

WESTCONNEX THE NEW M5

Construction Noise and Vibration Management Plan

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CPB Dragados Samsung Joint Venture

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Supplementary professional advice should be sought in respect of these issues.

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1 Introduction

1.1 Context

This Construction Noise and Vibration Management Plan (CNVMP) forms part of the Construction Environmental Management Plan (CEMP) developed for the construction of the WestConnex New M5 project (New M5 or Project). The CNVMP describes how the CPB Dragados Samsung Joint Venture (CDS) will manage and mitigate noise and vibration during construction of the Project.

The project is a component of the WestConnex scheme, a NSW Government initiative to connect Sydney's west and south-west with the Sydney Airport and the Port Botany precinct. The Proponent for the project is Roads and Maritime Services (Roads and Maritime) and the Project Company (SMC) is delivering the project. SMC has engaged CDS (the Contractor) to design and construct the project.

The project will link to the upgraded King Georges Road Interchange on the existing M5 East Motorway at Beverly Hills and run via twin tunnels to St Peters. A detailed project description is included in Section 2 of the CEMP. The project is described and assessed in detail in the New M5 Environmental Impact Statement (EIS) (AECOM, November 2015). Submissions received on the EIS were then considered in the New M5 Submissions Report (AECOM, March 2016).

The project was approved on 21 April 2016, subject to the Minister's Conditions of Approval (CoA). This CNVMP has been prepared to address applicable legislation, the relevant CoA and the revised environmental management measures (REMMs) listed in the New M5 Submissions Report.

1.2 Objectives and Targets

CoA D68(b) requires the development of a CNVMP to detail how construction noise and vibration impacts will be minimised and managed.

The CNVMP identifies the process for determining reasonable and feasible mitigation measures in accordance with the ICNG, a monitoring program to verify that construction noise and vibration is within the predicted levels, and a strategy for responding to any exceedances of the noise and vibration management levels. The following noise and vibration objectives will apply to the construction of the project:

- All works and activities would be undertaken in a manner that will minimise noise and vibration impacts on sensitive receivers.
- Minimise unreasonable noise and vibration impacts on residents and businesses.
- Avoid cosmetic and structural damage to buildings or heritage items as a result of construction vibration.
- Undertake active community consultation.

- Maintain positive, cooperative relationships with schools, childcare centres, local residents and building owners.

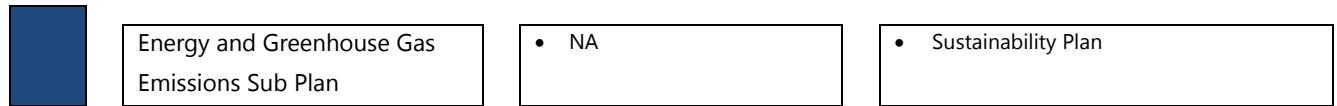
1.3 New M5 Environmental Management Structure

1.3.1 Interactions with other management documents

This CNVMP is part of an integrated set of sub-plans to the CEMP. Table 1.1 shows the CEMP framework for the Project.

Table 1.1: New M5 CEMP Framework

Construction Environmental Management Plan	Sub-plans to CEMP	Sub-plan attachments	Standalone Documentation (linked to CEMP)
	Construction Air Quality Sub Plan	<ul style="list-style-type: none"> • NA 	<ul style="list-style-type: none"> • Sustainability Plan • Ancillary Facilities Management Plan
	Construction Noise and Vibration Sub Plan	<ul style="list-style-type: none"> • Out of Hours Works Protocol • Blast Management Strategy 	<ul style="list-style-type: none"> • Land Use Survey • Sustainability Plan • Ancillary Facilities Management Plan • Temporary Noise Barrier Strategy
	Construction Traffic & Access Management Plan	<ul style="list-style-type: none"> • NA 	<ul style="list-style-type: none"> • Traffic Management Plans • Ancillary Facilities Management Plan • Local Road Dilapidation Report • Road Safety Audit • Construction Parking and Access Strategy
	Construction Soil & Water Quality Sub Plan	<ul style="list-style-type: none"> • Acid Sulfate Soil Management Plan 	<ul style="list-style-type: none"> • Flood Management Strategy • Groundwater and Soil Salinity Report • Sustainability Plan • Geotechnical Model • Ancillary Facilities Management Plan • Water Quality Plan and Monitoring Program • Acid Sulfate Soil Management Procedure • Asbestos Guideline
	Construction Heritage Sub Plan	<ul style="list-style-type: none"> • Historical Archaeological Research Design • Unexpected Heritage Finds 	<ul style="list-style-type: none"> • Sustainability Plan • Geotechnical Model • Ancillary Facilities Management Plan
	Construction Flora & Fauna Sub Plan	<ul style="list-style-type: none"> • Pathogen and Weed Management Strategy • Nest Box Plan 	<ul style="list-style-type: none"> • Sustainability Plan • Ancillary Facilities Management Plan • Urban Design and Landscape Management Plan • Revegetation Strategy • Green and Gold Bell Frog Management Plan • Biodiversity Offsets Package • Tree Reports
	Waste and Resource Sub-Plan	<ul style="list-style-type: none"> • NA 	<ul style="list-style-type: none"> • Water Reuse Strategy • Spoil Management Plan • Sustainability Plan



1.3.2 Structure of this CNVMP

The structure of this CNVMP is shown in Figure 1 below. Under the CNVMP sit individual CNVISs that provide detailed prediction, assessment and management of impacts for individual construction sites and activities (e.g. tunnelling). Section 5.2 provides more detail on the CNVIS process.

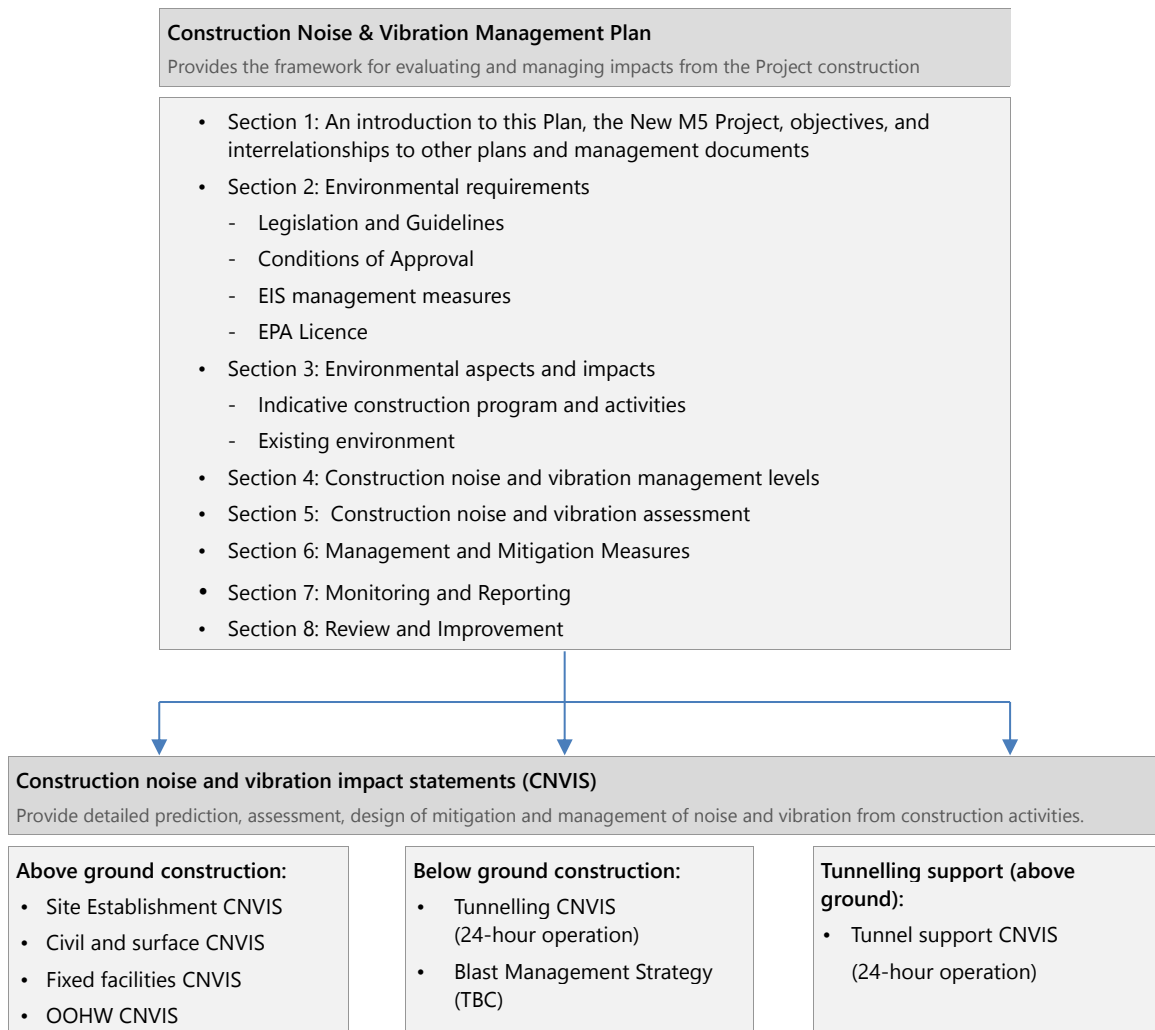
Appendix A contains a glossary of acoustic terms used in this report.

1.3.3 Construction Noise and Vibration Impact Statements

Site- and activity-specific Construction Noise and Vibration Impact Statements (CNVISs) will be prepared by Renzo Tonin and Associates to address the following works associated with the New M5:

- construction worksite establishment;
- civil and surface (and fixed facility) works;
- tunnel support works;
- tunnelling;
- Out of Hours Local Area (Road) Works and utility relocation, protection and connection works surrounding each work area.

The CNVISs will provide detailed prediction, assessment, design of mitigation and management of noise and vibration from construction activities. Where required under the Environment Protection Licence (EPL, see Section 2.5 for more information), a CNVIS will be submitted to the EPA. Adjacent residential and other sensitive receivers, Noise Catchment Areas (NCAs) and site specific management measures identified in the CNVIS will be progressively incorporated into the Site Environment Plans.

Figure 1: New M5 Construction Noise and Vibration Management Plan structure

1.4 Training

All personnel working on the site will undertake a site induction, which will provide initial training on various environmental aspects including Noise and vibration.

Further to this, noise and vibration management requirements are to be regularly tool boxed. Further details regarding training are outlined below:

- Induction training will include noise and vibration information on:
 - Standard construction hours
 - Out of hours works
 - Sensitive receivers
 - Noise and vibration mitigation and management measures
- Toolboxing will be undertaken on the Construction Noise Impact Statements, and will also reinforce and reiterate information from inductions. The tool box talks will be presented when

changes in work practices (e.g. OOHV) or seasonal weather increases the risk of adverse impact from noise and/ or vibration.

1.5 Consultation

Consultation with the Environment Protection Authority (EPA) was undertaken during the development of this CNVMP.

Further development of CNVISs and strategies will include consultation with:

- potentially-affected community, religious and educational institutions;
- proponents of other construction works in the vicinity of the New M5;
- Environmental Protection Authority and other relevant agencies;
- Environmental Protection Authority with regard to the preparation of a Blast Management Strategy.

Stakeholder feedback relevant to construction noise and vibration will be incorporated into CNVISs, and this CNVMP where appropriate. The agency and stakeholder consultation register is provided in the CEMP.

2 Environmental requirements

2.1 Legislation

This CNVMP is prepared in accordance with the:

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

Refer to the CEMP for further details.

2.2 Guidelines

Additional guidelines and standards relating to the management of construction noise and vibration from this project include:

- NSW Interim Construction Noise Guideline (ICNG), Dept of Environment and Climate Change 2009
- NSW Road Noise Policy, Dept. of Environment, Climate Change and Water 2011
- NSW Assessing Vibration – a technical guideline (AVTG), Department of Environment and Conservation 2006
- 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), Transport for NSW 2012
- Environmental Noise Management Manual (ENMM), Roads and Traffic Authority 2001

2.3 Conditions of Approval

The CoA that relate to construction noise and vibration management are provided in Table 2.1. A cross reference is included to indicate where each condition is addressed in this CNVMP or other project management documents.

Table 2.1: Conditions of Approval that address construction noise and vibration
(refer to Table 2.2 for Noise and Vibration mitigation measures (NVMS))

Condition	Key requirement	Relevant section of this CNVMP
Land Use Survey		
D10	A detailed land use survey must be undertaken to confirm sensitive receivers (including critical working areas such as operating theatres and precision laboratories) potentially exposed to construction vibration and vibration, construction ground-borne noise and operational noise. The survey may be undertaken on a progressive basis but must be undertaken in any one area prior to the commencement of construction works which generate construction or operational noise, vibration or ground-borne noise in that area. The results of the survey must be included in the (or an updated) Construction Noise and Vibration Management Plan as required by condition D68(b).	Section 3.2.1 APPENDIX B APPENDIX C
Vibration and Building Condition Survey		
D11	Prior to construction, properties that are at risk from construction vibration must be notified and incorporated into the Construction Noise and Vibration Management Plan as required by condition D68(b).	APPENDIX B
Construction Hours		
D12	Construction activities associated with the SSI shall be undertaken during the following standard construction hours: (a) 7:00am to 6:00pm Mondays to Fridays, inclusive; (b) 8:00am to 1:00pm Saturdays; and (c) at no time on Sundays or public holidays.	Section 4.1.1 NVM14
D13	Notwithstanding condition D12, tunnelling may be undertaken 24 hours, seven days per week. Other activities associated with tunnelling (such as spoil haulage only if approved under the Spoil Management Plan, deliveries, work area establishment, temporary road and intersection modifications, roads/cut-and-cover/dive structures and approach roads and ramps, excavation and ground support, civil, mechanical, and electrical, and ventilation facilities construction) may be undertaken outside of the hours specified in condition D12 where allowed in accordance with condition D15.	Section 4.1.1 Section 4.1.2
D14	Except as permitted by an EPL, activities resulting in impulsive or tonal noise emissions 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 hours each with a minimum respite from those activities and works of not less than one hour between each block. For the purposes of this condition 'continuous' includes any period during which there is less than a one-hour respite between ceasing and recommencing any of the work the subject of this condition.	Section 4.1.1 Section 4.1.3 NVM14, NVM15

Condition	Key requirement	Relevant section of this CNVMP
D15	<p>Notwithstanding conditions D12 and D14, construction works associated with the SSI may be undertaken outside the hours specified under those conditions in the following circumstances:</p> <p>(a) construction works that cause $L_{Aeq(15\text{ minute})}$ noise levels that are -</p> <p>(i) no more than 5 dB(A) above rating background level at any residence in accordance with the Interim Construction Noise Guideline (DECC, 2009), and</p> <p>(ii) no more than the noise management levels specified in Table 3 of the Interim Construction Noise Guideline (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 those for human exposure to vibration, specified in Table 2.2 of Assessing vibration: a technical guideline (DEC, 2006), and</p> <p>(iv) intermittent vibration values measured at the most affected residence are no more than those for human exposure to vibration, specified in Table 2.4 of Assessing vibration: a technical guideline (DEC, 2006); or</p> <p>(b) where a negotiated agreement has been reached with affected receivers, where the prescribed noise and/or vibration levels cannot be achieved; or</p> <p>(c) for the delivery of materials required by the police or other authorities for safety reasons; or</p> <p>(d) where it is required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm; or</p> <p>(e) construction works approved through an Out-Of-Hours Work Protocol prepared as part of the Construction Noise and Vibration Management Plan required by condition D68(b), provided the relevant council, local residents and other affected stakeholders and sensitive receivers are informed of the timing and duration at least five days and no more than 14 days prior to the commencement of the works; or</p> <p>(f) construction works approved through an EPL.</p>	<p>Section 4.1.1</p> <p>Table 4.1</p> <p>Section 4.1.4</p> <p>Section 4.1.5</p> <p>NVM16</p>
Construction Noise and Vibration		
D16	<p>The Proponent must implement all reasonable and feasible noise mitigation measures with the aim of achieving the following construction noise management levels and vibration criteria:</p> <p>(a) construction noise management levels established using the Interim Construction Noise Guideline (DECC, 2009);</p> <p>(b) vibration criteria established using the Assessing vibration: a technical guideline (DECC 2006) (for human exposure);</p> <p>(c) Australian Standard AS 2187.2 - 2006 Explosives - Storage and Use - Use of Explosives;</p> <p>(d) BS 7385 Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2" as applicable to Australian conditions; and</p> <p>(e) the vibration limits set out in the German Standard DIN 4150-3: Structural Vibration – effects of vibration on structures (for structural damage).</p> <p>Any construction activities identified as exceeding the construction noise management levels and/or vibration criteria shall be managed in accordance with the Construction Noise and Vibration Management Plan required by condition D68(b).</p> <p>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 NML.</p>	<p>Section 4.2</p> <p>Section 4.4</p> <p>Section 4.3</p> <p>Section 4.3.2</p> <p>This document</p> <p>Section 4.2.4</p>
D17	<p>Feasible and reasonable noise mitigation measures should be applied to construction activities when the following residential ground-borne noise levels are exceeded:</p> <p>(a) evening (6:00pm to 10 pm) — Internal $L_{Aeq(15\text{ minute})}$: 40dB(A); and</p> <p>(b) night (10pm to 7am) — Internal $L_{Aeq(15\text{ minute})}$: 35 dB(A).</p> <p>The mitigation measures should be outlined in the Construction Noise and Vibration Management Plan, including the Out-Of-Hours Work Protocol, required by condition D68(b).</p>	<p>Section 4.4</p> <p>Section 6</p> <p>NVM13, NVM14, NVM16, NVM27</p>

