to 7:00 am) — internal LAeq(15 minute): 35 dB(A).</p> <p>The mitigation measures must be outlined in the Construction Noise and Vibration Management Sub-plan, including in any Out-of-Hours Work Protocol, required by Condition E77.</p>
E83	<p>Owners and occupiers of properties at risk of exceeding the screening criteria for cosmetic damage must be notified before works that generate vibration commences in the vicinity of those properties. If the potential exceedance is to occur more than once or extend over a period of 24 hours, owner and occupiers are to be provided a schedule of potential exceedances on a monthly basis for the duration of the potential exceedances, unless otherwise agreed by the owner and occupier. These properties must be identified and considered in the Construction Noise and Vibration Management Sub-plan.</p>
E84	<p>The Proponent must conduct vibration testing before and during vibration generating activities that have the potential to impact on heritage items to identify minimum working distances to prevent cosmetic damage. In the event that the vibration testing and monitoring shows that the preferred values for vibration are likely to be exceeded, the Proponent must review the construction methodology and, if necessary, implement additional mitigation measures.</p>
E85	<p>The Proponent must seek the advice of a heritage specialist on methods and locations for installing equipment used for vibration, movement and noise monitoring at heritage-listed structures.</p>
Construction Fatigue and Amenity – Mitigation	
E88	<p>At receiver noise mitigation in the form of at-property treatment must be offered to the land owner for habitable living spaces, or other mitigation or management measures as agreed by the occupier, to residential properties identified in Appendix E. Mitigation must be offered prior to works commencing.</p> <p>This requirement does not apply if the sensitive receiver has been provided with noise mitigation under the RMS Noise Abatement Program or the <i>State Environment Planning Policy (Infrastructure) 2007</i> (clause 102(3)). The adequacy of at-property treatments will be reviewed where previous treatments have been installed as part of other SSI or CSSI projects.</p> <p><i>Note: This condition does not preclude the application of other noise and vibration mitigation and management measures.</i></p>

Table 3.1 Conditions of Approval for construction and vibration

Condition	Key requirement
<p>APPENDIX E CONSTRUCTION FATIGUE AND AMENITY - MITIGATION (Condition E88)</p>	
Noise Insulation Program	
E89	<p>A Noise Insulation Program must be prepared and implemented for the duration of CSSI works for receivers at/to which the requirements of Conditions E87 and E88 apply.</p> <p>The Program must be incorporated into the Construction Noise and Vibration Management Sub-plan. The Noise Insulation Program must detail the following matters:</p> <ul style="list-style-type: none"> (a) receivers eligible for the scheme; (b) the scope of the insulation package; (c) responsibility for the noise insulation works; (d) procedure and the terms of the noise insulation works; (e) program monitoring; and (f) program review and amendment. <p>The Noise Insulation Program must be endorsed by the AA.</p>
E90	<p>Receivers which are eligible for receiving treatment under the Noise Insulation Program required under Condition E89 must have treatment implemented within six (6) months following the commencement of construction which would affect the receiver. The implementation of the Noise Insulation Program must be prioritised based on the degree and duration of exceedance with high priority exceedances undertaken within three (3) months of the commencement of construction.</p>

4 Existing environment

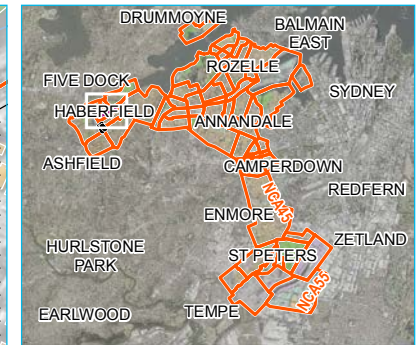
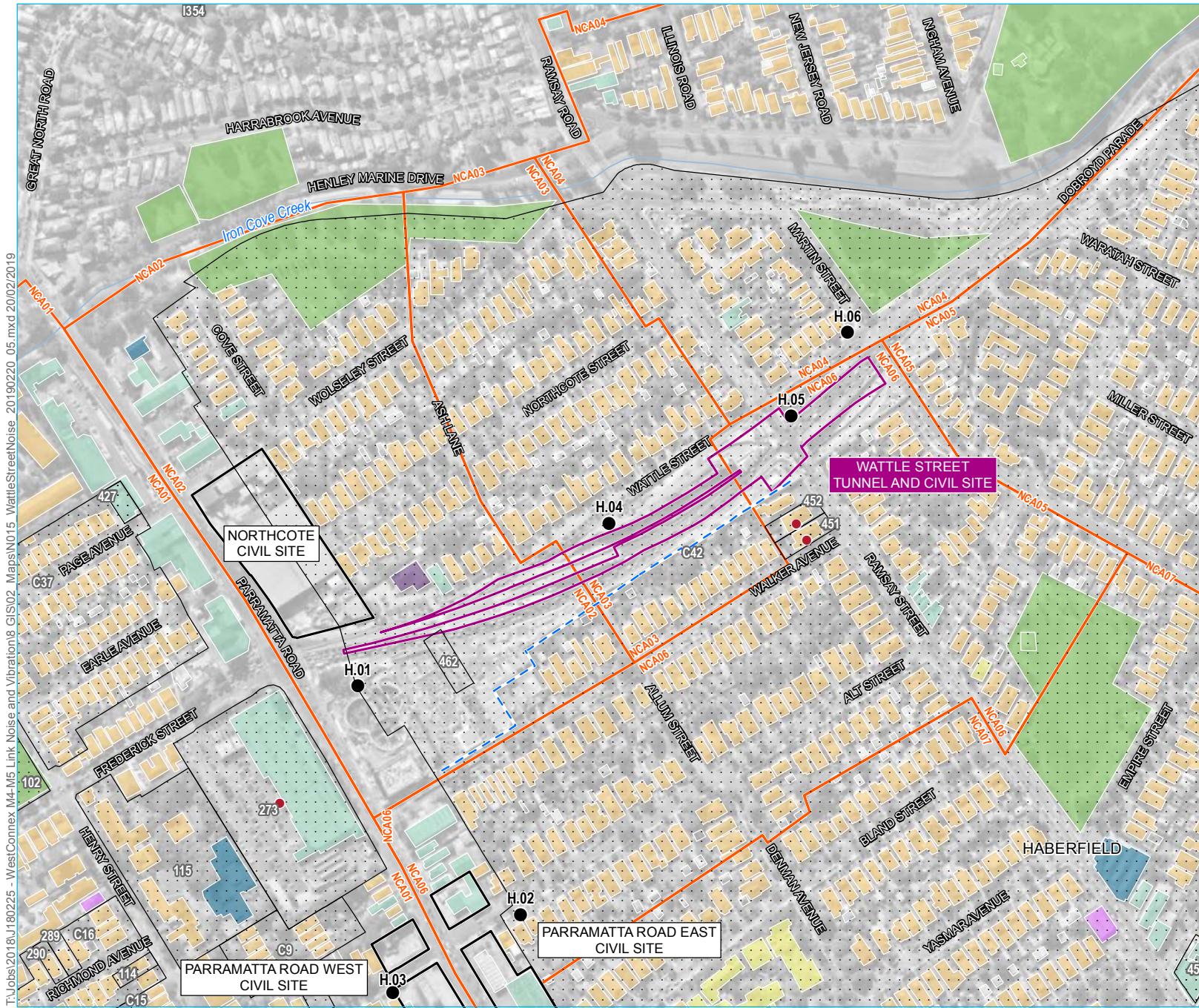
4.1 Noise and vibration sensitive receivers

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 CNVMP. 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 for each site are shown in Figure 4.1.

Heritage items of importance where vibration emission needs to be considered are also shown in Figure 4.1.



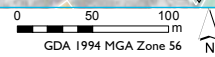
- KEY**
- Noise logger location
 - Heritage item identified in EIS
 - Watercourse / drainage line
 - - - M4 East noise wall (existing)
 - ▭ Noise catchment boundary
 - ▭ Heritage item (local environmental plan)
- Noise receiver
- Commercial
 - Residential
 - Other (childcare)
 - Other (educational)
 - Other (medical)
 - Other (outdoor active)
 - Other (place of worship)

Noise catchment areas, receivers and baseline monitoring locations
 M4-M5 Link Mainline Tunnels
 Construction noise and vibration impact statement, Wattle Street

Figure 4.1

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



4.2 Noise catchment areas

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

Table 4.1 Noise catchment areas relevant to site

NCA	Description
NCA01	South of Parramatta Road between Iron Cove Creek and Bland Street. Land use comprises of a mix of residential receivers, special use facilities, active and passive recreation areas and commercial receivers fronting Parramatta Road
NCA02	North of Parramatta Road between Henley Marine Drive and Walker Avenue. Land use comprises of a mix of residential and commercial receivers, a place of worship and a childcare centre
NCA03	Catchment adjoins either side of Wattle Street between Ash Lane and Ramsay Street. Land use consists of residential receivers
NCA04	Catchment area adjoins Ramsay Street and the western side of Wattle Street. Land use consists of residential receivers, isolated commercial receivers and a passive recreational area
NCA05	South of Dobroyd Parade between Hawthorne Parade and Martin Street. Land use consists of residential receivers with isolated commercial receivers and educational facilities
NCA06	North of Parramatta Road between Walker Avenue and Alt Street residences. Land use consists of residential and commercial receivers and an educational facility on Ramsay Street

Source: M4 East EIS

4.3 Background noise levels

This CNVIS has adopted background noise level data documented in the M4 East EIS which are presented in Table 4.2 for each relevant NCA. Representative baseline monitoring locations are shown in Figure 4.1.

The majority of the NCAs surrounding the project are influenced by road traffic noise levels from major roads. In accordance with prescribed methods in the NSW INP (Section 3.3) and the NSW Road Noise Policy (Section 2.5.5), the background noise logging data for the Project was reviewed in greater detail to identify potential shoulder periods.

This review identified background noise levels in the night period between 10 pm and 12 am and 5 am to 7 am that were elevated in comparison to the total night-time RBL. This is most likely caused by the presence of higher road traffic volumes during these times. The shoulder period analysis is provided and outlined in more detail in the M4-M5 Link Mainline Tunnels Noise and Vibration Management Sub-plan Appendix B2 dated September 2018.

It is proposed to adopt the INP mid-point approach for RBLs and NMLs during the shoulder periods of 5 am to 7 am in order to manage noise according to the noise characteristics of the catchments. For the morning shoulder 5 am to 7 am, this involves taking the mid-point of the night and day RBL.