Condition	Key requirement	Relevant section of this CNVMP
D18	Wherever practical, piling activities that affect sensitive receivers must be undertaken using quieter alternative methods than impact or percussion piling, such as bored piles or vibrated piles.	Section 6.2 NVM6
D19	The Proponent must implement operational noise mitigation measures (such as noise barriers or at-property architectural treatments) in areas where the documents referred to in conditions A2(b) and A2(c) have identified the receivers would be subject to construction noise impacts and in areas where existing noise barriers are to be altered or removed prior to commencement of construction, where feasible and reasonable. Where this is not feasible and reasonable, the Proponent must submit to the Secretary for approval a report providing justification as to why along with details of the temporary measures that would be implemented to reduce construction noise impacts until such time that the operational noise mitigation measures are implemented. The report must be provided to the Secretary prior to the commencement of construction works which would affect the identified receivers. Nothing in this condition prevents the Proponent from submitting separate reports for separate areas of construction.	Section 6.2 NVM24 Section 6.6.4 and APPENDIX E Refer also to detailed assessment in individual CNVIS reports.
D20	The Proponent must develop and implement a Temporary Noise Barrier Strategy which includes: (a) identification and confirmation of all temporary noise barriers including - <ul style="list-style-type: none"> (i) the provision of a temporary noise barrier on the northern side of the Kingsgrove North construction compound to provide noise mitigation to highly affected residents at a level greater than that identified in the documents referred to in condition A2(b), (ii) consideration of the installation of temporary noise barriers on the southern and northern side of the M5 East Motorway during the relocation of the existing permanent noise barriers (or detail on why these noise barriers are not considered feasible and reasonable), (iii) consideration of the installation of temporary noise barriers along Campbell Road, Campbell Street and Euston Road (or detail on why these noise barriers are not considered feasible and reasonable), and (iv) temporary noise barriers around construction compounds; (b) the consultation and decision-making process for all temporary noise barriers; and (c) an acoustic report detailing the final barrier heights, material analysis and predicted benefits. The temporary barrier options must be developed in consultation with the landowners adjacent to the barrier locations prior to the adoption of a final design. The Temporary Noise Barrier Strategy must be approved by the Secretary prior to site establishment works or construction works at the Kingsgrove North construction compound, the permanent noise barriers on the northern and southern side of the M5 East Motorway are removed, and/or road widening works are undertaken along Campbell Road, Campbell Street or Euston Road.	NVM25 Refer also to individual Temporary Noise Barrier Strategy and detailed Temporary Noise Barrier Acoustic Report.
D21	All acoustic sheds and non-acoustic sheds must be erected at construction ancillary facilities as soon as site establishment works at the facilities are completed and prior to undertaking any works or activities which are required to be conducted within the sheds.	Section 4.1.6, Section 5, Section 6.2, refer also to detailed mitigation measures in individual CNVIS reports.

Condition	Key requirement	Relevant section of this CNVMP
D22	The Proponent must conduct vibration testing prior to commencing vibration generating activities that have the potential to impact on heritage items and vibration monitoring during initial vibration generating activities to identify minimum working distances to retained heritage items to prevent cosmetic damage to these items. 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 feasible and reasonable mitigation measures, unless otherwise agreed to by the Secretary. Vibration monitoring must be undertaken where structures are identified to be within safe working distances of vibration generating equipment/ activities.	Section 6.3 Section 7.1.2
D23	The Proponent must undertake noise monitoring during initial high noise generating activities (such as piling, rock hammering, jack hammering) to accurately establish the L_{Aeq} to L_{A1} (1 minute) differential and confirm the number of sensitive receivers which may experience sleep disturbance as a result of construction of the SSI during the evening and night-time periods. Management measures must be employed to minimise sleep disturbance impacts in accordance with the Construction Noise and Vibration Management Plan required by condition D68(b).	Section 4.2.3 NVM28 Section 7.1.1
D24	The Proponent must consult with potentially-affected community, religious, educational institutions and vibration-sensitive business and critical working areas (such as theatres, laboratories and operating theatres) to ensure that, where feasible and reasonable, noise generating construction works in the vicinity of the affected receivers are not timetabled during sensitive periods, unless other reasonable arrangements to the affected institutions are made at no cost to the affected institution. Consultation must be undertaken at least five days prior to undertaking noise generating construction works that would impact on the potentially affected vibration-sensitive receivers.	Section 1.5, Section 6.4 NVM11 and NVM12 Community Engagement Plan
D25	During construction, proponents of other construction works in the vicinity of the SSI must be consulted and reasonable steps taken to coordinate works to minimise impacts on, and maximise respite for, affected sensitive receivers.	Section 6.2 NVM11
Construction Traffic Noise		
D26	The Proponent is to ensure that construction vehicle contractors operate so as to minimise any sleep disturbance impacts. Measures that could be used include toolbox talks, contracts that include provisions to deal with unsatisfactory noise performance for the vehicle and/or the operator, and specifying non-tonal movement alarms in place of reversing beepers or alternatives such as reversing cameras and proximity alarms, or a combination of these, where tonal alarms are not mandated by legislation.	Section 4.6 Section 6.2 NVM5, NVM20
D27	Use of compression brakes must not be permitted for construction vehicles associated with the SSI during construction, unless in an emergency situation.	Section 6.2 NVM5

Condition	Key requirement	Relevant section of this CNVMP
Blasting		
D28	<p>Should blasting be required, the Proponent must prepare a Blast Management Strategy in consultation with the EPA and submit the Blast Management Strategy to the Secretary prior to any blasting. The Blast Management Strategy must demonstrate that all blasting and associated activities will be undertaken in a manner that will not generate unacceptable noise and vibration impacts or pose a significant risk impact to residences and sensitive receptors. The Blast Management Strategy must also address the principles outlined in Hazardous Industry Planning Advisory Paper No 6: Hazard Analysis (Department of Planning, January 2011) and Assessment Guideline: Multi-Level Risk Assessment (Department of Planning and Infrastructure, May 2011) for the handling and storage of hazardous materials. Issues to be considered in the Blast Management Strategy must include, but not be limited to:</p> <p>(a) details of blasting to be performed, including location, method and justification of the need to blast;</p> <p>(b) identification of any potentially affected noise and vibration sensitive sites including heritage buildings and utilities;</p> <p>(c) establishment of appropriate criteria for blast overpressure and ground vibration levels at each category of noise sensitive site;</p> <p>(d) details of the storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction site;</p> <p>(e) identification of hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives;</p> <p>(f) determination of potential noise and vibration and risk impacts from blasting and appropriate monitoring and best management practices to minimise and manage any blasting impacts and assess compliance with conditions D34 and D35; and</p> <p>(g) community consultation procedures.</p>	Section 4.1.7 APPENDIX I
D29	The vibration levels for blasting activities, including both above ground and underground work, must meet the requirements of conditions D34 and D35.	Section 4.5
D30	<p>Blasts must be limited to an average of one single detonation in any one day, per sensitive receiver, and a maximum of six per week per sensitive receiver, unless otherwise agreed by the EPA through consultation on the Blast Management Strategy.</p> <p>Note: For the purposes of this condition a single detonation may involve a number of individual blasts fired in quick succession in a discrete area</p>	Section 4.1.7 Section 4.5.3 NVM22
D31	For any section of tunnel construction where blasting is proposed, a series of initial trials at reduced scale must be conducted prior to production blasting to determine site-specific blast response characteristics and to define allowable blast sizes to meet the airblast overpressure and ground vibration limits in conditions D34 and D35.	Section 4.1.7 APPENDIX I NVM21
D32	<p>Blasting associated with the project must only be undertaken during the following hours:</p> <p>(a) 9:00 am to 5:00 pm, Monday to Friday, inclusive;</p> <p>(b) 9:00 am to 1:00 pm Saturday; and</p> <p>(c) at no time on Sunday or on a public holiday;</p> <p>or as authorised through an EPL if blasting is proposed outside of these hours.</p> <p>This condition does not apply in the event of a direction from police or other relevant authority for safety or emergency reasons to avoid loss of life, property loss and/or to prevent environmental harm.</p>	Section 4.1.1 Section 4.1.7
D33	Where vibration levels exceed the acceptable vibration dose values, feasible and reasonable mitigation measures must be considered and implemented.	Section 5.1 Section 6.2

Condition	Key requirement	Relevant section of this CNVMP												
D34	<p>Airblast overpressure generated by blasting associated with the SSI must not exceed the criteria specified in Table 2 when measured at the most affected residence or other sensitive receiver.</p> <p>Table 2 — Airblast Overpressure Criteria</p> <table border="1"> <thead> <tr> <th>Airblast overpressure (dB(Lin Peak))</th> <th>Allowable exceedance</th> </tr> </thead> <tbody> <tr> <td>115</td> <td>5% of total number of blasts over a 12 month period</td> </tr> <tr> <td>120</td> <td>0%</td> </tr> </tbody> </table>	Airblast overpressure (dB(Lin Peak))	Allowable exceedance	115	5% of total number of blasts over a 12 month period	120	0%	Section 4.5.1						
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115	5% of total number of blasts over a 12 month period													
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D35	<p>Ground vibration generated by blasting associated with the SSI must be limited for human comfort to the criteria specified in Table 3 when measured at the most affected residence or other sensitive receiver.</p> <p>Table 3 — Ground Vibration Limits for Human Comfort (AS 2187.2)</p> <table border="1"> <thead> <tr> <th>Receiver</th> <th>Type of blasting operations</th> <th>Peak component particle velocity (mm/s)</th> </tr> </thead> <tbody> <tr> <td>Sensitive site*</td> <td>Operations lasting longer than 12 months or more than 20 blasts</td> <td>5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply</td> </tr> <tr> <td>Sensitive site*</td> <td>Operations lasting for less than 12 months or less than 20 blasts</td> <td>10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply</td> </tr> <tr> <td>Occupied non-sensitive sites, such as factories and commercial premises</td> <td>All blasting</td> <td>25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation</td> </tr> </tbody> </table> <p><i>Notes:</i></p> <ul style="list-style-type: none"> A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people. The recommendations in Table J4.5(A) of AS 2187.2 – 2006 Explosives – Storage and Use – Use of Explosives are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions. 	Receiver	Type of blasting operations	Peak component particle velocity (mm/s)	Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply	Sensitive site*	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply	Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation	Section 4.5.2
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D36	<p>The blasting criteria identified in conditions D34 and D35 do not apply where the Proponent has a written agreement with the relevant landowners to exceed the criteria. The Proponent must submit to the Secretary details on the proposed increased blasting limits, where and when the blasting would occur, the mitigation and monitoring procedures that would be implemented and details of the consultation undertaken with the relevant landowners.</p> <p>The following exclusions apply to the application of this condition:</p> <p>(a) any agreements reached may be terminated by the landowner at any time should concerns about the increased blasting limits be unresolved;</p> <p>(b) the blasting limit agreed to under any agreement can at no time exceed a maximum Peak Particle Velocity vibration level of 25mm/s or maximum airblast overpressure level of 125dB(Lin Peak); and</p> <p>(c) the provisions under this condition (to increase applicable blast criteria in agreement with the relevant landowners) do not apply where the property is a heritage item.</p>	Section 4.1.7												
Construction Environmental Management Plan – Sub-plans														
D68(b)	<p>As part of the CEMP for the SSI, the Proponent must prepare and implement:</p> <p>(b) a Construction Noise and Vibration Management Plan to detail how construction noise and vibration impacts will be minimised and managed. The Plan must be consistent with the guidelines contained in the Interim Construction Noise Guidelines (DECC, 2009). The Construction Noise and Vibration Management Plan must include, but not be limited to -</p>	This report												
D68(b) i.	identification of the work areas, site compounds and access points,	APPENDIX C APPENDIX E												

Condition	Key requirement	Relevant section of this CNVMP
D68(b) ii.	identification of sensitive receivers and relevant construction noise and vibration goals applicable to the SSI and stipulated in the conditions above,	Section 3.2, Section 4 APPENDIX B
D68(b) iii.	details of construction activities and an indicative schedule for construction works, including the identification of key noise and/or vibration generating construction activities (based on representative construction scenarios, including at ancillary facilities) that have the potential to generate noise and/or vibration impacts on surrounding sensitive receivers, particularly residential areas,	Section 3.1 Section D.1 Details provided in CNVIS reports
D68(b) iv.	details of the predicted worst-case noise and vibration levels, including cumulative impacts arising from concurrent construction works and potential for sleep disturbance,	APPENDIX D and APPENDIX E Details provided in CNVIS reports
D68(b) v.	figures illustrating the predicted safe working distances for vibration intensive activities and equipment,	Section 6.3 Details provided in CNVIS reports
D68(b) vi.	an Out-of-Hours Work Protocol for the assessment, management and approval of works outside of standard construction hours as defined in condition D12 of this approval, for the Secretary's approval. The Out-of-Hours Work Protocol must be prepared in consultation with the EPA and be consistent with the out-of-hours work procedure detailed in the Construction Noise Strategy (Transport Construction Authority, 2011) and- (A) provide an assessment of out-of-hours works against the relevant noise and vibration criteria, (B) provide detailed mitigation measures for any residual impacts (that is, additional to general mitigation measures), including extent of at-receiver treatments, and (C) set out proposed notification arrangements;	Section 4.1.4 APPENDIX F
D68(b) vii.	justification for any construction works proposed to be undertaken within the Alexandria Landfill site outside of the construction hours specified in condition D12 and which do not meet the requirements of either conditions D13 and D15;	APPENDIX E
D68(b) viii.	identification of feasible and reasonable procedures and mitigation measures to ensure relevant vibration and blasting criteria are achieved, including a suitable blast program, applicable buffer distances for vibration intensive works, use of low vibration generating equipment/vibration dampeners or alternative construction methodology, and pre- and post- construction dilapidation surveys of sensitive structures (including heritage items) where blasting and/or vibration is likely to result in damage to buildings and structures (including surveys being undertaken immediately following a monitored exceedance of the criteria),	Section 6 APPENDIX I
D68(b) ix.	details of tunnelling including associated impacts, management and mitigation measures,	Section 4.1.2, Section 5.1 and Section 6 APPENDIX D and APPENDIX E Details provided in CNVIS reports

Condition	Key requirement	Relevant section of this CNVMP
D68(b) x.	<p>identification of feasible and reasonable measures proposed to be implemented to minimise and manage construction noise and vibration impacts, especially sleep disturbance (including construction traffic noise impacts), including, but not limited to, acoustic enclosures, erection of noise walls (hoardings), at property architectural treatments, respite periods and the limiting of truck movements during night periods including -</p> <p>(A) consideration of mitigation measures for sensitive receivers adjoining Campbell Road, Campbell Street and Euston Road,</p> <p>(B) the identification of receivers eligible for at-property acoustic treatment for the mitigation and management of operational noise (at-property acoustic treatments are to be installed prior to construction),</p> <p>(C) the identification of receivers eligible for alternative accommodation as determined by the criteria identified within Table 12-49 of the EIS described within condition A2 (inclusive of the consideration and identification of shift workers for alternate accommodation), and</p> <p>(D) the outcomes of community consultation regarding the implementation of any temporary noise barriers developed in accordance with condition D20;</p>	<p>Section 6</p> <p>APPENDIX D</p> <p>Details provided in CNVIS reports</p>
D68(b) xi.	a description of how the effectiveness of mitigation and management measures would be monitored during the proposed works, clearly indicating how often this monitoring would be conducted, the locations where monitoring would take place, how the results of this monitoring would be recorded and reported, and, if any exceedance is detected, how any noncompliance would be rectified;	Section 7
D68(b) xii.	evidence that the EPA has been consulted on the Out-of-Hours Work Protocol and where and how any issues raised by, or requirements of the, EPA have been addressed; and	APPENDIX E
D68(b) xiii.	mechanisms for the monitoring, review and amendment of the Construction Noise and Vibration Monitoring Plan.	Section 8

2.4 EIS management measures

Revised environmental management measures for construction noise and vibration that were identified through the impact assessment process are listed in Table 2.2.