It is noted that the Interim Construction Noise Guideline (ICNG) relies on methodologies contained within the NSW Industrial Noise Policy for the establishment of RBLs. Hence, this approach is deemed consistent with the guidance provided by the ICNG.

Table 4.2 Rating background levels

NCA	Representative monitoring location	Receiver type	Address	Rating background level (RBL)			
				5-7 am	Day	Evening	Night
NCA01	H.03 ²	Residential	119 Alt St, Ashfield	42	46	46	38
NCA02	H.01 ²	Residential	1A Wattle St, Haberfield ³	55	58	58	52
NCA03	H.04 ²	Residential	35 Wattle St, Haberfield ³	51	58	55	44
NCA04	H.06 ²	Residential	68 Wattle St, Haberfield	50	56	53	43
NCA06	H.02 ²	Residential	141 Alt St, Haberfield	45	46	46	43
NCA06	H.05 ²	Residential	259 Ramsay St, Haberfield ³	52	60	58	44

Notes: 1. ICNG defines daytime period as 7 am to 6 pm Monday to Saturday, 8 am to 6 pm Sunday; Evening as 6 pm to 10 pm; Night as 10 pm to 7 am Monday to Saturday, 10 pm to 8 am Sunday.
 2. Taken from M4 East EIS.
 3. 259 Ramsay Street from M4 East EIS has since been demolished as part of M4 East construction works

5 Construction noise criteria

5.1 Interim Construction Noise Guideline (ICNG)

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 1 pm to 6 pm on Saturdays which deviates slightly from ICNG recommended standard hours.

Table 5.1 ICNG residential noise management levels

Time of day	Management level $L_{Aeq,15\text{ minute}}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 6 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	<p>The noise affected level represents the point above which there may be some community reaction to noise.</p> <ul style="list-style-type: none"> Where the predicted or measured $L_{Aeq,15\text{ minute}}$ 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	<p>The highly noise affected level represents the point above which there may be strong community reaction to noise.</p> <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> – 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	<ul style="list-style-type: none"> A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 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, $L_{Aeq,15 \text{ minute}}$
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 $L_{Aeq (15 \text{ min})}$ 75 dB(A)
- offices, retail outlets: external $L_{Aeq (15 \text{ min})}$ 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 (10 pm to 7 am). Therefore, the assessment of potential sleep disturbance at residences is required in accordance with the INP. Sleep disturbance is defined as both awakenings and disturbance to sleep stages.

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

A detailed maximum noise level event assessment is required if the screening criteria is exceeded. Further guidance with regards 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 awakenings.

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. The highly noise affected NML also applies to all residential receivers during standard hours.

Table 5.3 Project specific NMLs at residential locations

NCA	Representative monitoring location	Standard construction NMLs (RBL + 10 dB) Day ¹	Out of hours NMLs (RBL + 5 dB) 1				Sleep disturbance screening criteria (RBL + 15 dB) ³
			5 am – 6 am	Day ²	Evening	Night	
NCA01	H.03	56	47	51	51	43	53
NCA02	H.01	68	60	63	63	57	67
NCA03	H.04	68	56	63	60	49	59
NCA04	H.06	66	55	61	58	48	58
NCA06	H.02	56	50	51	51	48	58
NCA06	H.05	70	57	65	63	49	59

1. $L_{Aeq, 15minute}$ 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.
2. This applies to daytime and outside of standard ICNG hours.
3. Level applies at the nearest and/or most exposed facade to construction noise levels.

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, $L_{Aeq,15\text{ minute}}$ (apply when premise is in use)
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 (7 am to 10 pm) External noise level 60 dB (10 pm to 7 am)
Hotels ¹	External noise level 65 dB (7 am to 10 pm) External noise level 60 dB (10 pm to 7 am)
Theatre/auditorium ¹	External noise level 45 dB
Recording studio ¹	External noise level 45 dB
Public building ¹	Determined on site specific basis

1. NML based on AS2017 recommend maximum internal noise level and the premise that windows and doors for such development could be open for ventilation purposes, hence providing 10 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). CoA E81 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 (1-80Hz).

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%.

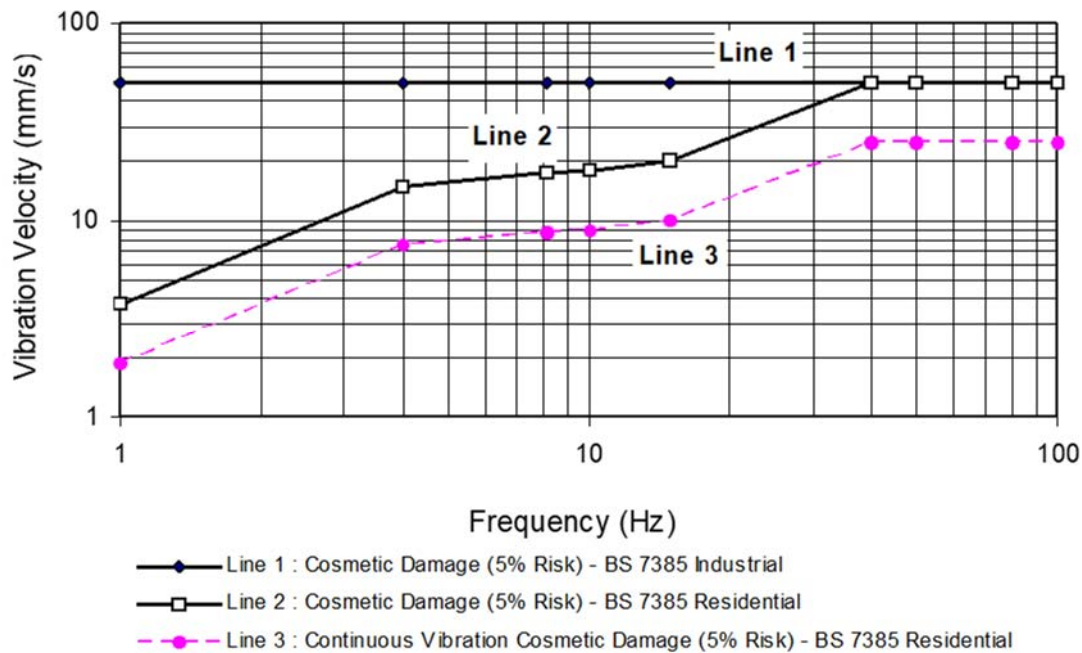


Figure 6.1 Graph of transient vibration guide values for cosmetic damage

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 6.3, 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 6.2.

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 7.5 mm/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 5 mm/s and 20 mm/s respectively. These limits increase with frequency values above 10 Hz. The operational frequency of construction plant typically ranges between 10 Hz to 30 Hz, 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
		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	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 Table 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.

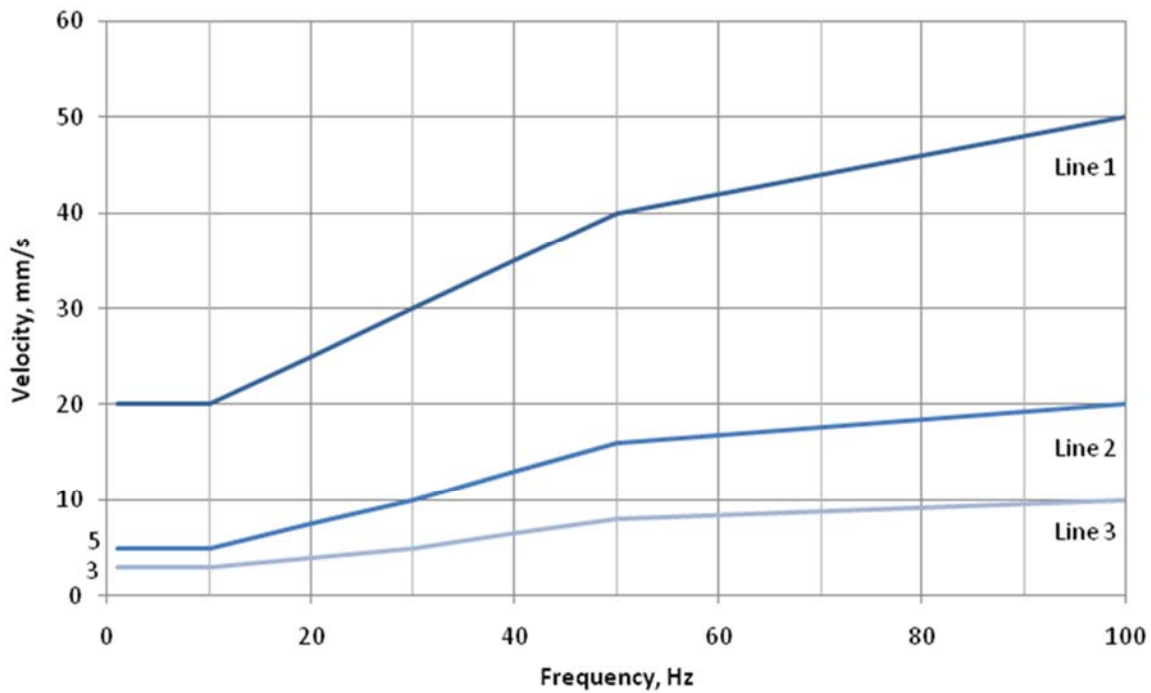


Figure 6.2 DIN4150 structural damage guideline values of vibration velocity

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

Methods and base parameters used to model construction noise emissions from surface excavation and tunnelling support works at the Site are presented in this section.

Potential construction noise levels from the project were predicted using a computer generated model using Brüel & Kjær Predictor software (the model). The model calculates total noise levels at assessment locations from concurrent operation of multiple noise sources. It considers factors that influence noise propagation such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the site and surrounding area, other noise attenuating features such as buildings and barriers and applicable meteorological conditions.

The model was populated with 3-D topography of the project and surrounding area, extending out to nearest assessment locations and buildings. Construction plant and equipment including temporary ventilation systems representing the range of proposed construction scenarios was placed at locations which would represent typical to worst case noise levels throughout the construction program.

7.2 Construction scenarios and sound power levels

Acoustically significant fixed and mobile equipment items considered in the model are provided in Table 7.1 for the civil and tunnelling support site. A detailed list of equipment items per scenario is provided in Appendix A.