Table 2.2: EIS management measures (REMMs) for construction noise and vibration

No.	Environmental management measure	Relevant section of this CNVMP
Construction - General		
NV1	<p>A construction noise and vibration management plan(s) will be prepared and implemented consistent with the requirements of the Interim Construction Noise Guideline (DECC, 2009), and will include the following:</p> <ul style="list-style-type: none"> • Identification of nearby residences and other sensitive land uses • Description of approved hours of work • Description and identification of construction activities, including work areas, equipment and duration • Description of what work practices (generic and specific) will be applied to minimise noise and vibration • A complaints handling process • Noise and vibration monitoring procedures • Overview of community consultation required for identified high impact works. 	This report

No.	Environmental management measure	Relevant section of this CNVMP
Construction noise		
NV2	Induction and training will be provided to relevant staff and subcontractors outlining their responsibilities with regard to noise.	Section 1.4
NV3	Noisy activities that cannot be undertaken during standard construction hours will be scheduled as early as possible during the evening and/or night time periods.	Section 6.2, NVM14
NV4	Permanent noise barriers will be scheduled for completion as early as possible in order to minimise construction noise.	Section 6.2, NVM24
NV5	Property treatments identified for the operational phase of the project will be considered for installation before or early in the construction period, where they would improve noise levels.	Section 6.2, NVM24
NV6	Acoustic sheds will be erected at the Kingsgrove North (C1), Bexley Road North (C4) and Bexley Road South (C5) construction compounds, to mitigate noise generated by tunnelling support activities. The noise attenuation requirements for these acoustic sheds will be reviewed and confirmed during detailed design.	Section 6 and site specific CNVISs
NV7	Temporary acoustic hoardings will be installed at the Kingsgrove North (C1), Commercial Road (C3), Bexley Road North (C4), Bexley Road South (C5), Bexley Road East (C6), Arncliffe (C7), the Marsh Street ponds site, Canal Road (C8) and Campbell Road (C9) construction compounds. The design and location of acoustic hoardings will be confirmed during detailed design.	Section 6.2, NVM23 and site specific CNVISs
NV8	When working adjacent to schools, particularly noisy activities will be scheduled outside normal school hours, where practicable.	Section 6.2, NVM12, NVM14
NV9	Where feasible and reasonable, equipment with directional noise emissions will be oriented away from sensitive receivers.	Section 6.2, NVM19
NV10	Verification checks on the noise emissions of plant and machinery will be conducted.	Section 6.2, NVM28
NV11	Ongoing noise monitoring will be undertaken during construction at sensitive receivers during critical periods to identify and assist in managing high risk noise events.	Section 7 and APPENDIX H
NV12	Reversing of equipment will be minimised to prevent nuisance caused by reversing alarms. Use of non-tonal reversing alarms ('quackers') will be implemented to further reduce the nuisance caused by reversing alarms.	Section 6.2, NVM8, NVM20
NV13	Loading and unloading will be carried out away from sensitive receivers, where practicable.	Section 6.2, NVM17
NV14	Deliveries will be carried out during standard construction hours where feasible and reasonable.	Section 6.2, NVM17
NV15	Additional noise mitigation measures during out of hours works will be determined on a case-by-case basis using individual receiver predictions, and may consist of offers of alternative accommodation, monitoring, individual briefings, letter box drops, project specific respite offers, phone calls and specific notifications.	Section 6.4
NV16	Respite periods (eg one hour respite for every three hours of continuous construction activity) will be scheduled for high noise impact works where appropriate.	Section 4.1.3
Construction traffic noise		
NV17	Truck drivers will be advised of designated vehicle routes, parking and queuing locations, acceptable delivery hours and other relevant practices (i.e. minimising the use of engine brakes, and no extended periods of engine idling).	Section 6.2, NVM5
NV18	Deliveries and spoil removal will be planned to avoid queuing of trucks around construction compounds.	Section 6.2, NVM5

No.	Environmental management measure	Relevant section of this CNVMP
Construction vibration		
NV19	Before the start of tunnelling or other vibration intensive works at each site, condition surveys will be undertaken on properties and structures within the preferred project corridor (the zone on the surface equal to 50 metres from the outer edge of the tunnels) and within 50 metres of surface works.	Section 6.2, NVM1
NV20	The safe working distances will be complied with where feasible and reasonable. This will include the consideration of smaller equipment when working close to existing structures.	Section 6.3, Section H.3.4
NV21	If vibration intensive works are required within the safe working distances, vibration monitoring or attended vibration trials will be undertaken at the outset of these works to ensure that levels are within relevant criteria.	Section H.3.4
NV22	Building condition surveys of potentially affected structures will be completed both before and after the works to identify existing damage and any damage due to the works.	Section 6.2, NVM1
Ground borne noise		
NV23	Vibration intensive construction works will be confined to the less sensitive daytime period (9.00 am to 12.00 pm and 2.00 pm to 5.00 pm) as far as reasonably practicable.	Section 6.2, NVM14
NV24	A detailed ground-borne noise assessment will be undertaken following further geotechnical investigations. This will include developing the vibration site law for the project.	Section 6.2, NVM13
Blasting		
NV25	Noise and vibration mitigation methods specific to blasting will be incorporated into the construction noise and vibration management plans where required.	Section 6.2 APPENDIX I
NV26	Blasting with the potential to generate an impact at the surface will be restricted to standard daytime hours (except where approved by the relevant authority). Blasting would occur between 9:00am and 5:00pm, up to five days per week (Monday to Friday) and on Saturdays (9:00 am to 1:00pm). Blasts would be limited to one single detonation in any one day per receiver group, unless otherwise agreed by the NSW EPA through consultation on the Construction Noise and Vibration Management Plan.	Section 4.1.1 Section 4.1.7
NV27	Site investigations will be conducted prior to production blasting to define suitable blast sizes to comply with project blasting noise and vibration criteria.	Section 4.1.7 APPENDIX I
NV28	Dilapidation studies of nearby receiver buildings will be undertaken where the potential for exceedances of the blasting criteria is identified.	Section 6.2 APPENDIX I
NV29	Where the predicted levels exceed the noise or vibration criteria for blasting, alternative construction methods, such as penetrating cone fracture, will be utilised.	Section 6.2 , NVM6
Consultation with impacted receivers		
NV30	Community consultation protocols for sensitive receivers likely to be impacted by construction activities such as blasting, vibration and noise will be prepared and implemented.	Section 6.2, NVM2

2.5 EPA Licence

The New M5 project construction activities will be regulated by Environmental Protection Licences (EPL) 20772 and 4627, issued by the NSW Environment Protection Authority (EPA). EPL conditions relevant to construction noise and vibration management have been included in Table 2.3.

Table 2.3: EPL conditions relevant to the management of noise and vibration

No.	Relevant condition	Reference						
P1.5	Air blast overpressure & ground vibration peak particle velocity monitoring Monitoring locations at the nearest residential properties, heritage properties and/or commercial properties as identified in section 13 of the "Blast Management Strategy - Stage 2M5", HP1511-3, prepared by Heilig & Partners Pty Ltd, December 2016							
L3	Noise Limits							
L3.1	All works and activities must be undertaken in a manner that will minimise noise and vibration impacts on sensitive receivers.	This plan, in particular: Sections 3, 5 and 6						
L3.2	The licensee must ensure that all feasible and reasonable noise and vibration mitigation and management measures are implemented during construction work authorised by this licence in accordance with the Interim Construction Noise Guideline, Department of Environment and Climate Change (DECC) 2009.	Section 6 APPENDIX E						
L4.1	At monitoring locations described in condition P1.5 the airblast overpressure level from blasting operations in or on the premises must not exceed: a) 115 dB(Lin Peak) for more than 5% of the total number of blasts during each reporting period; and b) 120 dB(Lin Peak) at any time	Section 4.1.7						
L4.2	At monitoring locations described in condition P1.5, the ground vibration peak particle velocity from blasting operations carried out in or on the premises must not exceed 10mm/s at any time	Section 4.1.7						
L4.3	Where an agreement has been reached with affected property owners in accordance with the Infrastructure Approval, Condition D36, a maximum airblast overpressure level of 125 dB(Lin Peak) and maximum Peak Particle Velocity vibration level of 25 mm/s shall apply.	Section 4.1.7						
L4.4	Blasting must be undertaken in accordance with the approved "Blast Management Strategy-Stage 2 M5", HP1511-3, December 2016	Section 4.1.7						
L4.5	Prior to each blast the licensee must provide the EPA with the location details of the monitoring locations described in Condition P1.5. To remove doubt the update of the monitoring location does not need to occur where the monitoring location has already been notified to the EPA and that there are no changes.	Section 4.1.7						
L4.6	Blasts must be limited to an average of one single detonation in any one day, per sensitive receiver, and a maximum of six per week per sensitive receiver. This condition does not apply to blasts that are part of trial blasting	Section 4.1.7						
L4.7	To determine compliance with conditions L4.1, L4.2 and L4.3 airblast overpressure and ground vibration levels must be measured and electronically recorded for monitoring points for the parameters specified in Column 1 of the table below	Section 4.1.7						
	<table border="1"> <thead> <tr> <th>Parameter</th> <th>Unit of Pressure</th> </tr> </thead> <tbody> <tr> <td>Airblast Overpressure</td> <td>dB(Lin Peak)</td> </tr> <tr> <td>Ground Vibration Peak Particle Velocity</td> <td>Mm/second</td> </tr> </tbody> </table>	Parameter	Unit of Pressure	Airblast Overpressure	dB(Lin Peak)	Ground Vibration Peak Particle Velocity	Mm/second	
Parameter	Unit of Pressure							
Airblast Overpressure	dB(Lin Peak)							
Ground Vibration Peak Particle Velocity	Mm/second							

No.	Relevant condition	Reference
L4.8	<p>A maximum of two detonations may be undertaken in one day near the Arncliffe and St Peters construction site, provided that:</p> <p>(a) The detonations occur between chainages 8500 and 7500 for the Arncliffe site, and between chainages 8500 and 10895 for the St Peters site; and</p> <p>(b) No sensitive receiver is exposed to noise and vibration impacts from more than two detonations per day; and</p> <p>(c) No sensitive receiver is exposed to noise and vibration impacts from more than 12 detonations per week; and</p> <p>(d) The blasting does not occur outside of the hours of:</p> <p>(i) 7am to 6pm Monday to Friday; and</p> <p>(ii) 8am to 1pm on Saturdays;</p> <p>(e) No blasts are undertaken at any time on a Sunday or on a Public Holiday.</p>	Section 4.5.4
L5	Hours of Operation	
L5.1	<p>Unless otherwise specified by any other condition of this licence, construction work is:</p> <p>(a) restricted to between the hours of 7:00 am and 6:00 pm Monday to Friday;</p> <p>(b) restricted to between the hours of 8:00 am and 1:00 pm Saturday; and</p> <p>© not to be undertaken on Sundays or Public Holidays.</p>	Section 4.1
L5.2	<p>Work generating high noise impact</p> <p>Unless otherwise specified, any high noise impact works must only be undertaken:</p> <p>a) between the hours of 8:00am and 6:00pm Monday to Friday;</p> <p>b) between the hours of 8:00am and 1:00pm Saturday; and</p> <p>c) in continuous blocks of no more than 3 hours, with at least a 1-hour respite between each block of work generating high noise impact, where the location of the work is likely to impact the same receivers; except as expressly permitted by another condition of this licence.</p> <p>For the purposes of this Condition 'continuous' includes any period during which there is less than a 1-hour respite between ceasing and recommencing any of the work the subject of this Condition.</p>	Section 4.1.3
L5.3	<p>Condition L5.2 does not apply to high noise impact work as defined in condition E1.1 (Special Dictionary)</p> <p>when it is generating a predicted and validated LAeq(15 minute) noise level below the highly noise affected level at the most noise effected residences or at other sensitive land uses.</p>	Section 4.1.3

No.	Relevant condition	Reference
L5.4	<p>Notification of works approved outside of standard construction hours</p> <p>a) The licensee must notify potentially affected noise sensitive receivers of works approved outside of standard construction hours not less than 5 days and not more than 14 days before those works are to be undertaken.</p> <p>b) The notification must be:</p> <ul style="list-style-type: none"> • by letterbox drop or email; and • be detailed on the project website. <p>c) The notification required by paragraphs (a) and (b) of this condition must:</p> <ul style="list-style-type: none"> • clearly outline the reason that the work is required to be undertaken outside the hours specified in Condition L4.1; • include a diagram that clearly identifies the location of the proposed works in relation to nearby cross streets and local landmarks; • include details of relevant time restrictions that apply to the proposed works; • clearly outline, in plain English, the location, nature, scope and duration of the proposed works; • detail the expected noise impact of the works on noise sensitive receivers; • clearly state how complaints may be made and additional information obtained; and • include the number of the telephone complaints line required by Condition M7.1, an after-hours contact phone number specific to the works undertaken outside the hours specified in Condition L4.1, and the project website address. <p>Note: For the avoidance of doubt condition L4.3 does not apply to works undertaken pursuant to condition L4.6 a) or b) or condition L4.10</p>	<p>Section 6.2</p> <p>APPENDIX E and site specific CNVISs</p> <p>Community Involvement Plan</p>
L5.5	<p>The licensee may undertake works outside of standard construction hours if agreement between the licensee and a substantial majority of potentially affected sensitive receivers has been reached</p>	APPENDIX E
L5.6	<p>Any agreement(s) between the licensee and the potentially affected noise sensitive receivers referred to in Condition L4.4 must be recorded in writing and a copy of the agreement(s) kept on the premises by the licensee for the duration of this licence.</p>	APPENDIX E
L5.7	<p>The licensee may undertake construction work out of hours if that work does not cause;</p> <p>a) $L_{Aeq(15 \text{ minute})}$ noise levels no more than 5 dB(A) above rating background level at any residence in accordance with the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009); and</p> <p>b) $L_{Aeq(15 \text{ minute})}$ noise levels no more than the noise management levels specified in Table 3 of the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009) at other sensitive receivers; and</p> <p>(c) continuous or impulsive vibration values, measured at the most affected residence, greater than those for human exposure to vibration, set out for residences in Table 2.2 to the technical guideline 'Environmental Noise Management Assessing Vibration' published by the Department of Environment and Conservation in February 2006, and</p> <p>(d) intermittent vibration values, measured at the most affected residence, greater than those for human exposure to vibration, set out for residences in Table 2.4 to the technical guideline 'Environmental Noise Management</p>	<p>Section 6</p> <p>APPENDIX E</p>

No.	Relevant condition	Reference
L5.8	<p>Works Approved Outside of Standard Construction Hours</p> <p>(a) Activities and works may be undertaken outside of standard construction hours specified in L4.1 but only if one or more of the following applies:</p> <p>(i) carrying on those works and activities during the hours specified in Condition L4.1 would cause unacceptable risks to one or more of the following:</p> <p>(1) construction personnel safety;</p> <p>(2) road user and public safety;</p> <p>(3) road network operational performance as may be notified from time to time by the Roads and Maritime Services; and/or</p> <p>(4) essential utility services; and/or</p> <p>(ii) the TfNSW Transport Management Centre (or other road authority) refuse to issue a road occupancy licence for the works or activities during the hours specified in Condition L4.1.</p> <p>(iii) Sydney Trains require a Rail Possession (involving week night and/or weekend rail shutdown) for the works or activities to be performed.</p>	APPENDIX E
L5.9	<p>In undertaking any works or activities under Condition L4.7 the licensee must:</p> <p>(i) comply with the requirements of the 'Manage Environment Noise Issues Procedure', document number M5N-ES-PRC-PWD-0043, revision date 29 April 2016; and</p> <p>(ii) implement noise and vibration mitigation detailed in the Interim Construction Noise Guidelines (DECC 2009).</p>	<p>Section 6</p> <p>APPENDIX E</p> <p>Site specific CNVISs</p>
L5.10	<p>A copy of the 'Manage Environment Noise Issues Procedure' must be available for public access on the project website.</p>	<p>This plan including the 'Manage Environment Noise Issues Procedure' will be made available on the WestConnex website:</p> <p>www.westconnex.com.au/</p>
L5.11	<p>The licensee may undertake works outside of standard construction hours if:</p> <p>(i) the delivery of oversized plant or structures has been determined by the police or other authorised authorities to require special arrangements to transport along public roads; or</p> <p>(ii) emergency work is required to avoid the loss of lives or property, or to prevent environmental harm.</p>	<p>Section 4.1.4 Section 4.1.5</p> <p>APPENDIX E</p>
L5.12	<p>Tunnelling works may be undertaken 24 hours per day, seven days per week provided that works and mitigations are as per the description provided in M5N-ES-RPT-PWD-0011-03- Construction Noise and Vibration Impact Statement: Tunnelling.</p>	<p>Section 4.1.2</p> <p>Appendix D</p>
L5.13	<p>Tunnel Support Activities may be undertaken at Arncliffe (Kogarah Golf Course), Bexley Road (Bexley South and Bexley North work sites) and Kingsgrove tunnelling sites, 24 hours per day, seven days per week, provided that works and mitigations are as per the descriptions provided in the Construction Noise and Vibration Impact Statements for each site.</p>	<p>Section 4.1.2</p> <p>Appendix D</p>
L5.14	<p>Works associated with the permanent shafts at the Arncliffe Construction Compound may be undertaken 24 hours per day, seven days per week provided that works are undertaken in accordance with the most recent version of the Construction Noise and Vibration Impact Statement: Arncliffe Permanent Shafts Excavation, which is approved in writing and held on file by the EPA. The licensee must implement monitoring requirements and the procedure to resolve noise exceedances as detailed in this statement.</p>	Appendix D
O2	Maintenance of Plant and Equipment	

No.	Relevant condition	Reference
O2.1	All plant and equipment installed at the premises or used in connection with the licensed activity: a) must be maintained in a proper and efficient condition; and b) must be operated in a proper and efficient manner.	Section 6.2 NVM3, NVM4, NVM28 and NVM29
M4	Environmental Monitoring	
M4.1	Noise monitoring must be carried out in accordance with Australian Standard AS 2659.1 – 1998: Guide to the use of sound measuring equipment – Portable sound level meters, and the compliance monitoring guidance provided in the NSW Industrial Noise Policy.	Section 7.1.1 APPENDIX H
M4.2	Vibration monitoring must be carried out in accordance with the guidance provided in the Environmental Noise Management Assessing Vibration: A Technical Guideline, published by the Department of Environment and Conservation, February 2006.	Section 7.1.2 APPENDIX H
M4.3	The licensee must undertake noise and vibration monitoring as directed by an authorised officer of the EPA.	Section 7
M7	Telephone Complaints Line	Section 7.2
M7.4	Noise and Vibration Complaints a) The licensee must investigate noise and vibration complaints received via the telephone complaints line from the occupants of dwellings or the management of noise sensitive receivers other than dwellings: (i) within two hours of the complaint being made; or (ii) in accordance with any prior complaint management agreement the licensee may have made with the complainant.	Section 7.2 Community Involvement Plan
R4.1	a) Upon request of an authorised officer of the EPA, the licensee must submit a Preliminary Investigation Report to the EPA in respect of any noise or vibration monitoring undertaken in accordance with the requirements of Condition M7.4.	Section 7
	b) The Preliminary Investigation Report must be submitted to the EPA by 4.30 pm of the afternoon of the next working day following any noise or vibration monitoring.	Section 7
	c) The Preliminary Investigation Report must: (i) include numerical and/or graphical representation of the noise and vibration monitoring results; and (ii) highlight any detected exceedance of noise goals or limits specified in: (1) this licence; (2) relevant noise guidelines; and (3) relevant noise modelling.	Section 7
	d) In the event of any exceedance of the noise goals or limits referred to in Condition R4.2 c)(ii), the licensee must: (i) modify work practices and methods and implement all practicable and reasonable measures to prevent a recurrence of the exceedance; and (ii) submit a Follow-up Investigation Report to the EPA within 5 working days of any noise or vibration monitoring having been undertaken (unless otherwise approved by the EPA).	

No.	Relevant condition	Reference
	<p>e) the Follow-up Investigation Report must include:</p> <ul style="list-style-type: none"> (i) confirmation of whether noise monitoring has been undertaken in accordance with AS2659 and the compliance monitoring guidance provided in the INP; (ii) confirmation of whether vibration monitoring has been undertaken in accordance with the guidance provided in the Assessing vibration: a technical guideline (DEC, 2006); (iii) details of the prevailing meteorological conditions during the period when the noise or vibration monitoring was undertaken; (iv) a map of each noise and vibration monitoring location in relation to the noise source, including relevant distances; (v) numerical and graphical representation of the noise and vibration monitoring results; (vi) an analysis of the noise and vibration monitoring results; (vii) details of any remedial action taken in relation to the matter; and (viii) in cases not the subject of remedial action, detailed justification of the decision not to undertake remedial action. 	Section 7

3 Environmental aspects and impacts

3.1 Indicative construction program and activities

3.1.1 Overview of construction works

The construction activities associated with the New M5 are summarised below:

- Civil works: surface earthworks, bridges and structures
 - Site establishment and construction of the work compounds, including:

Kingsgrove North (C1)	Canal Road (C8),
Kingsgrove South (C2)	Campbell Road (C9),
Commercial Road (C3)	Landfill Closure (C10),
Bexley Road North (C4)	Burrows Road (C11),
Bexley Road South (C5)	Campbell Road bridge (C12),
Bexley Road East (C6)	Gardeners Road bridge (C13)
Arncliffe (C7)	Sydney Park (C14)
 - Western surface works, including the M5 East Motorway integration works and portal construction
 - Closure of the Alexandria Landfill, including bulk earthworks, landfill capping, leachate and groundwater management systems and a gas collection and management system
 - Construction of the St Peters interchange including bridges over Alexandra Canal, shared path ramps and bridge over Campbell Road
 - Local road upgrades to Euston Road, Campbell Road/ Campbell Street, Bedwin Road, Bourke Road/ Bourke Street, Gardeners Road, construction of new and upgrades/ modifications to existing bridges
 - Construction of the operational infrastructure, including:

Kingsgrove motorway operations complex (MOC1)
Tolling infrastructure on the M5 East Motorway
Bexley Road South motorway operations complex (MOC2)
Arncliffe motorway operations complex (MOC3)
St Peters motorway operations complex (MOC4)
Burrows Road motorway operations complex (MOC5)
- Tunnelling and tunnel support:

- Excavation of main alignment tunnels between the King Georges Road interchange and the St Peters interchange
- Excavation of Southern extension stub tunnels near the Arncliffe (C7) compound and M4-M5 Link stub tunnels near the St Peters interchange
- Tunnel access, spoil haulage, ventilation at the tunnel support compounds:

Kingsgrove North (C1)	Bexley Road South (C5)
Commercial Road (C3)	Arncliffe (C7)
Bexley Road North (C4)	Landfill Closure (C10)

3.1.2 Construction program

Subject to environmental planning approval, construction of the New M5 is planned to commence in the mid-2016, with completion of construction in the second quarter of 2020. Refer to the CEMP for further detail on the construction programme.

3.2 Existing environment

3.2.1 Noise and vibration sensitive receivers

To satisfy CoA D10 a detailed land use survey has been completed prior to the commencement of construction. The survey identified potentially critical areas that are sensitive to construction noise, vibration and ground-borne noise impacts, which have been documented in a Land Use Survey included in APPENDIX B. The results of the survey have been incorporated into this CNVMP to ensure construction noise and vibration impacts at all identified sensitive receivers are appropriately managed.

The land use survey will be updated progressively in the Project GIS during the detailed design process. Any additional identified receivers will be included in an updated CNVMP. This information will feed directly into the construction noise and vibration models established to predict the impact from construction associated with the Project.

In order to assess and manage construction noise impact, the residential areas surrounding the Project have been divided into Noise Catchment Areas (NCAs) based on each area's similar acoustic environment prior to the commencement of construction works. The NCAs, established in the EIS for the M5 project [5], have been reviewed and modified as a result of more detailed design information and site specific characteristics. A description of each NCA is provided in Table 3.1 below. There are three NCAs additional to those identified in the EIS, NCAs T-1, T-2 and T-3 along the tunnel alignment between the above-ground work areas. In addition, NCAs 06, 16 and 26 have been subdivided into sub-catchments to better represent the acoustic environment in these key catchment areas around the construction compounds.

An indicative list of the nearest sensitive receiver types in each NCA is summarised in Table 3.1, based on the Land Use Survey in APPENDIX B. Potential noise and vibration from construction of the New M5 will be predicted to all sensitive receivers surrounding the worksites and along the tunnel alignment and presented in the CNVISs under this CNVMP.

Noise and vibration sensitive receivers will be consulted with by the CDS if they are going to be potentially affected by the works as required by CoA D24.

Table 3.1: Noise Catchment Areas

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
St Peters Interchange/ compounds					
NCA01	10-450 m	<p>Receivers within NCA 1 are primarily residential, comprising both medium density apartments and single and double storey semi-detached houses.</p> <p>The existing acoustic environment is considered as urban and is dominated by traffic noise from Sydney Park Road and to a lesser extent Mitchell Road, Euston Road and the East Hills, Airport and Inner West railway line.</p>	Local roadworks	None	None
NCA02	50-800 m	<p>Receivers within NCA 2 are primarily residential, comprising single and double storey semi-detached and detached houses.</p> <p>The existing acoustic environment is considered as urban and is dominated by traffic noise from King Street and to a lesser extent rail traffic the local road network and the East Hills, Airport and Inner West railway line.</p>	Local roadworks	None	None
NCA03	10-650 m	<p>NCA 3 comprises a mix of commercial, industrial and residential receivers. Residential receivers are generally single storey detached buildings and two to three storey apartment buildings.</p> <p>The existing acoustic environment is considered as urban and is dominated by traffic along May Street, the Princes Highway, Campbell Street and the East Hills, Airport and Inner West railway line.</p>	Local roadworks St Peters Interchange works	Canal Road construction compound (C8) Campbell Road construction compound (C9) Landfill closure construction compound (C10) Sydney Park construction compound (C14)	None
NCA04	< 10 m	<p>Receivers within NCA 4 are primarily commercial and recreational with a small number of residential receivers comprising single and double storey houses.</p> <p>The existing acoustic environment is considered as urban and is dominated by traffic along the Princes Highway, Campbell Road and Sydney Park Road.</p>	Local roadworks St Peters Interchange works	Canal Road construction compound (C8) Campbell Road construction compound (C9) Landfill closure construction compound (C10) Burrows Road construction compound (C11) Alexandra Canal construction compound (C12) Gardeners Road bridge construction compound (C13) Sydney Park construction compound (C14)	None

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
NCA05	<20 m	NCA 5 comprises industrial and commercial receivers only; no noise sensitive receivers are located within this NCA. Industrial and commercial receivers typically only operate within the daytime. Commercial and industrial receivers generally have a higher tolerance to noise than residential receivers and other types of sensitive receivers.	Local roadworks St Peters Interchange works	Canal Road construction compound (C8) Campbell Road construction compound (C9) Burrows Road construction compound (C11) Alexandra Canal construction compound (C12) Gardeners Road bridge construction compound (C13) Sydney Park construction compound (C14)	None
NCA06A	10-550 m	Receivers within NCA06A are primarily residential, comprising single and double storey terrace, semi-detached and detached houses. The existing acoustic environment is considered as urban and is dominated by road traffic travelling along the Princes Highway, Campbell Street and local roads. Aircraft noise also contributes to the noise environment.	Local roadworks St Peters Interchange works	Canal Road compound (C8) Campbell Road construction compound (C9) Landfill closure construction compound (C10) Sydney Park construction compound (C14)	M4-M5 Link tunnel stubs.
NCA06B	10-550 m	Receivers within NCA 6B are primarily residential, comprising single and double storey terrace, semi-detached and detached houses. The existing acoustic environment is considered as urban, but residences are shielded from direct road traffic noise by buildings. The background noise environment is contributed to by traffic noise from the Princes Highway and Campbell Street and rail traffic on the East Hills, Airport and Inner West railway line. Aircraft noise also contributes to the noise environment.	Local roadworks St Peters Interchange works	Canal Road compound (C8) Campbell Road construction compound (C9) Landfill closure construction compound (C10) Sydney Park construction compound (C14)	M4-M5 Link tunnel stubs.
NCA07	10-400 m	Receivers within NCA 7 comprise mostly commercial receivers (including a hotel), industrial receivers, with some residential receivers and a school. Residential receivers include single and double storey, terraced and detached buildings and two to three storey mixed-used buildings. The existing acoustic environment is considered as urban and is dominated by road traffic noise from the Princes Highway and to a lesser extent Campbell Street.	Local roadworks St Peters Interchange works	Canal Road compound (C8) Campbell Road construction compound (C9) Landfill closure construction compound (C10) Sydney Park construction compound (C14)	None

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
NCA08	10-250 m	<p>Receivers within NCA 8 are primarily residential single storey semi-detached and terraced houses.</p> <p>The existing acoustic environment is considered as urban and is dominated by road traffic on Princes Highway, Campbell Road, Campbell Street and Barwon Park Road.</p>	<p>Local roadworks</p> <p>St Peters Interchange works</p>	<p>Canal Road construction compound (C8)</p> <p>Campbell Road construction compound (C9)</p> <p>Landfill closure construction compound (C10)</p> <p>Alexandra Canal bridge construction compound (C12)</p> <p>Sydney Park construction compound (C14)</p>	None
NCA09	300-800 m	<p>Receivers within NCA 9 are predominantly residential single and double storey semi-detached and detached houses.</p> <p>The existing acoustic environment is considered as urban and is dominated by road traffic travelling along the Princes Highway and to a lesser extent Railway Road. Rail traffic on the East Hills, Airport and Inner West railway line also contributes to the ambient noise environment in addition to aircraft noise.</p>	Local roadworks	Canal Road compound (C8)	Main alignment tunnels.
NCA10	100-700 m	<p>Receivers within NCA 10 are predominantly industrial and commercial, with some single storey detached residential receivers along the Princes Highway.</p> <p>The existing acoustic environment is considered as urban and is dominated by road traffic travelling along the Princes Highway. Air traffic also significantly contributes to the noise environment.</p>	<p>Local roadworks</p> <p>St Peters Interchange works</p>	<p>Canal Road construction compound (C8)</p> <p>Landfill closure construction compound (C10)</p> <p>Burrows Road construction compound (C11)</p>	Main alignment tunnels.
NCA11	20-350 m	<p>Receivers within NCA 11 are predominantly industrial and commercial, with some medium density apartment buildings at the eastern side of the NCA.</p> <p>The existing acoustic environment is considered as urban and is dominated by road traffic movements along the Gardeners Road and O'Riordan Street.</p>	Local roadworks	<p>Canal Road construction compound (C8)</p> <p>Campbell Road construction compound (C9)</p> <p>Landfill closure construction compound (C10)</p> <p>Burrows Road construction compound (C11)</p> <p>Alexandra Canal bridge construction compound (C12)</p>	None
NCA T3	Above tunnel alignment	<p>Receivers in NCA T3 are a mix of low to medium density residential with commercial/industrial and some recreational land uses. The existing acoustic environment is considered as urban and is dominated by road traffic noise and aircraft noise from Sydney Airport</p>	None	None	Main alignment tunnels.