Equipment sound power levels have been sourced from the following in order of precedence:

- Transport for NSW 2016, Construction Noise Strategy;
- AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance;
- Department of Environment, Food and Rural Affairs (DEFRA) 2005, Update of Noise Database for Prediction of Noise on Construction and Open Sites;
- Recommendations for the calculation of sound emissions of parking areas, motorcar centres and bus stations as well as of multi-storey car parks and underground car parks 6th Edition (Bavarian Landesamt für Umwelt 2007); and
- EMM in-house measurement databases.

A 5 dB penalty has been added to plant that is considered to be impulsive, intermittent or contain other characteristics relative to overall construction activity noise that may cause greater annoyance as required by the ICNG and the CoA.

Works at the Site have been separated into two scenarios comprising tunnelling support works and surface works which represent the possible worst case noise level snapshots in time. These scenarios are detailed in Table 7.1. The Site was previously construction zone as part of the M4 East project, accordingly a site establishment phase of works is not anticipated. However initial road works, traffic management and provision of utilities including site office and amenities, guard station and vehicle parking is anticipated.

Road headers would be launched from this site to excavate the tunnels that would connect the Wattle Street interchange entry and exit ramps with the M4-M5 Link mainline tunnels.

Tunnelling would commence from the end of the cut and cover structure, approximately 100 m from the Wattle Street ramp portals. Sub-surface concrete supply, ventilation and spoil removal to support the tunnelling activities would occur 24/7.

Surface works for lowering of Wattle Street ramps would commence following completion of significant tunnelling works and would occur within ICNG standard day hours as far as practicable.

Airborne noise associated with the early stages of the tunnelling activities is considered in this CNVIS in conjunction with tunnelling support activities (spoil handling, spoil haulage, ventilation and concrete supply). As tunnelling proceeds further underground, ground borne noise and ground vibration becomes the principle source of potential impacts and addressed in the Tunnelling CNVIS.

Noise mitigation and management measures discussed in Table 7.1 and shown in and Figure 4.1 were incorporated into the noise model to reduce construction noise levels with the aim of satisfying NMLs:

- cuttings as presented in Figure 4.1;
- incorporation of automatic fast acting PVC or equivalent (min. 3 mm thick with installed acoustic performance not less than Rw 15) roller doors to tunnel portals to be closed during night hours and only open briefly to allow passage of concrete trucks. Head infill and side panels to portals between door frame rails and tunnel to be filled to maintain acoustic performance of doors;
- tunnelling activities to commence within cut and cover and no closer than 100 m to tunnel cut and cover portal openings;
- stockpiling of spoil and loading of haulage trucks to occur within cut and cover and no closer than 40m to tunnel portal openings;
- where the above distances cannot be maintained or where plant and equipment utilised is altered, the provision of noise mitigation in the form of brattice walls or fast acting roller doors within tunnels may be required to satisfy NMLs;
- in situ concrete jersey kerbs on edge of existing cut levels, road reserves and retained walls as per M4 East project;
- construction tunnelling ventilation incorporate fans and silencers equivalent to those listed in Appendix B and incorporate additional attenuation measures comprising a minimum of:
 - inlet attenuator comprising Fantech C2-200 3600 mm or equivalent;
 - inlet internally acoustically lined (50 mm) 90 degree elbow between intake and fan;
 - discharge attenuator Fantech C2-200 3600 mm or equivalent prior to bag connection linking to working tunnel face;
 - installed on vibration isolation mounts /hangers providing a minimum isolation efficiency of 95%;
 - connection from silencers to fans shall be by flexible means only;
 - external lagging of fan casing, flexible connection and first 2000mm of silencer (or located in acoustic box) with Pyrotek Soundlag 4525C, Soundlag 4512 or equivalent; and

- consideration of additional noise mitigation measures to surface miners in the form of upgraded engine exhausts, engine enclosures and acoustic air intakes where practical.

Table 7.1 Wattle Street construction scenarios

ID	Description	Proposed Hours of work (ICNG hours)				Activity sound power level, dBA			Physical noise mitigation (refer Figure 4.1)
		Day	Day OOH	Eve OOH	Night OOH	Day Leq	OOH Leq	Night OOH Lmax	
1	underground support activities (road headers, trucks, loader), concrete supply, tunnel ventilation [^] , spoil haulage (3 trucks/15 min)	Yes	Yes	Yes	No	113	113	n/a	Existing retained walls at eastbound and westbound portals respectively, loading located within cut and cover, noise controls to fans as documented in Section 7 and 10 and Figure 1.2.
2	underground support activities (road headers, trucks, loader), concrete supply, tunnel ventilation [^] , spoil haulage (2.5 trucks/15 min)	No	No	Yes	Yes	113	112	108	Existing retained walls at eastbound and westbound portals respectively, loading located within cut and cover, acrylic roller doors to tunnel portals to be closed during all night OOH operations, noise controls to fans as documented in Section 7 and 10 and Figure 1.2.
3	Lowering of ramps to tunnel portals (surface miner / profiler), spoil haulage Lowering of ramps to tunnel portals (surface miner / profiler), spoil haulage	Yes	Yes	No	No	121	n/a	n/a	In situ concrete jersey kerbs on edge of existing cut levels, road reserves and retained walls as per M4 East project.

Notes: OOH - Out-of-hours

Day - 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 6:00 pm Saturday

Day OOH - Day out of hours Sunday and Public holidays 8:00 am to 6:00 pm

Eve - Evening 6:00 pm to 10:00 pm Monday to Sunday Night - Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays

Leq - Leq,15minutes

5 dB penalty factor added for activities that may cause greater annoyance such as hammering, percussive drilling, piling and crushing

Lw of 95 dB(A) for each portal entry (open door) 87 dB(A) (door closed)

[^] details of tunnel ventilation equipment was provided by LSBJV and presented in Appendix B—Ventilation equipment would consist of 2 x 350 kW fans that would remain in a static location at the portal entries

7.3 Results

7.3.1 Residential

i Construction activities $L_{Aeq,15min}$

Predicted noise levels from construction activities are provided in Appendix C and Appendix D for the Wattle Street tunnelling support and ramp lowering activities. Predictions have been split into four categories to represent the number of receivers which exceed NMLs by:

- 1 to 5 dB;
- 5 to 15 dB;
- 15 to 25 dB
- greater than 25 dB; and
- Highly noise affected (ie >75 dB during the daytime).

A summary of predicted noise levels which exceed NMLs due to the proposed Wattle Street site activities are provided in Table 7.2 for standard hours and out of hours periods.

- Scenario 1 – no exceedances of the NMLs were predicted;
- Scenario 2 –
 - six exceedances above NML at night, comprising:
 - two of 1 dB to 5 dB above NML; and
 - four of 5 dB to 15 dB above NML.
 - up to nine exceedances are identified for sleep disturbance criteria, comprising:
 - two of 1 dB to 5 dB; and
 - seven of 5 dB to 15 dB.
- Scenario 3 – during ramp lowering activities (standard hours only) a total of 35 exceedances above NML were predicted, comprising:
 - 30 of 1 dB to 5 dB
 - 5 of 5 dB to 15 dB.

Pavement and infrastructure works including envisaged ramp activities are reported in the EIS with more than 200 predicted exceedances. By comparison this CNVIS provides a significant improvement predicting 35 exceedances. With respect to sleep disturbance the EIS predicted eight exceedances consistent with the outcomes of this CNVIS. The EIS did not predict exceedances during evening and night OOH tunnel support activities whilst the CNVIS has predicted between six to nine exceedances.

It appears that the predictions presented in the EIS may have underestimated truck movements or did not consider truck movements on the ramps which accounts for the variation in outcomes.

Tunnelling support works would be undertaken 24/7 (Scenarios 1 and 2). Predicted noise levels from Scenario 2 activities are above the noise affected NMLs at a number of residential locations notwithstanding the incorporation of noise mitigation measures outlined in Section 7.2. The result of the mitigation has reduced exceedances into the 1 to 5 dB exceedance category for two assessment locations. Whilst a further four assessment locations are predicted to have exceedances in the 5 to 15 dB category (6 to 7 dB above NML). Further mitigation was not feasible as noise exceedances were from truck movements on the ramps to the tunnel portals.

Construction noise levels are greatest during early stages of Scenario 3 when plant and equipment will be operating at heights close to the existing road level. The highest noise levels are at properties that directly front Wattle Street where there is little opportunity to provide acoustic screening. Noise levels progressively decrease as plant and equipment descend into the ramp and are located more remotely from cut and cover portals. As a result, the number of receivers with construction noise levels above NMLs would reduce significantly.

Mitigation and management measures to improve this environmental outcome are presented in Section 9.1. Furthermore, the affected receivers are eligible for noise mitigation measures under Condition E88 of the Approval as discussed in Section 9.

ii Sleep disturbance L_{Amax}

Construction noise levels above the sleep disturbance screening criterion are also predicted during the night from proposed truck movements under Scenarios 1 and 2. Two assessment locations are predicted to exceed the sleep disturbance screening criterion by 1 to 5 dB and seven locations by 5 to 15 dB. Notwithstanding the predicted exceedances, the levels are lower than the existing measured night time L_{Amax} noise level range of 77 dB(A) to 99 dB(A) with an average of 84 dB(A) recorded at NCA03 for the representative receiver locations.

A review of the existing baseline noise monitoring data for H.04 (NCA 03) confirms that 100% of existing night-time $L_{Amax,15min}$ noise levels exceed the sleep disturbance screening criteria and a lowest recorded $L_{Amax,15min}$ level of 77 dB(A).

Table 7.2 Wattle Street assessment of noise predictions – residential

Scenario	Assessment category	Predicted number of noise affected receivers above NML				
		Day noise affected NML (RBL + 10 dB)	Day highly noise affected NML (75 dB)	Evening noise affected NML (RBL + 5 dB)	Night noise affected NML (RBL + 5 dB)	Night sleep disturbance screen criteria (RBL + 15 dB)
1 Underground support	Total exceedances	0	0	0	0	0
	1-5 dB	0	-	-	-	-
	5-15 dB	0	-	-	-	-
	15-25 dB	0	-	-	-	-
	>25 dB	0	-	-	-	-
2 Underground support	Total exceedances	0	0	0	6	9
	1-5 dB	0	-	-	2	2
	5-15 dB	0	-	-	4	7
	15-25 dB	0	-	-	-	-
	>25 dB	0	-	-	-	-
3 Ramp lowering activities	Total exceedances	35	0	n/a	n/a	n/a
	1-5 dB	30	-	-	-	-
	5-15 dB	5	-	-	-	-
	15-25 dB	0	-	-	-	-
	>25 dB	0	-	-	-	-

Notes: 1. ICNG defines daytime period as 7 am to 6 pm Monday to Saturday, 8 am to 6 pm Sunday; Evening as 6 pm to 10 pm; Night as 10 pm to 7 am Monday to Saturday, 10 pm to 8 am Sunday.

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 Non-residential

A summary of predicted noise levels which exceed noise affected NMLs during standard hours are provided in Table 7.3.

Construction noise levels above noise affected NMLs are predicted at a place of worship. The exceedance is predicted to occur during early phases of Scenario 3. The duration of exposure for the place of worship is expected to be less than two months and unlikely to coincide with normal church usage on Sundays. As the Wattle Street ramp excavation proceeds to the north and descends, and as ramp lowering activities are located more remotely from cut and cover portals, construction noise levels are expected to satisfy the NMLs.

The EIS predicted four locations that would exceed the NMLs, this assessment has demonstrated that noise levels can be controlled to limit exceedances to one location.

Construction noise levels are predicted to satisfy NMLs at all non-residential receivers during OOH periods.

Mitigation and management measures accounted for in predictions shown in Section 7.2 have improved this environmental outcome.

Table 7.3 Wattle Street assessment of noise predictions - non-residential

Scenario	Assessment category	Predicted number of receivers above NML				
		Day noise affected NML (RBL + 10 dB)	Day highly noise affected NML (75 dB)	Evening noise affected NML (RBL + 5 dB)	Night noise affected NML (RBL + 5 dB)	Night sleep disturbance screen criteria (RBL + 15 dB)
1 Underground support	Total exceedances	0	0	n/a	n/a	n/a
	1-5 dB	0	-	-	-	-
	5-15 dB	0	-	-	-	-
	15-25 dB	0	-	-	-	-
	>25 dB	0	-	-	-	-
2 Underground support	Total exceedances	0	0	0	0	n/a
	1-5 dB	0	-	-	-	-
	5-15 dB	0	-	-	-	-
	15-25 dB	0	-	-	-	-
	>25 dB	0	-	-	-	-
3 Ramp lowering activities	Total exceedances	1	0	n/a	n/a	n/a
	1-5 dB	0	-	-	-	-
	5-15 dB	1	-	-	-	-
	15-25 dB	0	-	-	-	-
	>25 dB	0	-	-	-	-

Notes: 1. ICNG defines daytime period as 7 am to 6 pm Monday to Saturday, 8 am to 6 pm Sunday; Evening as 6 pm to 10 pm; Night as 10 pm to 7 am Monday to Saturday, 10 pm to 8 am Sunday.

7.3.3 Cumulative noise

A review of WestConnex M4 East Construction Noise and Vibration Management Plan (M4 East CNVMP) confirms finishing works for the M4 East are forecast to be completed by Quarter 1 2019 (Section 5.1 of the M4 East CNVMP). The Project works are forecast to commence in Quarter 2 2019, accordingly there is no overlap and cumulative noise has not been considered further.

There is potential for additional noise exposure for a number of residences fronting Wattle Street from the M4-M5LinkNorthcote Civil and Tunnelling site.

The assessment and design of work for the Northcote site is currently under review. Noise contributions are expected to be in accordance with and align with the outcomes of WestConnex M4 East Construction Noise and Vibration Impact Statement: Northcote Tunnel Support Site prepared by Renzo Tonin & Associates dated 29 June 2016 (Appendix D) confirming predicted levels of <39 dB(A) at the closest residential assessment locations on Wattle Street (16-24 Wattle Street inclusive). These M4 East levels are more than 10 dB below the levels predicted for Wattle Street civil and tunnel support activities (M4-M5 Link) and therefore would not contribute to the overall noise level (a noise source 10 dB lower than another does not influence the total noise).

The next closest site associated with the M4-M5 Link Mainline Tunnels is the Parramatta Road East and West (PREW) which is located more than 250 m from the Wattle Street site and would not contribute to cumulative noise levels for the Wattle Street receivers.

8 Construction vibration assessment

8.1 Safe working distances and assessment methodology

Table 8.1 provides an indication of potential offset distances required from sensitive receivers in order to comply with relevant vibration criteria. This information should be used by relevant personnel when planning their work to identify when other forms of construction methodology or vibration mitigation and/or management measures may need to be investigated or implemented. This data is based on information provided in the noise and vibration assessment prepared for the EIS as well as publicly available data for other large infrastructure projects in Sydney.

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

Table 8.1 Vibration levels and safe working distance guidance – transient vibration

Source	Estimated safe working distance			
	Human comfort	Commercial, Industrial or similar structures	Dwellings and similar structures	Heritage and other sensitive structures
Large Vibratory Roller (20t)	100 m	5 m	33 m	50 m
Medium Vibratory Roller (10t)	100 m	5 m	20 m	31 m
Compactor (7t)	50 m	5 m	20 m	20 m
Hand operated whacka packer on backfill	10 m	5 m	5 m	5 m
Hand operated whacka packer on asphalt	10 m	5 m	5 m	5 m
Heavy Hydraulic Hammer (1500kg hammer on 30t excavator)	73 m	5 m	22 m	44 m
Medium Hydraulic Hammer (900kg hammer on 18t excavator)	23 m	5 m	10 m	15 m
Light Hydraulic Hammer (300kg on 5t excavator)	10 m	5 m	5 m	5 m
Jack Hammer	Avoid contact with structure	5 m	5 m	5 m
Air Track Drill	20 m	5 m	5 m	10 m
Small rock drill (estimate)	10 m	5 m	5 m	5 m
Down the Hole Hammer	10 m	5 m	5 m	5 m
Ripping (measured in Sydney sandstone)	10 m	5 m	5 m	5 m
Impact Piling	30 m	5 m	10 m	20 m
Vibratory Piling	30 m	5 m	26 m	100 m
Rock Sawing	10 m	5 m	5 m	5 m
Bored Piling	N/A	5 m	10 m	10 m

Notes: 1. Based on information provided in the NorthConnex Construction Noise and Vibration Management Sub Plan prepared by Lend Lease Bouygues Joint Venture dated 1 May 2017.

Information regarding equipment likely to be used and their proposed locations at Wattle Street has been provided by LSBJV. This information has been utilised to determine where, if at all, the safe working distances are likely to be encroached and, if so, likely areas of impact.

Construction scenarios considered are consistent with those presented for the noise assessment. Proposed works with greatest potential to cause vibration impact at nearby vibration-sensitive receptors include the use of vibratory roller and excavation including the use of rock hammers during Scenario 3 ramp lowering activities.

The number of receptors where vibration could potentially exceed relevant criteria include from a 12-18 t excavator with 900 kg hammer and a 10 t vibratory roller as summarised in Table 8.2. Vibration levels from surface miners are significantly lower in magnitude and therefore are not considered further.

Table 8.2 Potential vibration impacts

Location / Construction scenario	Task	Number of receptors with potential to exceed vibration criteria ¹			
		Human comfort (residences)	Dwellings, garages	Commercial, industrial or similar	Heritage and other sensitive structures
1	Medium hydraulic hammer ¹	0	0	0	0
	Vibratory roller (10t)	53	0	0	0

Notes: Number of potentially affected receptors have been calculated based on the most conservative safe distances provided in Table 8.1
 1. 900 kg hammer on 12-18 t excavator.

Vibration Screening Drawings have been prepared for LSBJV to assist in managing vibration during the construction activities which are provided in the CNVMP sub-plan and have been included in Appendix F of this report.

Vibration mitigation and management measures are detailed in Section 9.2.

Potential vibration from tunnelling activities for the project were assessed in detail and presented in the M4-M5 Mainline Tunnels Tunnelling CNVIS.

9 Noise and vibration mitigation and management

9.1 Noise

9.1.1 General

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

Noise levels above NMLs have been predicted for OOH works at night and the early stages of the surface works with the incorporation of noise mitigation measures. Under the CoA the Project can conduct tunnelling activities 24/7 and do not require an Out of Hours Work Permit (OOHWP), accordingly noise exceedances (if any) are minimised with the application of all feasible and reasonable measures. Surface works associated with ramp lowering activities would be conducted during standard daytime construction hours in order to minimise noise impacts. 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.

Site specific feasible and reasonable noise mitigation and management were incorporated into the noise model (Section 7) for the site to reduce construction noise levels with the aim of satisfying NMLs:

Under Condition E88 of the Approval, at receiver noise mitigation in the form of property treatment 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 Approval and shown in Figure 3.1. The receivers identified within this CNVIS that exceed the NML's are located within the area that noise mitigation is to be offered. Although the implementation of at receiver mitigation is principally an outcome of the approval conditions, the receivers identified within this CNVIS that exceed the NMLs are all indicated to receive at-receiver treatments which will assist in mitigating noise from the Site and results in internal noise levels that would satisfy an 'equivalent internal' NML criteria (NML -10 dB).

Other mitigation and management measures that can be implemented on site are provided in the following sections.

9.1.2 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).

9.1.3 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;
- 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.

9.1.4 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 5 dB 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

9.1.5 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.

Table 9.2 CNVG additional noise mitigation measures

ID	Name	Description
		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 6:00 pm to 10:00 pm, Saturday 7:00 am to 8:00 am and 1:00 pm – 10:00 pm, Sunday/Public Holiday 8:00 am to 6:00 pm) 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.
R2	Respite period 2	Night time construction in OOHW period 2 (Monday to Friday 10:00 pm to 7:00 am, Saturday 10:00 pm to 8:00 am, Sunday/Public Holiday 6:00 pm to 7:00 am) 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 11 pm.
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 (7 am – 6 pm), Sat (8 am – 1 pm), 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 (6 pm – 10 pm), Sat (7 am – 8 am & 1 pm – 10 pm), Sun/Pub Hol (8 am – 6 pm)				
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 (10 pm – 7 am), Sat (10 pm – 8 am), Sun/Pub Hol (6 pm – 7 am)				
Noticeable	5 to 10	<5	N	NML
Clearly audible	10 to 20	5 to 15	V, N, R2, DR	NML + 5
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).

Additional noise mitigation measures for Wattle Street based on Table 9.3 are presented in Appendix G.

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

9.2 Vibration

The primary form of mitigation of vibration would be ensuring vibration intensive works do not occur within the safe working distances described Table 8.1. Further mitigation of vibration would not be required where the safe working distances are adhered to.