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
Arncliffe compound					
NCA12	20-350 m	Receivers within NCA 12 are primarily residential, comprising single or double storey detached houses. The existing acoustic environment is considered as urban and is dominated by road traffic travelling along Marsh Street, West Botany Street and the Princes Highway and aircraft noise from Sydney Airport.	There would be no impact from surface works	Arncliffe construction compound (C7)	None
NCA13	250-450 m	Receivers within NCA 13 are primarily residential, comprising mainly single storey detached houses. The existing acoustic environment is considered as urban and is dominated by road traffic travelling along the M5East Motorway, West Botany Street and Wickham Street and aircraft noise from Sydney Airport.	There would be no impact from surface works	Arncliffe construction compound (C7)	None
NCA14	300-650 m	Receivers within NCA 14 are primarily residential, comprising single and double storey detached houses. The existing acoustic environment is considered as urban and is dominated by road traffic travelling along the M5East Motorway and West Botany Street and aircraft noise from Sydney Airport.	There would be no impact from surface works	Arncliffe construction compound (C7)	None
NCA T2	Above tunnel alignment	Receivers in NCA T2 are predominantly low to medium density residential with commercial/industrial land uses. There are heritage properties identified within the NCA. The existing acoustic environment is considered as urban and is dominated by road traffic noise	None	None	Main alignment tunnels.
NCA T1	Above tunnel alignment	Receivers in NCA T1 are a mix of low to medium density residential and recreational land uses. There are heritage properties identified within the NCA. The existing acoustic environment is considered as urban.	None	None	Main alignment tunnels.
Bexley compound					
NCA15	10-450 m	Receivers within NCA 15 are primarily residential, comprising single and double storey detached houses. The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along Bexley Road.	Toll infrastructure works	Bexley Road North construction compound (C4) Bexley Road South construction compound (C5)	Main alignment tunnels.

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
NCA16A	10 to 500 m	Receivers within NCA 16A are primarily residential, comprising single and double storey detached houses. The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along Bexley Road and the M5 East Motorway.	Toll infrastructure works	Bexley Road North construction compound (C4) Bexley Road South construction compound (C5) Bexley Road East construction compound (C6)	None
NCA16B NCA16D	10 to 150 m	Receivers within NCA 16B and 16D are primarily residential, comprising single and double storey detached houses. The existing acoustic environment is considered as suburban and residences are shielded from noise generated by road traffic travelling along Bexley Road and the M5 East Motorway, although distant traffic still forms part of the background noise environment.	Toll infrastructure works	Bexley Road North construction compound (C4) Bexley Road South construction compound (C5) Bexley Road East construction compound (C6)	None
NCA16C	150 to 500 m	Receivers within NCA 16C are primarily residential, comprising single and double storey detached houses. The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along Bexley Road.	Toll infrastructure works	Bexley Road North construction compound (C4) Bexley Road South construction compound (C5) Bexley Road East construction compound (C6)	None
NCA17	30 to 750 m	Receivers within NCA 17 are primarily residential, comprising single and double storey detached houses. The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway, Bexley Road, Homer Street and to a lesser extent the local road network.	Western surface works Toll infrastructure works	Bexley Road North construction compound (C4) Bexley Road South construction compound (C5) Bexley Road East construction compound (C6)	None
NCA26A NCA26B NCA26C	50 to 1000 m	Receivers within NCA 26 are primarily residential, comprising single and double storey stand-alone houses. The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway and Bexley Road and by rail traffic on the East Hills and Airport railway line.	Toll infrastructure works Western surface works	Commercial Road construction compound (C3) Bexley Road North construction compound (C4) Bexley Road South construction compound (C5) Bexley Road East construction compound (C6)	Main alignment tunnels.

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
Kingsgrove Interchange					
NCA18	40 to 750 m	<p>NCA 18 comprises commercial, industrial and residential receivers. The residential receivers are generally single and double storey detached houses.</p> <p>The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway and Kingsgrove Road with some industrial noise contributions.</p>	Western surface works Toll infrastructure works	Kingsgrove North construction compound (C1) Kingsgrove South construction compound (C2) Commercial Road construction compound (C3)	None
NCA19	10 to 750 m	<p>Receivers within NCA 19 are primarily residential, comprising single and double storey detached houses. Some commercial receivers are located at the eastern side of the NCA.</p> <p>The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway and Moorefields Road.</p>	Western surface works	Kingsgrove North construction compound (C1) Kingsgrove South construction compound (C2) Commercial Road construction compound (C3)	None
NCA20	20 to 700 m	<p>Receivers within NCA 20 are primarily residential, comprising single and double storey detached houses.</p> <p>The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway and Moorefields Road.</p>	Western surface works	Kingsgrove North construction compound (C1) Kingsgrove South construction compound (C2)	None
NCA23	30 to 750 m	<p>Receivers within NCA 23 are primarily residential, comprising single and double storey detached houses.</p> <p>The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway and rail traffic on the East Hills and Airport railway line.</p>	Western surface works	Kingsgrove North construction compound (C1) Kingsgrove South construction compound (C2)	None
NCA24	20 to 650 m	<p>NCA 24 comprises residential and industrial receivers. The residential receivers include single and double storey detached houses</p> <p>The existing acoustic environment is considered as suburban and is dominated by road traffic travelling along the M5 East Motorway.</p>	Western surface works	Kingsgrove North construction compound (C1) Kingsgrove South construction compound (C2)	None

NCA	Offset distance to works	Description of NCA	Construction works which would potentially impact NCA		
			Surface works	Compounds	Tunnel works
NCA25	120 to 500 m	<p>NCA 25 comprises residential and industrial/commercial receivers. The residential receivers are generally single and double storey detached houses</p> <p>The existing acoustic environment is considered as suburban and is dominated by rail traffic travelling along the East Hills and Airport railway line and by road traffic on local roads.</p>	Western surface works	Kingsgrove North construction compound (C1) Kingsgrove South construction compound (C2) Commercial Road construction compound (C3)	None

Figure 2: Project alignment, compounds and Noise Catchment Areas - Kingsgrove



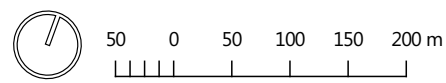
- Legend**
- AECOM EIS Noise Monitoring Locations
 - Additional monitoring locations (RTA)
 - Fixed Facilities
 - Compound sites
 - Noise catchment area

Client:
WestConnex New M5



Project:
 WestConnex Stage 2 M5

Description:
 Noise monitoring locations



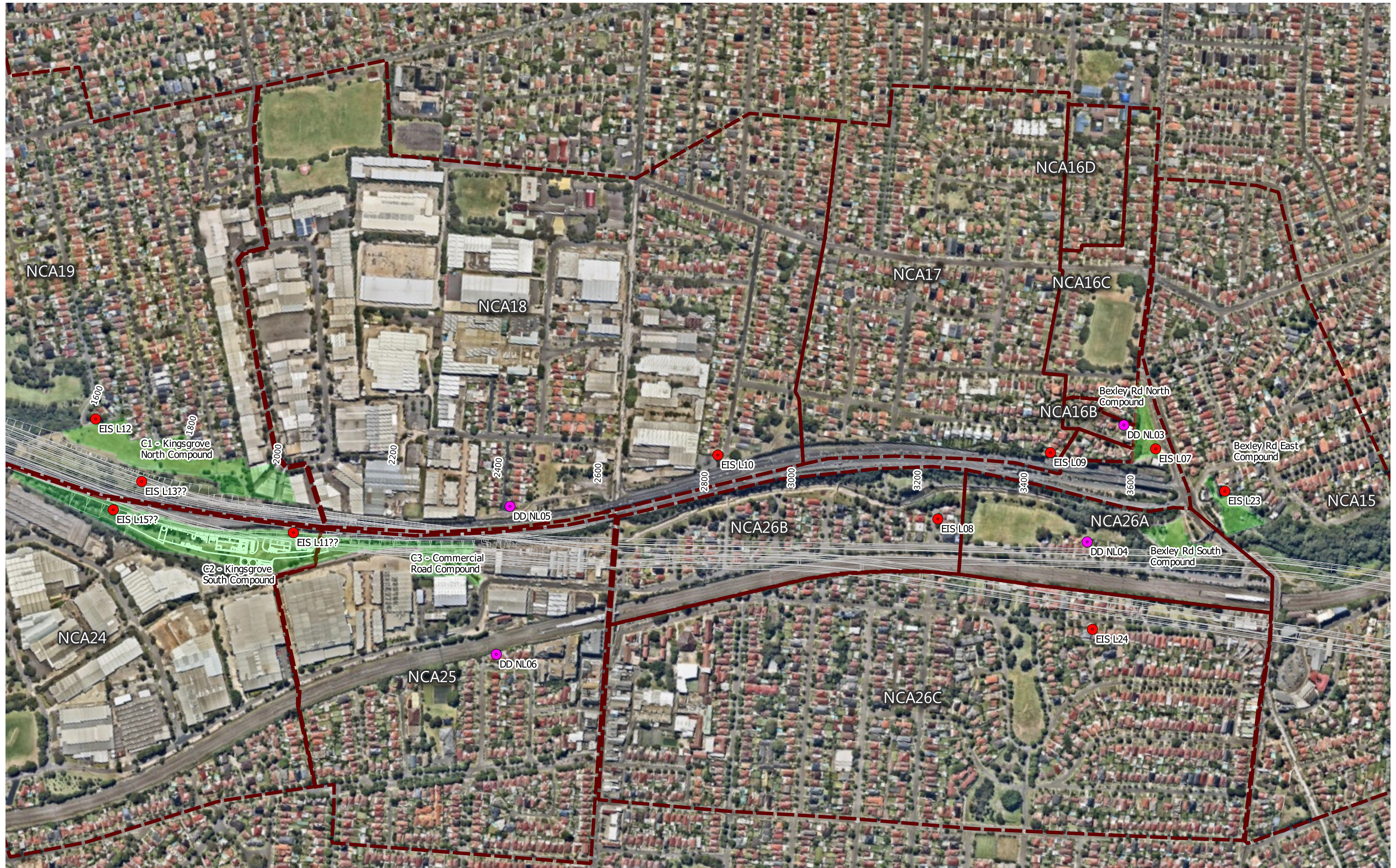
Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

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 Date: 29.07.2016
 Scale: 1:6,500 @ A3

Figure 3: Project alignment, compounds and Noise Catchment Areas - Kingsgrove-Bexley

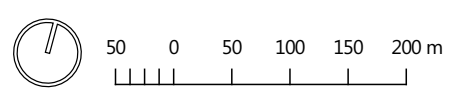


- Legend**
- AECOM EIS Noise Monitoring Locations
 - Additional monitoring locations (RTA)
 - Fixed Facilities
 - Compound sites
 - Noise catchment area

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

Description: **Noise monitoring locations**



Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

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Figure 4: Project alignment, compounds and Noise Catchment Areas - Arncliffe



- Legend**
- AECOM EIS Noise Monitoring Locations
 - Additional monitoring locations (RTA)
 - Fixed Facilities
 - Compound sites
 - Noise catchment area

Client:
WestConnex New M5

Project:
WestConnex Stage 2 M5

Description:
 Noise monitoring locations

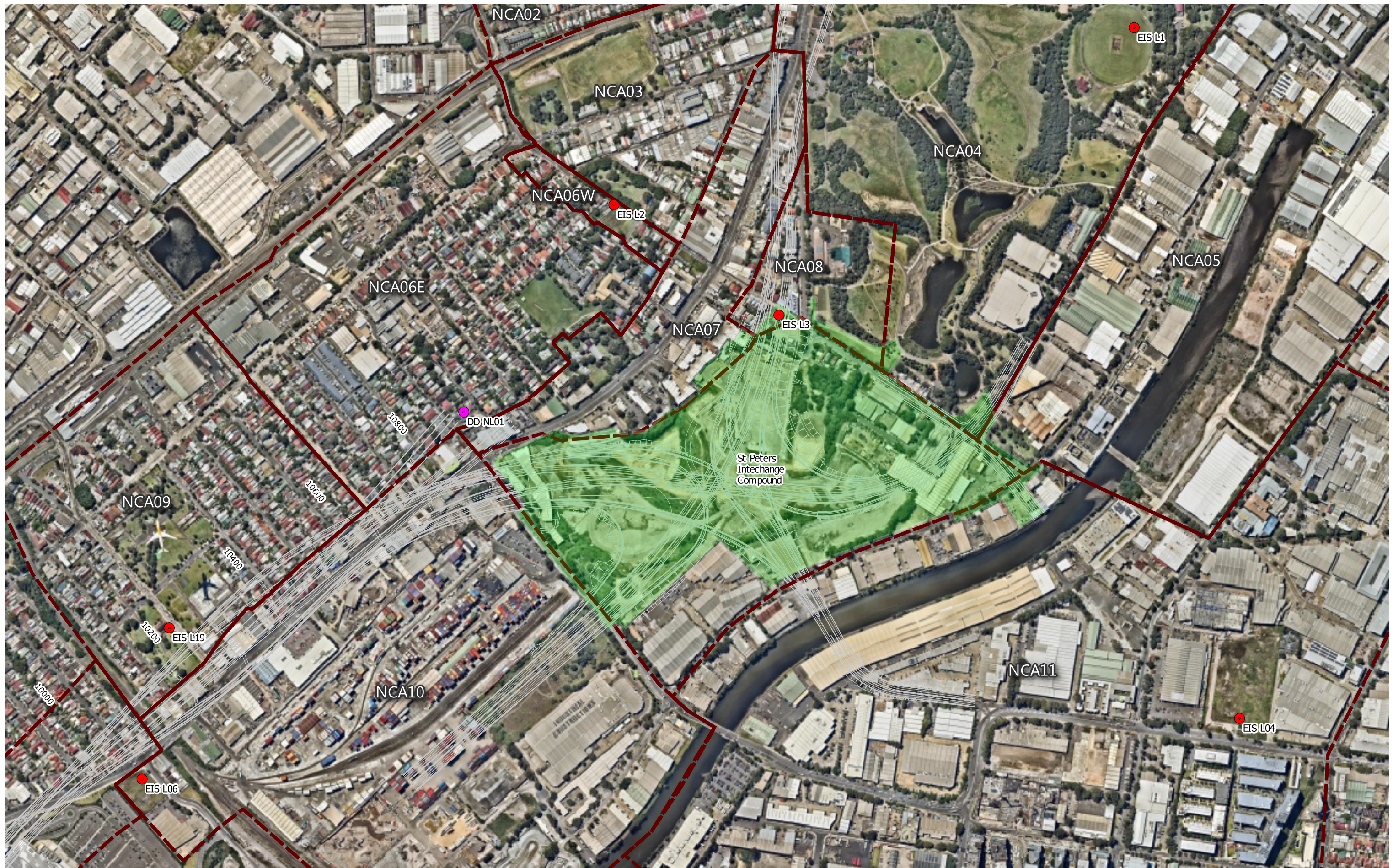
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Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

1/418A Elizabeth Street, SURRY HILLS NSW 2010
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 Date: 29.07.2016
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Figure 5: Project alignment, compounds and Noise Catchment Areas - St Peters

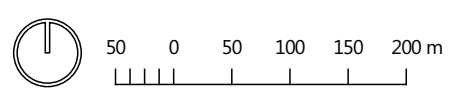


- Legend**
- AECOM EIS Noise Monitoring Locations
 - Additional monitoring locations (RTA)
 - Fixed Facilities
 - Compound sites
 - Noise catchment area

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

Description: **Noise monitoring locations**



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 Date: 29.07.2016
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3.2.2 Existing acoustic environment

The primary contributor to the ambient noise environment in the study area is traffic noise from the existing M5 South West Motorway. Other sub-arterial roads that contribute to the noise environment include Bexley Road, Kingsgrove Road and King Georges Road in the west, and Marsh Street, West Botany Street, and Princes Highway in the east. Other noise sources include the Main North Rail Line and aircraft noise associated with Sydney Airport.

Long-term noise monitoring was conducted by AECOM on behalf of SMC to quantify ambient noise levels for the Environmental Impact Statement (EIS). Section 3.5 of the EIS Noise and Vibration Technical Paper provides details of the resultant noise data used in the preparation of this CNVMP.

Additional pre-construction noise monitoring was carried out to establish more accurate noise goals for the updated Noise Catchment Areas (NCAs) around the construction compounds. Long-term, unattended noise monitoring was carried out between 16th to 30th June 2016. The results of the noise monitoring are documented in the Additional Noise Monitoring Report [ref: TH014-05 01F16 WXC_M5 Additional Monitoring (r1) dated 2016.07.04].

A summary of the background noise levels and subsequent Noise Management Levels for the purpose of managing airborne construction noise are summarised in APPENDIX C.