If vibration intensive works are planned within the safe working distances identified, alternative equipment would be identified where possible and vibration monitoring would be implemented.

In some circumstances, construction activity within the safe working distance will not be avoidable due to the work required and the prevalent geological site conditions.

For vibration intensive activities that occur within the safe working distances the following management methods will be adopted:

- Equipment selection and maintenance

Equipment size would be selected taking into account the safe working distances and the distance between the area of construction and the most affected sensitive receiver.

The use of less vibration intensive methods of construction or equipment would be considered where feasible and reasonable when working in proximity to existing structures. Equipment would be maintained and operated in an efficient manner, in accordance with manufacturer's specifications, to reduce the potential for adverse vibration impacts.

- Construction scheduling

Wherever feasible and reasonable, vibration intensive works should be limited to the least sensitive times of the day. These times would be determined based on the outcomes of consultation with relevant sensitive receivers.

- Condition surveys

Where vibration-intensive construction activity is unavoidable within the relevant safe working distance for cosmetic damage, condition surveys would be undertaken for all potentially affected buildings or structures prior to the commencement of the construction activity.

- Supplementary vibration monitoring

If the use of vibration intensive plant cannot be avoided within the safe working distance for cosmetic damage the following procedure would occur as a minimum:

- Notification of the works to the affected residents and community.
- Works would not proceed until operator-attended vibration measurements are undertaken to determine the risk of damage.

If ongoing works are required, a temporary relocatable vibration monitoring system would be installed, to warn operators (via flashing light, audible alarm, short message service (SMS) etc.) when vibration levels are approaching the cosmetic damage objective.

9.3 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

EMM has prepared a CNVIS for works proposed at the Site for the M4-M5 Mainline Link Tunnels Project. Activities at the Site are principally associated with tunnelling support to occur 24/7 at the extent of the cut and cover, and lowering of Wattle Street ramps during standard construction hours only.

The potential noise levels from the Site were assessed in accordance with relevant policies, standards, guidelines and the instrument of approval conditions.

The CNVIS has considered the $L_{Aeq,15min}$ and L_{Amax} potential noise impacts from proposed activities at the Site. Noise levels have been predicted to exceed the NMLs at a number of residential and non-residential receivers for standard and Out of Hours (OOH) periods. Condition E88 of the Approval 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 and shown in Table 3.1. Although the implementation of at receiver mitigation is principally an outcome of the approval conditions, the 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.

The assessment has also indicated potential for exceedance of sleep disturbance 'screening criterion' at night. However the predicted levels are less than the existing L_{Amax} noise levels that the residential receivers are exposed to from traffic on Wattle Street and typically less than the equivalent external facade level of 60-65 dB(A) as referenced in the NSW, Road Noise Policy (RNP). The receivers identified within this CNVIS that exceed the sleep disturbance screening criterion are all entitled to receive at-receiver treatments according to the Project Approval, which will mitigate this potential impact.

The construction scenarios presented in this report are considered representative of typical or worst case. The CNVIS provides methods on how noise can be managed and mitigated in Section 9.

The potential for cumulative noise impacts from the project with other components of the WestConnex project (ie M4 East) have been considered. However a review of the Site project timeframes confirms that cumulative noise is unlikely to occur. The next closest site associated with the M4-M5 Link Mainline Tunnels is the Parramatta Road East and West (PREW) which is located more than 250 m from the Wattle Street site and would not contribute to cumulative noise levels for the Wattle Street receivers.

Detailed assessment of ground vibration from excavation and tunnelling activities was addressed in the M4-M5 Mainline Link Tunnels Tunnelling CNVIS.

Appendix A

Plant and equipment modelling assumptions - Wattle Street

ID	Description	Equipment	Quantity	Periods				Equipment Sound Power Levels, dB						
				Day	Day	Evening	Night	Item LAeq, 15min	Typical runtime per 15min	Modifying factor	Item LAeq, 15min - adjusted	Group LAeq, 15min - Day	Group LAeq, 15min - Evening	Group Lmax - Night
1	Tunnel Support activities (commencing approximately 100m within cut and cover structure) DAY	Roadheader	2		Yes	Yes	Yes	108	100%		102	112	113	108
		Articulated Dump trucks (in tunnel)	4		Yes	Yes	Yes	109	33%		110			
		Ventilation Plant (350kw fans)	2		Yes	Yes	Yes	-	100%		99			
		Heavy vehicle (spoil trucks)	3		Yes	Yes	Yes	106	5%		98			
		Concrete trucks	1		Yes	Yes	Yes	106	5%		93			
		Compressor	1		Yes	Yes	Yes	102	100%		102			
		FEL CAT 966 or 980	1		Yes	Yes	Yes	106	33%		101			
2	Tunnel support activities (commencing approximately 100m within cut and cover structure) EVENING/NIGHT	Roadheader	2		Yes	Yes	Yes	108	100%		102	112	112	108
		Articulated Dump trucks (in tunnel)	4		Yes	Yes	Yes	109	33%		110			
		Ventilation Plant (350kw fans)	2		Yes	Yes	Yes	-	100%		99			
		Heavy vehicle (spoil trucks)	2.5		Yes	Yes	Yes	106	5%		97			
		Concrete trucks	1		Yes	Yes	Yes	106	5%		93			
		Compressor	1		Yes	Yes	Yes	102	100%		102			
		FEL CAT 966 or 980	1		Yes	Yes	Yes	106	33%		101			
3	Lowering of ramps	30t Excavator w/ rock hammer	2	Yes				108	100%	5	116	121	n/a	n/a
		Vibratory roller (limited use, only up to Allu	1	Yes				109	50%		106			
		Surface miner/profiler	1	Yes				118	100%		118			
		Watercart	1	Yes				98	100%		98			
		Heavy vehicle	2	Yes				105	100%		108			
		18t Franna crane	1	Yes				104	100%		104			
		Hand tools	1	Yes				94	100%		94			
		Shotcrete pump	2	Yes				106	100%		109			
		Concrete trucks	2	Yes				106	13%		100			
		Impact drill	1	Yes				104	100%		104			

Notes:

Day Day 7:00 am to 6:00 pm Monday to Friday, 8:00 am to 6:00 pm Saturday

Day

OOH Day out of hours Sunday and Public holidays 8:00 am to 6:00 pm

Evening Evening 6:00 pm to 10:00 pm Monday to Sunday

Night Night 10:00 pm to 7:00 am Monday to Friday and 10:00 pm to 8:00 am Saturday, Sunday and Public holidays

Appendix B

Construction tunnel ventilation – Zitron ZVN 1-20-355/4 (x2)



Axial Fan Noise Levels Rev.02

Customer: CPB - SAMSUNG - JOHN H JV
 Project: WestConnex Stg 1B - Temp. Vent.
 Our Ref.: D-14-0500
 Date: 23/12/2016

Tubular Silencer - ZVN 1-1600

Outlet diameter	1,900	mm								
Inner diameter	1,600	mm	<i>1600 mm diam - Tubular silencer octave band insertion loss</i>							
Length	2,400	mm	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Acoustic Pod	NO	-	6.1	8.4	13.8	18.3	16.8	13.8	8.4	6.1

Tubular Silencer - ZVN 1-1800

Outlet diameter	2,100	mm								
Inner diameter	1,800	mm	<i>1800 mm diam - Tubular silencer octave band insertion loss</i>							
Length	2,400	mm	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Acoustic Pod	NO	-	5.5	7.6	12.4	16.5	15.1	12.4	7.6	5.5

Tubular Silencer - ZVN 1-2000

Outlet diameter	2,300	mm								
Inner diameter	2,000	mm	<i>1800 mm diam - Tubular silencer octave band insertion loss</i>							
Length	2,400	mm	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Acoustic Pod	NO	-	5.0	6.8	11.1	14.9	13.6	9.9	6.8	5.0

Sound Power without Silencers

Fan Model	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB	dB(A)
ZVN 1600 mm										
ZVN 1-16-75/4	97.3	112.2	115.6	111.6	107.3	102.7	103.0	99.9	118.9	113.7
ZVN 1-16-90/4	98.3	113.2	116.6	112.6	108.3	103.7	104.0	100.9	119.9	114.7
ZVN 1-16-110/4	99.3	114.2	117.6	113.6	109.3	104.7	105.0	101.9	120.9	115.7
ZVN 1-16-132/4	100.6	115.5	118.9	114.9	110.6	106.0	106.3	103.2	122.2	117.0
ZVN 1-16-160/4	101.7	116.6	120.0	116.0	111.7	107.1	107.4	104.3	123.4	118.1
ZVN 1-16-180/4	102.5	117.4	120.8	116.8	112.5	107.9	108.2	105.1	124.1	118.9
ZVN 1-16-200/4	103.1	118.0	121.4	117.4	113.1	108.5	108.8	105.7	124.8	119.5
ZVN 1-16-220/4	103.8	118.7	122.1	118.1	113.8	109.2	109.5	106.4	125.4	120.2
ZVN 1800 mm										
ZVN 1-18-180/4	103.1	118.0	121.4	117.4	113.1	108.5	108.8	105.7	124.7	119.5
ZVN 1-18-200/4	103.8	118.7	122.1	118.1	113.8	109.2	109.5	106.4	125.4	120.2
ZVN 1-18-220/4	104.5	119.4	122.8	118.8	114.5	109.9	110.2	107.1	126.1	120.9
ZVN 1-18-250/4	105.2	120.1	123.5	119.5	115.2	110.6	110.9	107.8	126.8	121.6
ZVN 1-18-280/4	105.7	120.6	124.0	120.0	115.7	111.1	111.4	108.3	127.4	122.1
ZVN 1-18-315/4	106.3	121.2	124.6	120.6	116.3	111.7	112.0	108.9	127.9	122.7
ZVN 1-18-355/4	107.1	122.0	125.4	121.4	117.1	112.5	112.8	109.7	128.7	123.5
ZVN 2000 mm										
ZVN 1-20-250/4	106.5	121.4	124.8	120.8	116.5	111.9	112.2	109.1	128.1	122.9
ZVN 1-20-280/4	109.5	124.4	127.8	123.8	119.5	114.9	115.2	112.1	131.2	125.9
ZVN 1-20-355/4	111.4	126.3	129.7	125.7	121.4	116.8	117.1	114.0	133.0	127.8

Sound Power with Tubular Silencers (2.4 m long)

Fan Model	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	dB	dB(A)
ZVN 1600 mm										
ZVN 1-16-75/4	91.2	103.8	101.8	93.2	90.5	88.9	94.6	93.8	106.9	100.5
ZVN 1-16-90/4	92.2	104.8	102.9	94.3	91.5	90.0	95.6	94.8	108.0	101.6
ZVN 1-16-110/4	93.1	105.8	103.8	95.2	92.4	90.9	96.6	95.7	108.9	102.5
ZVN 1-16-132/4	94.5	107.1	105.1	96.5	93.8	92.2	97.9	97.1	110.3	103.8
ZVN 1-16-160/4	95.6	108.2	106.3	97.7	94.9	93.4	99.0	98.2	111.4	105.0
ZVN 1-16-180/4	96.4	109.0	107.0	98.4	95.7	94.1	99.8	99.0	112.1	105.7
ZVN 1-16-200/4	97.0	109.6	107.7	99.1	96.3	94.8	100.4	99.6	112.8	106.4
ZVN 1-16-220/4	97.7	110.3	108.3	99.8	97.0	95.4	101.1	100.3	113.5	107.1
ZVN 1800 mm										
ZVN 1-18-180/4	97.6	110.4	109.0	100.9	98.0	96.1	101.2	100.2	113.8	107.5
ZVN 1-18-200/4	98.3	111.2	109.7	101.6	98.7	96.8	102.0	100.9	114.6	108.2
ZVN 1-18-220/4	99.0	111.8	110.4	102.3	99.4	97.5	102.6	101.6	115.2	108.9
ZVN 1-18-250/4	99.7	112.5	111.1	103.0	100.0	98.2	103.3	102.3	115.9	109.6
ZVN 1-18-280/4	100.2	113.1	111.7	103.5	100.6	98.8	103.9	102.8	116.5	110.1
ZVN 1-18-315/4	100.8	113.6	112.2	104.1	101.2	99.3	104.4	103.4	117.0	110.7
ZVN 1-18-355/4	101.6	114.4	113.0	104.9	102.0	100.1	105.2	104.2	117.8	111.5
ZVN 2000 mm										
ZVN 1-20-250/4	101.5	114.6	113.6	105.9	102.9	102.0	105.4	104.1	118.2	112.1
ZVN 1-20-280/4	104.6	117.6	116.7	109.0	105.9	105.0	108.4	107.2	121.3	115.1
ZVN 1-20-355/4	106.4	119.5	118.5	110.8	107.8	106.9	110.3	109.0	123.1	117.0

Appendix C

Scenario 1 and 2 predicted noise levels

$L_{Aeq, 15min}$ - tunnelling support

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
7 Walker Avenue	Residential	6	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	48	n/a	38	yes
40 Wattle Street	Residential	3	Day*	68	49	n/a	yes
			Day OOH	63	49	n/a	yes
			Eve OOH	60	n/a	46	yes
			Night OOH	49	n/a	46	yes
41 Walker Avenue	Residential	6	Day*	56	46	n/a	yes
			Day OOH	51	46	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes
152 Alt Street	Residential	6	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	48	n/a	38	yes
35 Walker Avenue	Residential	6	Day*	56	47	n/a	yes
			Day OOH	51	47	n/a	yes
			Eve OOH	51	n/a	43	yes
			Night OOH	48	n/a	43	yes
1 Walker Avenue	Residential	6	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	37	yes
			Night OOH	48	n/a	37	yes
3 Walker Avenue	Residential	6	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	37	yes
			Night OOH	48	n/a	37	yes
5a Walker Avenue	Residential	6	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	37	yes
			Night OOH	48	n/a	37	yes
27 Walker Avenue	Residential	6	Day*	56	45	n/a	yes
			Day OOH	51	45	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
11 Walker Avenue	Residential	6	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	48	n/a	38	yes
24 Wattle Street	Residential	3 [#]	Day*	68	54	n/a	yes
			Day OOH	63	54	n/a	yes
			Eve OOH	60	n/a	53	yes
			Night OOH	49	n/a	53	no
5 Walker Avenue	Residential	6	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	48	n/a	38	yes
7a Walker Avenue	Residential	6	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	48	n/a	38	yes
154 Frederick Street	Residential	1	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	43	n/a	38	yes
38 Wattle Street	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	46	yes
			Night OOH	49	n/a	46	yes
9 Walker Avenue	Residential	6	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	48	n/a	38	yes
22 Earle Avenue	Residential	1	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	43	n/a	38	yes
38 Walker Avenue	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	45	yes
			Night OOH	49	n/a	45	yes

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
24 Earle Avenue	Residential	1	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	43	n/a	38	yes
54 Wattle Street	Residential	3	Day*	68	52	n/a	yes
			Day OOH	63	52	n/a	yes
			Eve OOH	60	n/a	47	yes
			Night OOH	49	n/a	47	yes
39 Walker Avenue	Residential	6	Day*	56	46	n/a	yes
			Day OOH	51	46	n/a	yes
			Eve OOH	51	n/a	43	yes
			Night OOH	48	n/a	43	yes
31 Walker Avenue	Residential	6	Day*	56	47	n/a	yes
			Day OOH	51	47	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes
251 Ramsay Street	Residential	6	Day*	56	42	n/a	yes
			Day OOH	51	42	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes
168 Alt Street	Residential	6	Day*	56	42	n/a	yes
			Day OOH	51	42	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes
174 Alt Street	Residential	6	Day*	56	44	n/a	yes
			Day OOH	51	44	n/a	yes
			Eve OOH	51	n/a	40	yes
			Night OOH	48	n/a	40	yes
29 Walker Avenue	Residential	6	Day*	56	46	n/a	yes
			Day OOH	51	46	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes
28 Walker Avenue	Residential	3	Day*	68	46	n/a	yes
			Day OOH	63	46	n/a	yes
			Eve OOH	60	n/a	44	yes
			Night OOH	49	n/a	44	yes

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
13 Earle Avenue	Residential	1	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	43	n/a	38	yes
156 Frederick Street	Residential	1	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	37	yes
			Night OOH	43	n/a	37	yes
26 Walker Avenue	Residential	3	Day*	68	46	n/a	yes
			Day OOH	63	46	n/a	yes
			Eve OOH	60	n/a	43	yes
			Night OOH	49	n/a	43	yes
11 Earle Avenue	Residential	1	Day*	56	40	n/a	yes
			Day OOH	51	40	n/a	yes
			Eve OOH	51	n/a	38	yes
			Night OOH	43	n/a	38	yes
34 Wattle Street	Residential	3	Day*	68	51	n/a	yes
			Day OOH	63	51	n/a	yes
			Eve OOH	60	n/a	48	yes
			Night OOH	49	n/a	48	yes
22 Wattle Street^	Residential	3 [#]	Day*	68	56	n/a	yes
			Day OOH	63	56	n/a	yes
			Eve OOH	60	n/a	55	yes
			Night OOH	49	n/a	55	no
170 Alt Street	Residential	6	Day*	56	44	n/a	yes
			Day OOH	51	44	n/a	yes
			Eve OOH	51	n/a	40	yes
			Night OOH	48	n/a	40	yes
16 Wattle Street	Residential	3 [#]	Day*	68	56	n/a	yes
			Day OOH	63	56	n/a	yes
			Eve OOH	60	n/a	55	yes
			Night OOH	49	n/a	55	no
32 Walker Avenue	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	46	yes
			Night OOH	49	n/a	46	yes

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
13 Walker Avenue	Residential	6	Day*	56	42	n/a	yes
			Day OOH	51	42	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes
23 Walker Avenue	Residential	6	Day*	56	44	n/a	yes
			Day OOH	51	44	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes
30 Walker Avenue	Residential	3	Day*	68	48	n/a	yes
			Day OOH	63	48	n/a	yes
			Eve OOH	60	n/a	45	yes
			Night OOH	49	n/a	45	yes
25 Walker Avenue	Residential	6	Day*	56	45	n/a	yes
			Day OOH	51	45	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes
58 Wattle Street	Residential	4	Day*	66	50	n/a	yes
			Day OOH	61	50	n/a	yes
			Eve OOH	58	n/a	46	yes
			Night OOH	48	n/a	46	yes
43 Walker Avenue	Residential	6	Day*	56	46	n/a	yes
			Day OOH	51	46	n/a	yes
			Eve OOH	51	n/a	42	yes
			Night OOH	48	n/a	42	yes
56 Wattle Street	Residential	3	Day*	68	54	n/a	yes
			Day OOH	63	54	n/a	yes
			Eve OOH	60	n/a	49	yes
			Night OOH	49	n/a	49	yes
154 Ramsay Street	Residential	6	Day*	56	50	n/a	yes
			Day OOH	51	50	n/a	yes
			Eve OOH	51	n/a	46	yes
			Night OOH	48	n/a	46	yes
156 Alt Street	Residential	6	Day*	56	42	n/a	yes
			Day OOH	51	42	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
18 Wattle Street^	Residential	3 [#]	Day*	68	57	n/a	yes
			Day OOH	63	57	n/a	yes
			Eve OOH	60	n/a	56	yes
			Night OOH	49	n/a	56	no
36a Wattle Street	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	47	yes
			Night OOH	49	n/a	47	yes
46 Wattle Street	Residential	3	Day*	68	51	n/a	yes
			Day OOH	63	51	n/a	yes
			Eve OOH	60	n/a	47	yes
			Night OOH	49	n/a	47	yes
15 Walker Street	Residential	6	Day*	56	43	n/a	yes
			Day OOH	51	43	n/a	yes
			Eve OOH	51	n/a	40	yes
			Night OOH	48	n/a	40	yes
17 Walker Street	Residential	6	Day*	56	43	n/a	yes
			Day OOH	51	43	n/a	yes
			Eve OOH	51	n/a	40	yes
			Night OOH	48	n/a	40	yes
160 Alt Street	Residential	6	Day*	56	41	n/a	yes
			Day OOH	51	41	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes
30 Wattle Street	Residential	3	Day*	68	51	n/a	yes
			Day OOH	63	51	n/a	yes
			Eve OOH	60	n/a	49	yes
			Night OOH	49	n/a	49	yes
24 Walker Avenue	Residential	3	Day*	68	45	n/a	yes
			Day OOH	63	45	n/a	yes
			Eve OOH	60	n/a	43	yes
			Night OOH	49	n/a	43	yes
162 Alt Street	Residential	6	Day*	56	42	n/a	yes
			Day OOH	51	42	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
164 Alt Street	Residential	6	Day*	56	43	n/a	yes
			Day OOH	51	43	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes
158 Alt Street	Residential	6	Day*	56	42	n/a	yes
			Day OOH	51	42	n/a	yes
			Eve OOH	51	n/a	39	yes
			Night OOH	48	n/a	39	yes
42 Wattle Street	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	46	yes
			Night OOH	49	n/a	46	yes
52 Wattle Street	Residential	3	Day*	68	52	n/a	yes
			Day OOH	63	52	n/a	yes
			Eve OOH	60	n/a	47	yes
			Night OOH	49	n/a	47	yes
6-12 Wattle Street	Place of Worship	3	When in use	55	50	48	yes
44 Wattle Street	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	46	yes
			Night OOH	49	n/a	46	yes
19 Walker Street	Residential	6	Day*	56	44	n/a	yes
			Day OOH	51	44	n/a	yes
			Eve OOH	51	n/a	41	yes
			Night OOH	48	n/a	41	yes
21 Walker Street	Residential	6	Day*	56	44	n/a	yes
			Day OOH	51	44	n/a	yes
			Eve OOH	51	n/a	41	yes
			Night OOH	48	n/a	41	yes
20 Wattle Street^	Residential	3 [#]	Day*	68	56	n/a	yes
			Day OOH	63	56	n/a	yes
			Eve OOH	60	n/a	55	yes
			Night OOH	49	n/a	55	no