4 Construction noise and vibration management levels

4.1 Construction hours, limitations and approach to works

4.1.1 Construction hours

The construction hours for the Project are defined by the Conditions of Approval D12, D13, D14, D15 and D32.

The standard construction hours of work are summarised in the table below. Also summarised are the admissible hours for tunnelling (including tunnel support) and for activities resulting in impulsive or tonal noise emissions (e.g. rock hammering, sheet piling) and the recommended times within which blasting should be carried out.

The out-of-hours work (OOHW) period is defined in Table 4.1 as OOHW Period 1 and 2.

Table 4.1: Construction Hours

Reference	Construction Activity	Monday to Friday	Saturday	Sunday/ Public holiday
Recommended standard construction hours				
D12	Standard Construction	7:00 am to 6:00 pm	8:00 am to 1:00 pm	No work
D13	Tunnelling (and tunnel support)	24 hours	24 hours	24 hours
D14	Construction activities with impulsive or tonal noise emissions	8:00 am to 6:00 pm [^]	8:00 am to 1:00 pm [^]	No work
D32	Blasting	9:00 am to 5:00 pm	9:00 am to 1:00 pm	No blasting
Outside recommended standard construction hours				
D15 and TfNSW CNS*	Out of Hours Work (OOHW) Period 1	6:00 pm to 10:00 pm	7:00 am to 8:00 am 1:00 pm to 10:00 pm	8:00 am to 6:00 pm
	Out of Hours Work (OOHW) Period 2	10:00 pm to 6:00 am	10:00 pm to 7:00 am	6:00 pm to 8:00 am

Notes: [^] In continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block in accordance with CoA D14 (see Section 4.1.3 below)

* Transport for NSW Construction Noise Strategy (ref: 7TP-ST-157/2.0) April 2012

4.1.2 Tunnelling works

CoA D13 allows for tunnelling, including associated tunnelling activities such as tunnel support, to be undertaken 24 hours per day, seven days per week (as indicated in Table 4.1 above). Associated tunnelling activities, such as tunnel support works (which may be at surface level), must be justified and noise levels are to be assessed under the Interim Construction Noise Guideline (DECC, 2009).

This condition does not relate to any other activities associated with the project.

4.1.3 Noise intensive activities

4.1.3.1 High noise impact works

Construction activities proven to be particularly annoying to receivers are defined in the EPL as 'High Noise Impact Works'. These include: grinding metal, concrete or masonry, rock drilling, line drilling, smooth drum vibratory rolling, bitumen milling and profiling, jackhammering, rock-hammering or rock breaking, impact piling and other work occurring on surfaces that generates noise with impulsive, intermittent, tonal or low frequency characteristics. High Noise Impact Works shall, in accordance with CoA D14, only be undertaken:

- Between the hours of 8:00am to 6:00pm Monday to Friday
- Between the hours of 8:00am to 1:00pm Saturday,
- In continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block, except as expressly permitted by the EPL issued for the Project,
- Outside the above requirements if the Environment Protection Licence (upon issue) permits.

For the purposes of this requirement 'continuous' includes any period during which there is less than one-hour respite between ceasing and recommencing any of the work that is subject to this requirement.

It is noted that any high noise impact works undertaken include a 5 dB penalty added to the predicted noise levels to account for additional annoyance caused by these activities, in accordance with the ICNG (p16).

4.1.3.2 Highly noise affected receivers

Where construction activities result in noise levels that exceed the highly noise affected NML (i.e. above 75 dB(A), CDS will communicate with the impacted residents by clearly explaining the duration and noise level of the works, and inform of any respite periods. Respite periods will restrict the hours that the very noisy activities can occur, taking into account:

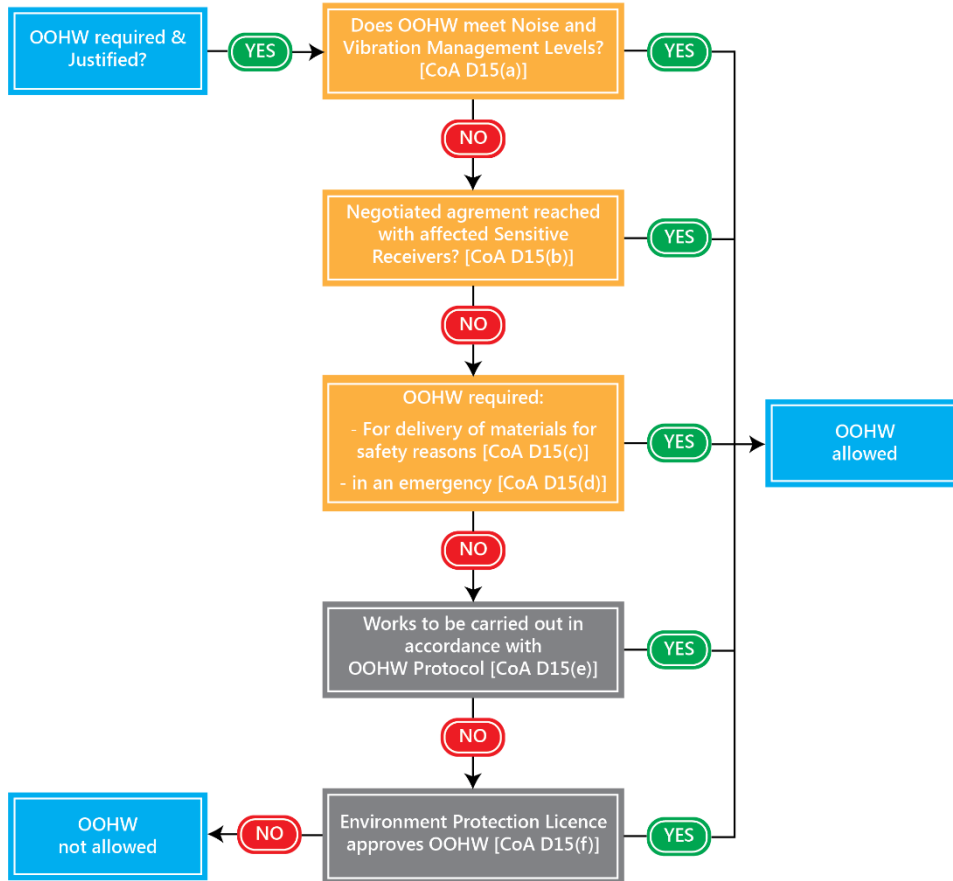
- Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

4.1.4 Construction work outside standard hours

CoA D15 allows for construction work associated with the New M5 to be undertaken outside standard construction hours, under defined circumstances. Construction Hours outside of standard construction

hours are defined in CoA D15. Figure 6 following shows the circumstances under which OOHW may be carried out.

Figure 6: Circumstances under which OOHW may be undertaken



NOTE: CDS-JV do not intend to seek approval for out-of-hours work by way of D15(e)

An Out of Hours Works Protocol has been prepared as part of the CNVMP and is presented in APPENDIX F. This protocol will be followed for all instances of OOHW.

4.1.5 Out-of-hours deliveries

Where possible, delivery of plant and equipment to the tunnel support and civil surface sites will be undertaken during standard construction hours. However, to support tunnel construction, some delivery of material, plant and equipment will be required out of hours to achieve the progress rates necessary to deliver the project to the required completion date, including oversized deliveries.

Oversized movements can cause disruptions to the existing traffic, and can be a potential hazard for road users. Therefore, there is a need for these vehicles to move during off-peak hours when traffic volumes are typically at a minimum, thereby ensuring road user and public safety and minimising disruption to the road network.

The transportation of oversized equipment and machinery may require the occupation of more than one traffic lane. Where this occurs, all movements are to be strictly in accordance with RMS guidelines for oversized movements and where required obtaining a permit from RMS's Special Permits Unit.

Out-of-hours deliveries (except in emergency situations) will be documented as part of the OOHW Procedure.

4.1.6 Approach to 24 Hour Tunnelling

Works in tunnels and underground activities (including the permanent shafts at Arncliffe) are to be undertaken 24 hours per day, seven days per week. EPL variations were issued in September 2016 following the commencement of site establishment, bulk earthworks/ excavation which proceeded to the extent that 24-hour tunnelling operations can occur. The EPL variation application was supported by:

- Construction Noise and Vibration Impact Statements (CNVISs) for the operation of each tunnelling support site (i.e. Kingsgrove North (C1), Commercial Road (C3), Bexley Road North (C4), Bexley Road South (C5), Arncliffe (C7) and Canal Road (C8);
- CNVIS for tunnelling works;
- Community Involvement Plan for tunnelling works

A staged approach to commencing 24 hour operations is proposed and indicative target dates are provided in Section 3.1. Assessment of tunnelling GBN and vibration impacts based on the preliminary design is included in Appendix D.7. This will be updated (if required) when the final design is reviewed.

The CNVISs will be a key site management tool to providing CDS with clear instructions for the management of each specific tunnelling support site and for the tunnelling operations. Each CNVIS will set out the mitigation measures that must be in place prior to the commencement of tunnelling works to satisfy CoAs D15 and D21, including noise walls, acoustic enclosures around fixed plant, and acoustic sheds, to mitigate the noise impacts of tunnelling support activities during 24 hour operations.

Surface works associated with tunnelling will be undertaken in accordance with any EPL requirements and the OOHW Protocol (APPENDIX E).

4.1.7 Approach to Blasting

Blasting may be used to reduce the tunnel excavation time and the need for long periods of heavy rock hammering. A Blast Management Strategy has been prepared in accordance with CoA D28 and was submitted to the Secretary prior to blasting. Blasting will be undertaken in accordance with the Blast Management Strategy, CoA D28 to D36 and the relevant conditions of the EPL.

In accordance with CoA D32, blasting associated with the project shall only be undertaken during the following hours:

- a. 9:00 am to 5:00 pm, Monday to Friday, inclusive;

- b. 9:00 am to 1:00 pm Saturday; and
- c. at no time on Sunday or on a public holiday.

An EPL variation was granted to allow Arncliffe blasting to be undertaken during the following hours:

- 7:00 am to 7:00 pm, Monday to Friday, inclusive;
- 9:00 am to 1:00 pm Saturday; and
- at no time on Sunday or on a public holiday.

Blasting may be carried out outside the above hours in the event of a direction from police or other relevant authority for safety or emergency reasons to avoid loss of life, property loss and/or to prevent environmental harm.

Potential vibration and air blast overpressure impacts generated through blasting will be managed primarily through the Blast Management Strategy under CoA D28. The Blast Management Strategy addresses:

- Blasting noise and vibration criteria, in accordance with conditions D34, D35 and D36 as set out in Section 4.5;
- Details of blasting to be performed, including location, method and justification of the need to blast;
- Identification of any potentially affected noise and vibration sensitive sites including heritage buildings and utilities;
- Establishment of appropriate criteria for blast overpressure and ground vibration levels at each category of noise sensitive site;
- Details of the storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction site;
- Identification of hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives;
- Determination of potential noise and vibration and risk impacts from blasting and appropriate monitoring and best management practices to minimise and manage any blasting impacts and assess compliance with conditions D34 and D35; and
- Community consultation procedures.

A site- and blast-specific assessment will be carried out once the proposed charge and blast configuration information becomes available. It is important that appropriate measures be taken to limit blast over-pressure and vibration to acceptable levels at the nearest affected receiver locations and, where relevant, the actual buffer zone relevant to the blast site be identified. Blast charge and blast

configurations shall therefore be selected to ensure the set blasting objectives identified in Section 4.5 are not exceeded.

In view of the proximity of some buildings to the New M5 tunnel alignment, a series of initial test blasts at reduced scale will be carried out prior to the commencement of full scale blasting in accordance with CoA D31. Air blast overpressure and vibration will be measured from test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions. This information will be used to define allowable blast sizes to meet the air blast overpressure and ground vibration limits, compliant with conditions D34 and D35.

To satisfy CoA D30, blasts shall be limited to an average of one single detonation in any one day per receiver group, and a maximum of six per week, unless otherwise agreed by the EPA through consultation on this CNVMP.

4.2 Airborne construction noise management levels

Construction noise management levels have been determined using the NSW Interim Construction Noise Guideline (ICNG), in accordance with CoA D16(a).

4.2.1 Residential receivers

Table 4.2 below (reproduced from Table 2 of the ICNG) sets out the noise management levels and how they are to be applied to residential receivers.

Table 4.2: Noise Management Levels at Residential Receivers

Time of Day	Noise Management Level $L_{Aeq(15min)}$	How to Apply
Standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: <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) • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times

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

4.2.2 Other noise sensitive receivers

Table 4.3 sets out the noise management levels for various noise-sensitive land use developments, including commercial premises adopted from the ICNG. The noise management levels are applicable where the premises are in use.

Table 4.3: Noise Management Levels at Other Noise Sensitive Land Uses

Land Use	Noise Management Level $L_{Aeq(15min)}$	Where NML Applies
Cinema Space	35 dB(A)	Internal noise level based on 'maximum' internal levels in AS2107
Classrooms at schools and other educational institutions	45 dB(A)	Internal noise level
Hospital wards and operating theatres	45 dB(A)	Internal noise level
Places of worship	45 dB(A)	Internal noise level
Community centres – Municipal Buildings	50 dB(A)	Internal noise level based on 'maximum' internal levels in AS2107
Active recreation areas (e.g. sports fields see Appendix A)	65 dB(A)	External noise level
Passive recreation areas (e.g. area used for reading, meditation, see Appendix A)	60 dB(A)	External noise level
Commercial premises (including offices and retail outlets)	70 dB(A)	External noise level
Industrial premises	75 dB(A)	External noise level

As identified for residential receivers, where the predicted or measured $L_{Aeq(15 min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted receivers of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

A highly affected noise objective of $L_{Aeq(15min)}$ 75dB(A) shall also apply at all 'other noise sensitive receivers'. Construction activity noise above this level should be handled as described in Table 4.2 above.

4.2.3 Sleep Disturbance

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the CNVIS (see Section 1.3.1) should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL. The ICNG also takes guidance from the NSW Environmental Criteria for Road Traffic Noise (ECRTN, Environment Protection Authority 1999) for recommended night time noise goals to minimise potential impacts and preserve acoustic amenity within receivers:

- Maximum internal noise levels below 50-55dB(A) are unlikely to cause awakening reactions.
- One or two events per night with maximum internal noise levels of 65-70dB(A) are not likely to affect health and wellbeing.

For each CNVIS addressing OOHW, an initial screening sleep disturbance criterion of $L_{A1(1min)} \leq L_{A90(15min)} + 15dB(A)$ shall be used as a first step guide. Where the screening criterion is not met, more detailed analysis will be incorporated into the CNVIS. The Application Notes of the NSW Industrial Noise Policy (2010) note the detailed analysis should include:

- the extent to which the maximum noise level emerge above the ambient L_{Aeq} noise level
- the number of times this happens during the night-time period, and
- the time of day (normally between 10pm and 7am).

4.2.4 High noise generating activities

In addition to the above, CoA D23 states that noise monitoring must be undertaken during initial high noise generating activities (such as piling, rock hammering, jack hammering) to accurately establish the $L_{A1(1min)}$ to L_{Aeq} differential and confirm the number of sensitive receivers which may experience sleep disturbance as a result of construction noise.

4.3 Construction Vibration Objectives

4.3.1 Human exposure to vibration

Vibration potentially disturbing human occupants of buildings is managed by reference to NSW DECC's 'Assessing Vibration; a technical guideline', published in February 2006, in accordance with CoA D16(b). This document provides criteria which are based on the British Standard BS 6472-2008, 'Evaluation of human exposure to vibration in buildings (1-80Hz)'.

Vibration sources are defined as Continuous, Impulsive or Intermittent. Table 4.4 provides a definition and examples of each type of vibration.