Table C.1 Scenario 1 and 2 predicted noise levels $L_{Aeq,15min}$ - tunnelling support

Receiver	Classification	NCA	Time Period	NML	Predicted noise levels, dB		
					Scenario 1	Scenario 2	Compliance
34 Walker Avenue	Residential	3	Day*	68	50	n/a	yes
			Day OOH	63	50	n/a	yes
			Eve OOH	60	n/a	46	yes
			Night OOH	49	n/a	46	yes
172 Alt Street	Residential	6	Day*	56	44	n/a	yes
			Day OOH	51	44	n/a	yes
			Eve OOH	51	n/a	41	yes
			Night OOH	48	n/a	41	yes
37 Walker Street	Residential	6	Day*	56	47	n/a	yes
			Day OOH	51	47	n/a	yes
			Eve OOH	51	n/a	43	yes
			Night OOH	48	n/a	43	yes
28 Wattle Street	Residential	3	Day*	68	51	n/a	yes
			Day OOH	63	51	n/a	yes
			Eve OOH	60	n/a	49	yes
			Night OOH	49	n/a	49	yes
26 Wattle Street	Residential	3	Day*	68	52	n/a	yes
			Day OOH	63	52	n/a	yes
			Eve OOH	60	n/a	51	yes
			Night OOH	49	n/a	51	no

Notes: Day/Evening/Night D/E/N
 1. Construction noise assessed in accordance with ICNG
 * Day – Standard Hours
 # RBL for NCA03 utilised for these residences as NCA02 RBL's were not considered representative

Appendix D

Scenario 3 predicted noise levels $L_{Aeq, 15min}$ – ramp lowering (short term works)

Table D.1 Scenario 3 predicted noise levels $L_{Aeq,15min}$ – ramp lowering

Receiver	Classification	NCA	Time Period	NML	Prediction, dB	
					Scenario 3	Compliance
7 Walker Avenue	Residential	6	Day*	56	56	yes
			Day OOH	51	n/a	yes
40 Wattle Street	Residential	3	Day*	68	64	yes
			Day OOH	63	n/a	yes
41 Walker Avenue	Residential	6	Day*	56	59	no
			Day OOH	51	n/a	yes
152 Alt Street	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
35 Walker Avenue	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
1 Walker Avenue	Residential	6	Day*	56	56	yes
			Day OOH	51	n/a	yes
3 Walker Avenue	Residential	6	Day*	56	56	yes
			Day OOH	51	n/a	yes
5 Walker Avenue	Residential	6	Day*	56	56	yes
			Day OOH	51	n/a	yes
27 Walker Avenue	Residential	6	Day*	56	61	no
			Day OOH	51	n/a	yes
11 Walker Avenue	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
24 Wattle Street	Residential	3 [#]	Day*	68	74	no
			Day OOH	63	n/a	yes
5 Walker Avenue	Residential	6	Day*	56	56	yes
			Day OOH	51	n/a	yes
7a Walker Avenue	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
154 Frederick Street	Residential	1	Day*	56	56	yes
			Day OOH	51	n/a	yes
38 Wattle Street	Residential	3	Day*	68	64	yes
			Day OOH	63	n/a	yes
9 Walker Avenue	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
22 Earle Avenue	Residential	1	Day*	56	56	yes
			Day OOH	51	n/a	yes
38 Walker Avenue	Residential	3	Day*	68	62	yes
			Day OOH	63	n/a	yes

Table D.1 Scenario 3 predicted noise levels $L_{Aeq,15min}$ – ramp lowering

Receiver	Classification	NCA	Time Period	NML	Prediction, dB	
					Scenario 3	Compliance
24 Earle Avenue	Residential	1	Day*	56	56	yes
			Day OOH	51	n/a	yes
54 Wattle Street	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
39 Walker Avenue	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
31 Walker Avenue	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
251 Ramsay Street	Residential	6	Day*	56	55	yes
			Day OOH	51	n/a	yes
168 Alt Street	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
174 Alt Street	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
29 Walker Avenue	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
28 Walker Avenue	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
13 Earle Avenue	Residential	1	Day*	56	56	yes
			Day OOH	51	n/a	yes
156 Frederick Street	Residential	1	Day*	56	55	yes
			Day OOH	51	n/a	yes
11 Earle Avenue	Residential	1	Day*	56	56	yes
			Day OOH	51	n/a	yes
34 Wattle Street	Residential	3	Day*	68	66	yes
			Day OOH	63	n/a	yes
22 Wattle Street^	Residential	3 [#]	Day*	68	74	no
			Day OOH	63	n/a	yes
170 Alt Street	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes
16 Wattle Street	Residential	3 [#]	Day*	68	74	no
			Day OOH	63	n/a	yes
32 Walker Avenue	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
13 Walker Avenue	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes

Table D.1 Scenario 3 predicted noise levels $L_{Aeq,15min}$ – ramp lowering

Receiver	Classification	NCA	Time Period	NML	Prediction, dB	
					Scenario 3	Compliance
23 Walker Avenue	Residential	6	Day*	56	61	no
			Day OOH	51	n/a	yes
30 Walker Avenue	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
25 Walker Avenue	Residential	6	Day*	56	61	no
			Day OOH	51	n/a	yes
58 Wattle Street	Residential	4	Day*	66	61	yes
			Day OOH	61	n/a	yes
43 Walker Avenue	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes
56 Wattle Street	Residential	3	Day*	68	64	yes
			Day OOH	63	n/a	yes
154 Ramsay Street	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
156 Alt Street	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes
18 Wattle Street^	Residential	3 [#]	Day*	68	74	no
			Day OOH	63	n/a	yes
36a Wattle Street	Residential	3	Day*	68	65	yes
			Day OOH	63	n/a	yes
46 Wattle Street	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
15 Walker Street	Residential	6	Day*	56	59	no
			Day OOH	51	n/a	yes
17 Walker Street	Residential	6	Day*	56	59	no
			Day OOH	51	n/a	yes
160 Alt Street	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes
30 Wattle Street	Residential	3	Day*	68	67	yes
			Day OOH	63	n/a	yes
24 Walker Avenue	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
162 Alt Street	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes
164 Alt Street	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes

Table D.1 Scenario 3 predicted noise levels $L_{Aeq,15min}$ – ramp lowering

Receiver	Classification	NCA	Time Period	NML	Prediction, dB	
					Scenario 3	Compliance
158 Alt Street	Residential	6	Day*	56	57	no
			Day OOH	51	n/a	yes
42 Wattle Street	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
52 Wattle Street	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
6-12 Wattle Street	Place of Worship	3	When in use	55	67	no
44 Wattle Street	Residential	3	Day*	68	62	yes
			Day OOH	63	n/a	yes
19 Walker Street	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
21 Walker Street	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
20 Wattle Street [^]	Residential	3 [#]	Day*	68	74	no
			Day OOH	63	n/a	yes
34 Walker Avenue	Residential	3	Day*	68	63	yes
			Day OOH	63	n/a	yes
172 Alt Street	Residential	6	Day*	56	58	no
			Day OOH	51	n/a	yes
37 Walker Street	Residential	6	Day*	56	60	no
			Day OOH	51	n/a	yes
28 Wattle Street	Residential	3	Day*	68	68	yes
			Day OOH	63	n/a	yes
26 Wattle Street	Residential	3	Day*	68	69	no
			Day OOH	63	n/a	yes

Notes: Day/Evening/Night D/E/N
 1. Construction noise assessed in accordance with ICNG
 * Day – Standard Hours
[#] RBL for NCA03 utilised for these residences as NCA02 RBL's were not considered representative

Appendix E

Scenario 2 Predicted noise levels L_{Amax}

Table E.1 Scenario 2 - Predicted noise levels L_{Amax}

Receiver	Classification	NCA	Screening Criterion	Predicted Noise Levels	Compliance
			L_{Amax}	L_{Amax}	
7 Walker Avenue	Residential	6	58	51	yes
40 Wattle Street	Residential	3	59	57	yes
41 Walker Avenue	Residential	6	58	46	yes
152 Alt Street	Residential	6	58	49	yes
35 Walker Avenue	Residential	6	58	49	yes
1 Walker Avenue	Residential	6	58	50	yes
5 Walker Avenue	Residential	6	58	51	yes
27 Walker Avenue	Residential	6	58	53	yes
11 Walker Avenue	Residential	6	58	51	yes
24 Wattle Street	Residential	3 [#]	59	70	no
5 Walker Avenue	Residential	6	58	51	yes
7a Walker Avenue	Residential	6	58	51	yes
154 Frederick Street	Residential	1	53	51	yes
38 Wattle Street	Residential	3	59	58	yes
9 Walker Avenue	Residential	6	58	51	yes
22 Earle Avenue	Residential	1	53	46	yes
38 Walker Avenue	Residential	3	59	51	yes
24 Earle Avenue	Residential	1	53	47	yes
54 Wattle Street	Residential	3	59	51	yes
39 Walker Avenue	Residential	6	58	46	yes
31 Walker Avenue	Residential	6	58	49	yes
251 Ramsay Street	Residential	6	58	44	yes
168 Alt Street	Residential	6	58	48	yes
174 Alt Street	Residential	6	58	47	yes
29 Walker Avenue	Residential	6	58	50	yes
13 Earle Avenue	Residential	1	53	48	yes
156 Frederick Street	Residential	1	53	51	yes
11 Earle Avenue	Residential	1	53	47	yes
158 Frederick Avenue	Residential	1	53	51	yes
34 Wattle Street	Residential	3	59	60	no
22 Wattle Street	Residential	3 [#]	59	74	no
170 Alt Street	Residential	6	58	49	yes
16 Wattle Street	Residential	3 [#]	59	71	no
13 Walker Avenue	Residential	6	58	51	yes
23 Walker Avenue	Residential	6	58	53	yes
25 Walker Avenue	Residential	6	58	52	yes
58 Wattle Street	Residential	4	58	48	yes
43 Walker Avenue	Residential	6	58	45	yes
56 Wattle Street	Residential	3	59	50	yes
154 Ramsay Street	Residential	6	58	48	yes
156 Alt Street	Residential	6	58	48	yes