Table 4.4: Types of Vibration

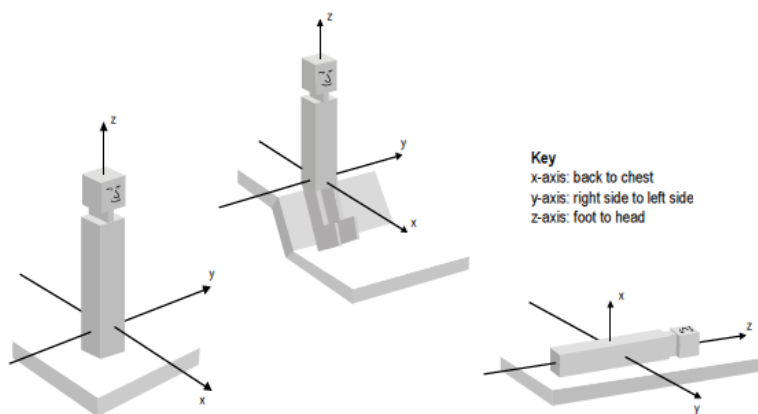
Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).	Machinery, steady road traffic, continuous construction activity (such as road headers).
Impulsive vibration	A rapid build-up to a peak followed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

Source: Assessing Vibration; a technical guideline, Dept Environment & Climate Change 2006

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states: 'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'

When applying the criteria, it is important to note that vibration may enter the body along different orthogonal axes, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). The three axes are referenced to the human body. Thus, vibration measured in the horizontal plane should be compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 7: Orthogonal axes for human exposure to vibration



Source: Assessing Vibration; a technical guideline, Dept Environment & Climate Change 2006 p4

Preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced below.

Table 4.5: Preferred and maximum levels for human comfort

Location	Assessment period ¹	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration³ (Weighted RMS Acceleration, m/s², 1-80Hz)					
Critical areas ²	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.040	0.029	0.080	0.058
Impulsive vibration³ (Weighted RMS Acceleration, m/s², 1-80Hz)					
Critical areas ²	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92
Intermittent vibration⁴ (Vibration Dose Values, VDV, m/s^{1.75}, 1-80Hz)					
Critical areas ²	Day- or night-time	0.10	0.20	-	-
Residences	Daytime	0.20	0.40	-	-
	Night-time	0.13	0.26	-	-
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40	0.80	-	-
Workshops	Day- or night-time	0.80	1.60	-	-

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above.

3. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-2008

4. For continuous and impulsive vibration the preferred and maximum values are weighted acceleration rms values (m/s²)

5. For intermittent vibration the preferred and maximum values are vibration dose values (VDVs), based on the weighted acceleration values (m/s^{1.75})

4.3.2 Structural damage to buildings

Currently there exists no Australian Standard for assessment of structural building damage caused by vibrational energy. Therefore, with regard to the assessing structural damage reference is made to German Standard DIN 4150: Part 3, which is referenced in the CoA D16(e).

The German Standard DIN 4150-3: 1999-02 - 'Structural vibration - Effects of vibration on structures', provides recommended maximum levels of vibration that reduce the likelihood of building damage

caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum 'safe limit' of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (e.g. historical with preservation orders), it is 3mm/s. These limits increase as the frequency content of the vibration increases. These values are presented in Table 4.6 are generally recognised to be conservative.

Table 4.6: DIN 4150-3 Structural damage criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		1 to 10 Hz	10 to 50Hz	50 to 100Hz ¹	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (e.g. buildings under a preservation order)	3	3 to 8	8 to 10	8

Note: At frequencies above 100 Hz, the values given in this column may be used as minimum values

Section 5.3 of DIN 4150: Part 3 also sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in Table 4.7 below.

Table 4.7: DIN 4150-3 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note: For gas and water supply pipes within 2 m of buildings, the levels given in Table 14 should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

For long-term vibration the guideline levels presented in Table 4.7 should be halved.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s. It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out. This may include a

specific CNVIS addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

4.3.3 Damage to vibration sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories utilise equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

There is no explicit guidance on acceptable vibration levels for such equipment, so recommended vibration levels should be obtained from instrument manufacturers. In the absence of equipment specific data provided by manufacturers, there are generic vibration criteria that can be used to assess the impact of vibration generating activities on buildings housing vibration sensitive equipment. For example, the Vibration Criteria (VC) curves are often referred to as they are generic and apply to all tools/ equipment types within each category. The VC curves are defined over the frequency range 8 to 100 Hz.

Table 4.8 below summarises a range of suitable and conservatively stringent vibration limits that are applicable to buildings housing vibration sensitive equipment which may potentially be affected by tunnelling works associated with the New M5 Project.

Table 4.8: Acceptable vibration limits for vibration measured on building structure housing sensitive equipment

Equipment Requirements	Vibration Limit ¹ mm/s,		Description of Use ³	Applicable Building for WCX New M5 Project
	RMS ⁴	Peak ⁵		
Computer Areas ²	0.7	1.0	Barely perceptible vibration. Adequate for computer equipment accommodation environments.	Preliminary review indicated none. TBC at detailed design.
Medical ^{2,3}	0.1	0.14	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.	Medical (sensitive equipment)
VC-A ³	0.05	0.07	Vibration not perceptible. Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc	Nil

Notes: 1. As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz. Vibration measured on the building structure near vibrating equipment or in areas containing sensitive equipment.

2. Based on AS 2834 Computer Accommodation (7)

3. Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment (7)

4. Root Mean Square value representing the average value of a signal

5. In the absence of Peak limits, RMS limits are converted to Peak by conservatively assuming the vibration signal is sinusoidal and random with a nominal crest factor of 1.414

4.4 Ground-borne construction noise management levels

Ground-borne noise management levels (GNMLs) are based on the ICNG, in accordance with CoA D16(a). Ground-borne noise is usually not a significant disturbance to building occupants during daytime periods due to higher ambient noise levels which mask the audibility of ground-borne noise emissions. During evening and night periods however, when ambient noise levels are often much lower, ground-borne noise is more prominent and may result in adverse comment from building occupants.

Table 4.9 below provides a summary of GNMLs, taken from the ICNG and from D16. These GNMLs apply where noise sensitive receivers are located above roadheader works or other construction activities (e.g. rock breaking) where ground-borne noise levels are higher than airborne noise levels.

Table 4.9: Ground-borne Noise Objectives at Residences

Time of Day	Ground-borne Noise Management Level, $L_{Aeq}(15\text{minute})$
Daytime 7:00am to 6:00pm	N/A - Human comfort vibration objectives only [as a guide 45 dB(A) internal]
Evening 6:00pm to 10:00pm	40 dB(A) internal
Night 10:00pm to 7:00am	35 dB(A) internal

For commercial receivers such as offices and retail areas, the ICNG does not provide guidance in relation to acceptable ground-borne noise levels. This CNVMP however has adopted an internal GNML derived from the airborne NML presented in the ICNG for commercial/ industrial premises and assuming a 10dB(A) noise reduction from outside to inside with windows open for ventilation. For other noise sensitive receivers, such as cinema spaces and recording studios, guidance has been taken from the recommended 'maximum' internal noise levels in AS/NZS 2107:2000 '*Acoustics - Recommended design sound levels and reverberation times for building interiors*' to determine suitable noise management levels.

The ground-borne noise objectives for 'other' noise sensitive land uses are identified below in Table 4.10.

Table 4.10: Ground-borne Noise Management Levels at 'Other' Noise Sensitive Land Uses

Land Use	Ground-borne Noise Management Level, $L_{Aeq}(15\text{minute})$
Cinema Space	35 dB(A) internal (when in use)
Classrooms at schools and other educational institutions	45 dB(A) internal (when in use)
Places of worship	45 dB(A) internal (when in use)
Commercial premises (including offices)	50 dB(A) internal (when in use)
Commercial premises (including retail outlets)	60 dB(A) internal (when in use)
Industrial premises	65 dB(A) internal (when in use)

Other noise sensitive receivers not identified above will be identified in the CNVISs prepared under this CNVMP.

4.5 Blast noise and vibration management levels

The Blast Management Strategy in APPENDIX I addresses blast management, including blasting outside standard conditions.

4.5.1 Airblast overpressure

Airblast overpressure generated by blasting associated with the project shall not exceed the criteria specified in CoA D34, reproduced in Table 4.11, when measured at the most affected residence or other sensitive receiver.

Table 4.11: Airblast overpressure criteria

Airblast overpressure (dB(Lin Peak))	Allowable Exceedance
115	5% of total number of blasts over a 12-month period
120	0%

4.5.2 Blast vibration (human comfort)

The criteria for managing ground vibration generated by blasting are outlined in CoA D35. The blast vibration criteria adopted in D35 are based on Australian Standard AS 2187.2-2006 'Explosives - Storage and use - Part 2 Use of explosives' and are designed to safeguard human comfort in relation to blasting. The human response to vibration from blasting is considered in terms of the likelihood of complaint, so that an appropriate community consultation program can be initiated to advise potentially affected receivers of the likely impacts from blasting. The Australian Standard suggests a limit of 10 mm/s PPV for human comfort for operations lasting less than 12 months, which would apply to this Project, as shown in Table 4.12.

Table 4.12: Ground Vibration Limits for human comfort (TABLE J4.5(A) AS 2187.2)

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site*	Operations lasting for less than 12 months or less than 20 blasts	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Notes: *A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

The recommendations in Table J4.5(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

4.5.3 Blast vibration (damage limits)

To assess the likelihood of building damage from blasting, we refer to the Australian Standard AS2187.2-2006. This document provides criteria which are based on the British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*'.

Table 4.13 sets out the criteria for cosmetic damage.

Table 4.13: Transient vibration guide values for cosmetic damage (TABLE J4.4.2.1 AS 2187.2).

Group	Type of structure	Peak component particle velocity, mm/s		
		4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50	50	50
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 to 20	20 to 50	50

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

4.5.4 Blast limit per day

CoA D30 states that blasts must be limited to an average of one single detonation in any one day, per sensitive receiver, and a maximum of six per week per sensitive receiver, unless otherwise agreed by the EPA through consultation on the Blast Management Strategy.

An EPL variation was approved to allow:

A maximum of two detonations may be undertaken in one day near the Arncliffe and St Peters construction site, provided that:

- (a) The detonations occur between chainages 8500 and 7500 for the Arncliffe site, and between chainages 8500 and 10895 for the St Peters site; and
- (b) No sensitive receiver is exposed to noise and vibration impacts from more than two detonations per day; and
- (c) No sensitive receiver is exposed to noise and vibration impacts from more than 12 detonations per week; and
- (d) The blasting does not occur outside of the hours of:
 - (i) 7am to 6pm Monday to Friday; and
 - (ii) 8am to 1pm on Saturdays;
- (e) No blasts are undertaken at any time on a Sunday or on a Public Holiday.

4.6 Construction related road traffic noise objectives

On the roads immediately adjacent to construction sites, the community may associate heavy vehicle movements with the New M5 project works. Construction traffic movements on public roads shall aim to minimise any sleep disturbance impacts in accordance with CoA D26. All feasible and reasonable noise mitigation and management measures shall be implemented. Any activities that could exceed the construction noise management levels shall be identified and managed in accordance with this CNVMP.

4.7 TfNSW construction noise strategy

The Transport for NSW a Construction Noise Strategy (2012) provides practical guidance on how to minimise, to the fullest extent practicable, the impacts on the community from airborne noise, ground-borne noise and vibration generated during the construction of infrastructure projects through the application of all feasible and reasonable mitigation measures.

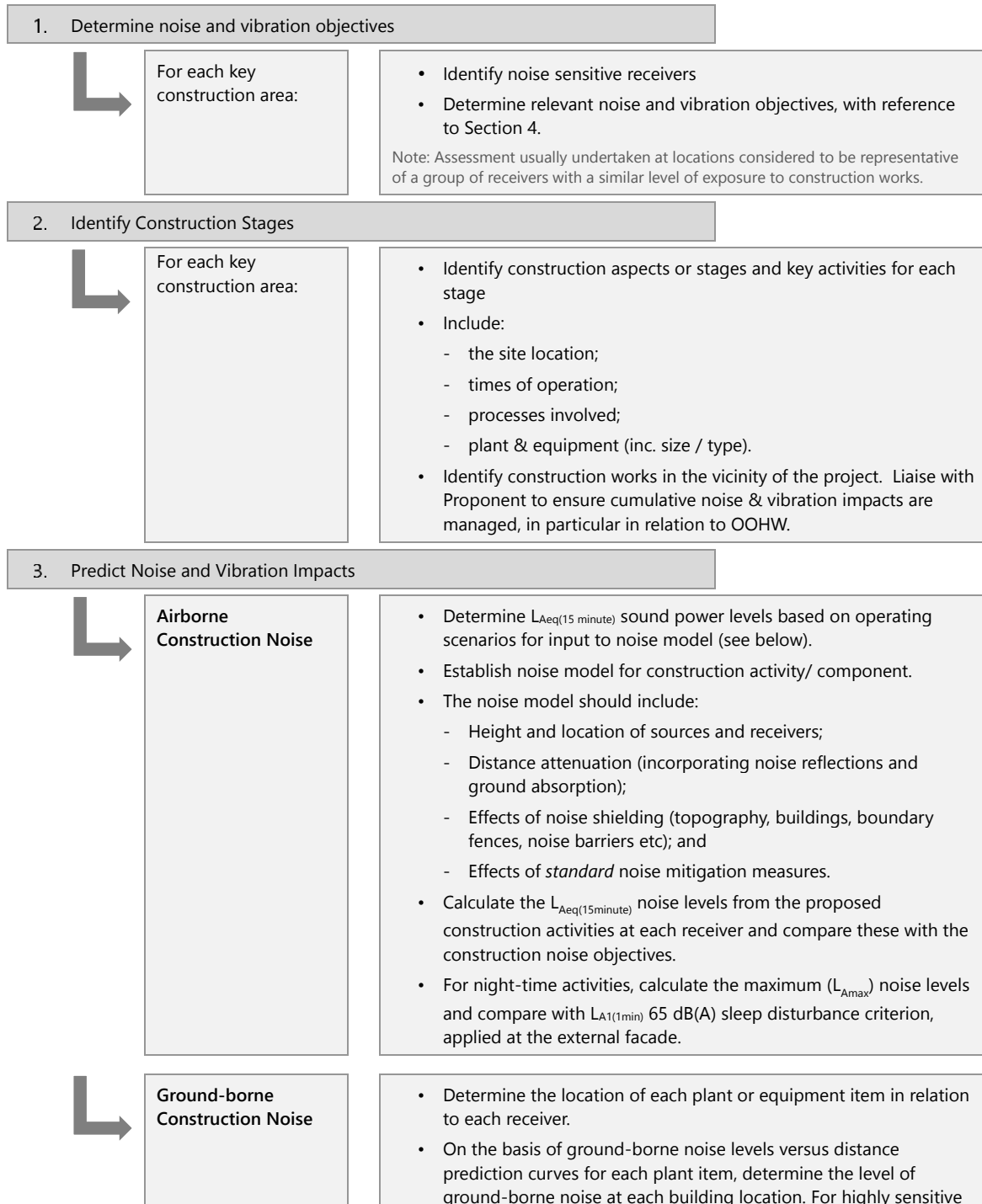
The TfNSW Construction Noise Strategy will be adopted by the project to assist in managing the impacts from construction noise and vibration.

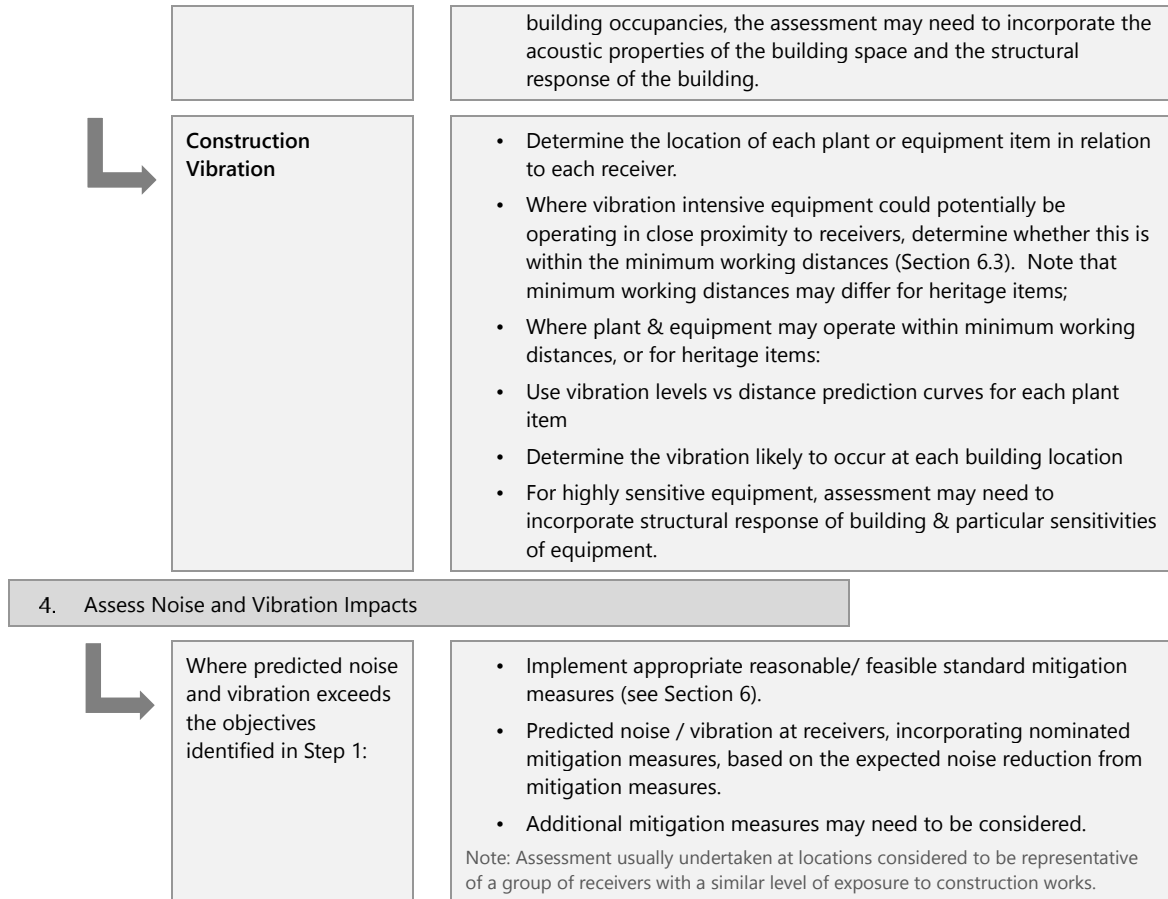
5 Construction noise and vibration assessment

5.1 Method for assessing construction noise and vibration

The process of assessment of construction noise and vibration impacts is detailed in Figure 8 below. This process will form the basis of the Construction Noise and Vibration Impact Statements (CNVISs) prepared to assess and manage each aspect of the construction of the Project.

Figure 8 Process for assessing construction noise and vibration





5.2 Construction noise and vibration impact statements

Detailed Construction Noise and Vibration Impact Statements (CNVIS) have been prepared for all construction sites and activities in accordance with this CNVMP. The CNVIS reports provide a detailed assessment of noise and vibration impacts from activities associated with the establishment and operation of the civil works areas and tunnel support facilities associated with the Project.

During the development of the site design, Renzo Tonin & Associates played a key role in assisting CDS to determine reasonable and feasible physical noise mitigation measures required to reduce noise impact from the construction of the Project. The mitigation measures have been documented in CNVIS reports for each site.

A summary of the CNVIS reports prepared under this CNVMP is provided in Table 5.1.

Table 5.1: Construction Noise and Vibration Impact Statements prepared under this CNVMP

Construction location	Construction activity	CNVIS reference
St Peters Interchange	Civil/ surface works - <ul style="list-style-type: none"> construction of compounds Canal Road (C8), Campbell Road (C9), Landfill closure (C10), Burrows Road (C11), Alexandra Canal (C12), Gardeners Road bridge (C13), Sydney Park (C14) construction of St Peters Interchange 	TH014-06 01F26 WXC_NM5 CNVIS SPI CV

Construction location	Construction activity	CNVIS reference
	Civil/ surface works - <ul style="list-style-type: none"> Local road works Construction of Campbell Road and Gardeners Road bridges 	TH014-06 01F27 WXC_NM5 CNVIS LRd CV
	Civil/ surface works - construction of tunnel support compound (C10) Tunnel support (C10)	TH014-06 01F24 WXC_NM5 CNVIS SPI TS
	Operational ancillary facilities - St Peters motorway operations complex (MOC4) and Burrows Road motorway operations complex (MOC5)	TH014-06 01F31 WXC_NM5 CNVIS SPI OF
Arncliffe	Civil/ surface works - construction of compounds Arncliffe (C7) Tunnel support - Arncliffe (C7)	TH014-06 01F23 WXC_NM5 CNVIS ARN TS
	Operational ancillary facilities - Arncliffe motorway operations complex (MOC3)	TH014-06 01F30 WXC_NM5 CNVIS ARN OF
	Permanent Shafts - Construction of permanent shafts at construction compound C7 including works 24/7	TH014-06 01F33.1 WCX_NM5 CNVIS Arncliffe PS (r1)
Bexley Road	Civil/ surface works - construction of compounds Bexley Road North (C4), Bexley Road South (C5) and Bexley Road East (C6) Tunnel support - Kingsgrove North (C1); Commercial Rd (C3)	TH014-06 01F22 WXC_NM5 CNVIS BXR TS
	Operational ancillary facilities - Bexley Road South motorway operations complex (MOC2)	TH014-06 01F29 WXC_NM5 CNVIS BXR OF
Kingsgrove Interchange	Civil/ surface works - construction of compounds Kingsgrove North (C1), Kingsgrove South (C2) and Commercial Road (C3); surface earthworks, construction of portals (cut & cover); M5 East road widening works	TH014-06 01F25 WXC_NM5 CNVIS KGR CV
	Civil/ surface works - construction of tunnel support compounds (C1 and C3) Tunnel support - Kingsgrove North (C1); Commercial Rd (C3)	TH014-06 01F21 WXC_NM5 CNVIS KGR TS
	Operational ancillary facilities - Kingsgrove motorway operations complex (MOC1)	TH014-06 01F28 WXC_NM5 CNVIS KGR OF
	Kingsgrove Concrete Batch Plant	TH014-10.14F01 (r3) WXC_NM5 CNVIS KGR BP
Project length	Site establishment - Kingsgrove North (C1), Kingsgrove South (C2), Commercial Road (C3), Bexley Road North (C4), Bexley Road South (C5) and Bexley Road East (C6), Arncliffe construction compound (C7), Canal Road (C8), Campbell Road (C9), Landfill closure (C10), Burrows Road (C11), Alexandra Canal (C12), Gardeners Road bridge (C13), Sydney Park (C14)	TH014-05 01F02 WCX_NM5 CNVIS
	Tunnelling	TH014-06 01F20 WXC_NM5 Tunnelling
OOHW	Site establishment OOHW - Power installation	TH014-05 01F03 CNVIS LAU001

A consolidated summary of the current CNVIS reports prepared for each site under this CNVMP is provided in APPENDIX D of this report, including a summary of the predicted construction noise impacts. Mitigation and management measures considered and where reasonable and feasible applied in each CNVIS are summarised in Section 6 following.

6 Management and Mitigation Measures

6.1 Roles and responsibilities

The roles and responsibilities of key New M5 Personnel with respect to construction noise and vibration are outlined in Table 6.1.

Table 6.1: Roles and responsibilities

Role	Responsibility with regard to construction noise and vibration
Project Director	<ul style="list-style-type: none"> Managing the delivery of the New M5 including overseeing implementation of noise and vibration management Act as Contractor's Representative
Commercial Director	<ul style="list-style-type: none"> Ensure that relevant noise and vibration management obligations are addressed in procuring materials and services.
Construction Directors	<ul style="list-style-type: none"> Manage the delivery of the construction process, in relation to noise and vibration management across all sites in conjunction with the Environment and Sustainability Manager
Quality Manager	<ul style="list-style-type: none"> Oversee tracking and reporting of noise and vibration against quality targets.
Environmental and Sustainability Manager	<ul style="list-style-type: none"> Oversee the implementation of all noise and vibration management initiatives Responsible for managing ongoing compliance with the environmental requirements. Ongoing assessment of f major site and works to ensure the adequacy of the noise and vibration mitigation measures for the actual design and construction methods.
Environmental Advisor Coordinators	<ul style="list-style-type: none"> Update this Plan in consultation with the Environmental and Approvals Manager Oversee implementation of noise and vibration management procedures on site
Project Manager, Senior Project Engineers, and Site Engineers and Supervisors	<ul style="list-style-type: none"> Implement noise and vibration management activities during construction works
Specialist Noise and Vibration Consultant	<ul style="list-style-type: none"> Specialist consultants will be engaged to undertake investigations, modelling, and specialised monitoring.
Community Relations Manager	<ul style="list-style-type: none"> Manage notification and consultation in relation to noise and vibration and liaise with the Environment and Sustainability Manager regarding the management of noise and vibration complaints. Undertaking activities required to consult, notify and deal with enquiries/complaints of Residential, Business and other Stakeholders
Specialist Noise and Vibration Consultant	<p>Renzo Tonin & Associates (RT&A) has been engaged as the specialist noise and vibration consultant to prepare this Plan. During delivery, RT&A will continue to provide specialist advice and services in the development and implementation of this Plan to ensure that impacts can be avoided, minimised or appropriately mitigated including:</p> <ul style="list-style-type: none"> Preparation of CNVISs Undertake some noise and vibration monitoring Assist with stakeholder meetings, where required Assist in community consultation, where required.

6.2 Standard noise and vibration management measures

Table 6.2 sets out an indicative list of standard noise and vibration mitigation measures to be implemented for the construction of the New M5 project as required to reduce construction noise and vibration, based on information available at the time of preparation of this CNVMP.

Table 6.2: Project noise and vibration mitigation and management measures

CDS No.	Action Required	Applies to	Details	Source	Responsibility
Construction Planning					
NVM1.	Building condition surveys	Vibration Blasting	Undertake building condition surveys on all buildings located within the determined minimum working distance or buffer zone prior to commencement of activities with the potential to cause property damage. Undertake condition surveys at potentially affected properties after the works.	RT&A recommended measure	Construction Director Community and Communications Manager
NVM2.	Implement community consultation measures – inform community of construction activity & potential impacts	Airborne noise Ground-borne noise Vibration Blasting	Refer to CEMP for community consultation measures.	CDS standard practice	Community and Communications Manager Environment and Sustainability Manager
NVM3.	Site inductions	Airborne noise Ground-borne noise Vibration	All employees, contractors & subcontractors are to receive a Project induction. The environmental component may be covered in toolboxes & must include: <ul style="list-style-type: none"> • Relevant licence & approval conditions • Permissible hours of work • Any limitations on high noise generating activities • Location of nearest sensitive receivers • Construction employee parking areas • Relevant site specific mitigation measures • Appropriate behavioural practises 	CDS standard practice	Environment and Sustainability Manager Environmental Advisors
NVM4.	Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height where practicable, throwing of items & slamming of doors.	CDS standard practice	Environment and Sustainability Manager Site Supervisors

CDS No.	Action Required	Applies to	Details	Source	Responsibility
NVM5.	Heavy Vehicle Code of Conduct		CDS has developed a Heavy Vehicle Code of Conduct for the Project (see Construction Traffic Management Plan (M5N-TM-PLN-PWD-0001)). The plan includes measures to ensure that the noise impacts of heavy vehicle traffic on surrounding streets are minimised. It will also instruct drivers to manage driving to minimise noise when entering and leaving the sites and driving through site, including when entering and leaving the spoil shed. Compression brakes will not be permitted to be used whilst vehicles are associated with the construction site.	CDS standard practice D26 D27	Environment and Sustainability Manager Environmental Advisors Site Supervisors
NVM6.	Equipment selection	Airborne noise Vibration	Use quieter & less noise/ vibration emitting construction methods where feasible & reasonable. Where noise/ vibration intensive equipment is used and is predicted to exceed noise/ vibration objectives, determine whether alternative construction methodology or less vibration intensive equipment can be used, eg. use bored piles rather than impact or percussion piling.	RT&A recommended measure D18	Project Managers Senior Project Engineers Project Engineers Site Supervisors
NVM7.	Rental plant and equipment	Airborne noise	The noise levels of plant & equipment items are to be considered in rental decisions.	RT&A recommended measure	Project Managers Senior Project Engineers Project Engineers Site Supervisors
NVM8.	Plan worksites and activities to minimise noise and vibration.	Airborne noise Vibration	Plan traffic flow, parking & loading/unloading areas to minimise reversing movements within the site.	CDS standard practice	Project Managers Senior Project Engineers Site Supervisors
NVM9.	Plan OOHW construction heavy vehicles movement on and off construction sites	Airborne noise Vibration	Heavy vehicle access and egress from site outside of standard construction hours will be via the major road network. Where practicable, restrict construction vehicle movements during the night-time along local roads to light vehicles only to limit potential night-time maximum noise events causing sleep disturbance	EIS V2C_Appl Section 11.4 D46	Project Managers Senior Project Engineers Site Supervisors
NVM10.	OOHW programming to limit consecutive nights of work	Airborne noise Vibration	OOHW should be programmed to minimise the number of consecutive nights work impacting the same receivers – likely to only apply to the moving corridor works and not the civil and tunnel sites.	EIS V2C_Appl Section 10.8.3	Project Managers Senior Project Engineers Site Supervisors

CDS No.	Action Required	Applies to	Details	Source	Responsibility
NVM11.	Liaise with Proponents of other construction works in the vicinity of the project		Proponents of other construction works in the vicinity of the project to be consulted and reasonable steps taken to coordinate works to minimise impacts on, and maximise respite for, affected sensitive receivers.	D25	Construction Director Community and Communications Manager
NVM12.	Community Consultation	Airborne noise Ground-borne noise Vibration	During construction, potentially-affected community, religious, educational institutions and vibration-sensitive business and critical working areas (such as theatres, laboratories and operating theatres) will be consulted to ensure that, where feasible and reasonable, noise generating construction works in the vicinity of the affected receivers are not timetabled during sensitive periods, unless other reasonable arrangements to the affected institutions are made at no cost to the affected institution. Consultation must be undertaken at least five days prior to undertaking noise generating construction works that would impact on the potentially affected vibration-sensitive receivers.	D24	Project Manager Community and Communications Manager
NVM13.	Ground-borne noise impact statement	Ground-borne noise	A detailed ground-borne noise assessment will be undertaken following further geotechnical investigations.	EIS commitment	Environment and Sustainability Manager Environmental Advisors
Hours of Work					
NVM14.	Construction hours and scheduling	Airborne noise Ground-borne noise Vibration	Where feasible & reasonable, construction should be carried out during the standard construction hours identified in Section 4.1.1 of this Plan. Work generating high noise and/or vibration levels should be scheduled as early as possible during the evening and/or night time periods, or during less sensitive time periods if practicable. Vibration intensive construction works will be confined to the less sensitive daytime period (9.00 am to 12.00 pm and 2.00 pm to 5.00 pm) as far as reasonably practicable.	RT&A recommended measure D12 D14 D17	Construction Director Site Supervisors
NVM15.	Construction respite period	Airborne noise Ground-borne noise Vibration	Any high noise impact works or activities with impulsive or tonal noise emissions (such as jack hammering, rock breaking, rock hammering, vibratory rolling) may only be undertaken as detailed in Section 4.1.3 of this report unless otherwise specified in the relevant approvals for the Project.	D14 EPL No. 20772 Condition L4.2	Project Manager Senior Project Engineers Site Supervisor

CDS No.	Action Required	Applies to	Details	Source	Responsibility
NVM16.	Out of Hours Works	Airborne noise Ground-borne noise Vibration	Out of Hours Works to be undertaken in accordance with: <ul style="list-style-type: none"> the Out of Hours Works Protocol, the Project EPL; and this CNVMP. 	D15 D68(b)(vi)	Construction Director Project Manager Senior Project Engineers Site Supervisor Environment and Sustainability Manager
NVM17.	Minimise disturbance arising from delivery of goods to construction sites.	Airborne noise	Ensure all deliveries occur during standard construction hours, except where detailed in Section 4.1.5. Loading and unloading will be carried out away from sensitive receivers, where practicable.	RT&A recommended measure	Project Manger Project Engineer Site Supervisor
Source Controls.					
NVM18.	Maximum noise levels	Airborne noise	All plant & equipment to be appropriately maintained to ensure optimum running conditions, with periodic monitoring as per Section 7.	RT&A recommended measure EIS V2C_Appl Section 10.8.3	Project Managers Project Engineers Site Supervisors
NVM19.	Use and siting of plant	Airborne noise Vibration	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be limited/ avoided where possible. The offset distance between noisy plant & adjacent sensitive receivers is to be maximised where practicable. Plant used intermittently to be throttled down or shut down when not in use where practicable. Noise-emitting plant to be directed away from sensitive receivers where possible, particularly during OOHW. NOTE: Due to limited land available for construction this may not at times be practical.	RT&A recommended measure	Project Managers Project