Table E.1 Scenario 2 - Predicted noise levels L_{Amax}

Receiver	Classification	NCA	Screening Criterion	Predicted Noise Levels	Compliance
			L_{Amax}	L_{Amax}	
18 Wattle Street	Residential	3 [#]	59	<i>71</i>	<i>no</i>
36A Wattle Street	Residential	3	59	59	yes
46 Wattle Street	Residential	3	59	54	yes
15 Walker Street	Residential	6	58	52	yes
17 Walker Street	Residential	6	58	52	yes
160 Alt Street	Residential	6	58	49	yes
30 Wattle Street	Residential	3	59	62	<i>no</i>
162 Alt Street	Residential	6	58	51	yes
164 Alt Street	Residential	6	58	49	yes
158 Alt Street	Residential	6	58	48	yes
42 Wattle Street	Residential	3	59	54	yes
52 Wattle Street	Residential	3	59	53	yes
6-12 Wattle Street	Place of Worship	3	59	n/a	yes
44 Wattle Street	Residential	3	59	52	yes
19 Walker Street	Residential	6	58	53	yes
21 Walker Street	Residential	6	58	53	yes
20 Wattle Street	Residential	3 [#]	59	<i>73</i>	<i>no</i>
172 Alt Street	Residential	6	58	50	yes
37 Walker Street	Residential	6	58	48	yes
28 Wattle Street	Residential	3	59	<i>68</i>	<i>no</i>
26 Wattle Street	Residential	3	59	<i>66</i>	<i>no</i>

Notes: Day/Evening/Night D/E/N

1. Construction noise assessed in accordance with ICNG

2. L_{Amax} assessed to top floor of apartment buildings

Levels in 'Italics' exceedances of screening criterion

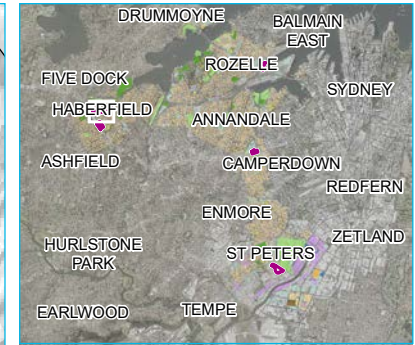
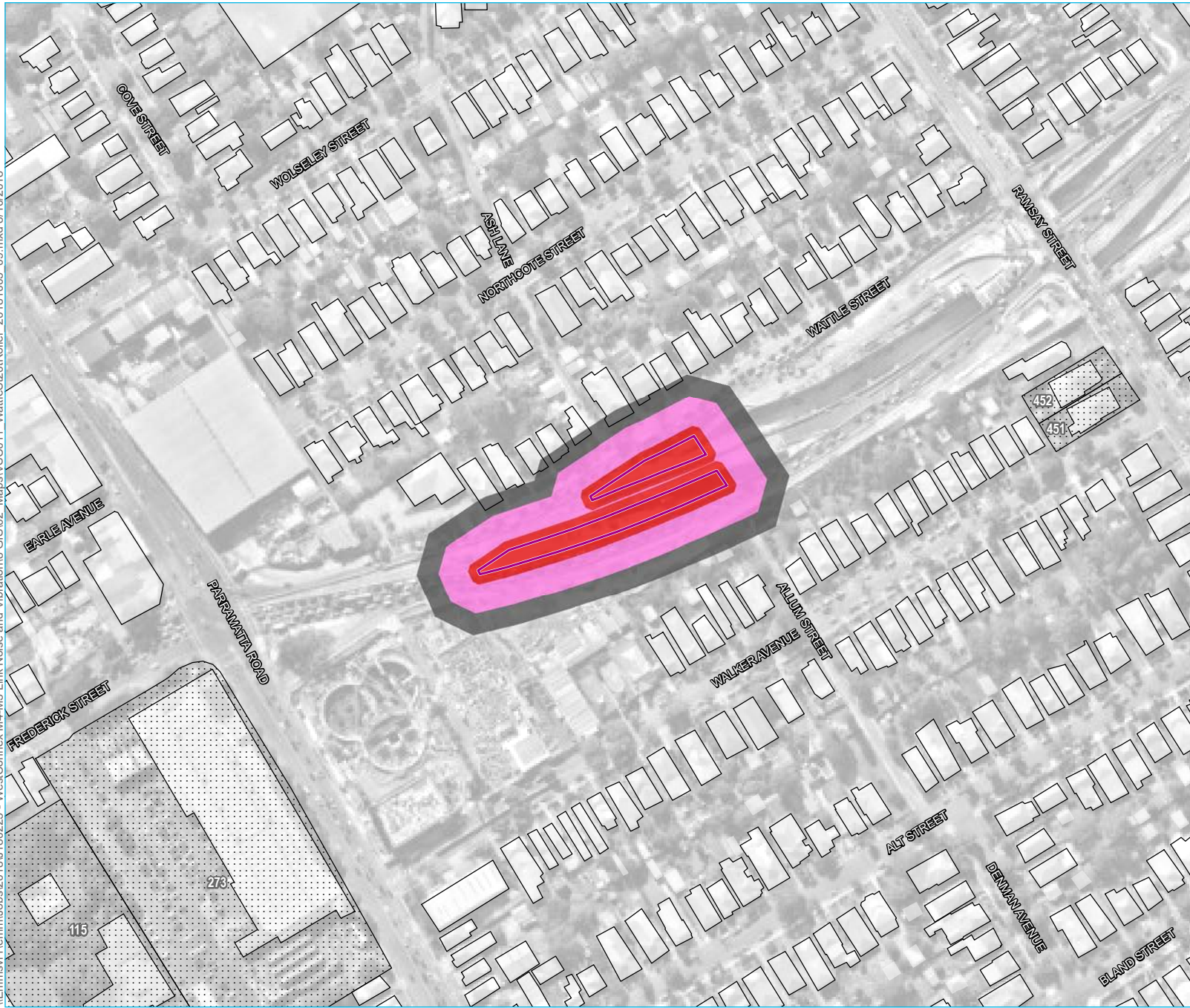
* Day – Standard Hours

RBL for NCA03 utilised for these residences as NCA02 RBL's were not considered representative

Appendix F

Vibration screening drawings

\\Emsv1\emmm\Jobs\2018\J180225 - WestConnex M4-M5 Link Noise and Vibration\8 GIS\02 Maps\VSC011 WattleSt201Roller 20181005 09.mxd 8/10/2018



- KEY**
- Heritage item (LEP/SHR)
 - Approximate works boundary
 - 10 t vibratory roller - areas of potential exceedance*
 - Cosmetic damage - commercial and industrial
 - Cosmetic damage - residential
 - Cosmetic damage - heritage

NOTE: Larger plant could be used pending results from actual vibration monitoring

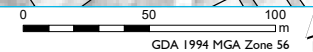
Wattle Street Ramps – 10 t vibratory roller

M4-M5 Link Mainline Tunnels
Vibration Screening Criteria Drawings

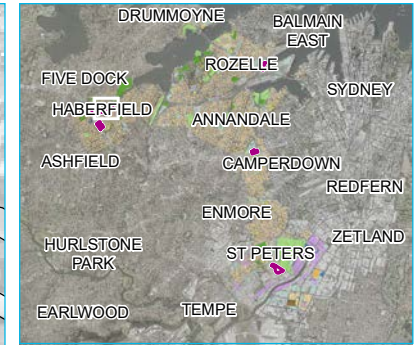


Source: EMM (2018); LendLease (2018); DFSI (2017)

*NOTE: Vibration screening criteria are based on German Standard DIN 4150-3: Structural Vibration - effects of vibration on structures (for structural damage)



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KEY

- Watercourse / drainage line
- Heritage item (LEP/SHR)
- Approximate works boundary
- 12-18 t excavator with 900 kg hammer - areas of potential exceedance*
- Commercial, industrial & similar structures
- Dwellings & similar structures
- Heritage & other sensitive structures

NOTE: Larger plant could be used pending results from actual vibration monitoring

Wattle Street Ramps – 12-18 t excavator with 900 kg medium hammer

M4-M5 Link Mainline Tunnels
Vibration Screening Criteria Drawings



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

*NOTE: Vibration screening criteria are based on German Standard DIN 4150-3: Structural Vibration - effects of vibration on structures (for structural damage)

Appendix G

Additional CNVG noise mitigation measures

Table G.1 Additional CNVG noise mitigation measures

Easting	Northing	Address	Type	NCA	Scenario 1	Scenario 1	Scenario 3	Scenario 2	Scenario 2
					Day	Day OOH	Day	Eve OOH	Night OOH
327201	6250040	24 Wattle Street	RES	2	Nil	Nil	Nil	Nil	V, N, R2, DR
327201	6250011	22 Wattle Street	RES	2	Nil	Nil	N, V, RO	Nil	V, N, R2, DR
327175	6249998	18 Wattle Street	RES	2	Nil	Nil	N, V, RO	Nil	V, N, R2, DR
327190	6250003	20 Wattle Street	RES	2	Nil	Nil	N, V, RO	Nil	V, N, R2, DR
327249	6250042	28 Wattle Street	RES	3	Nil	Nil	Nil	Nil	N
327214	6250051	26 Wattle Street	RES	3	Nil	Nil	Nil	Nil	N

Notes: only properties which require additional mitigation measures are listed and it can be inferred that no measures are required for remaining properties

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).



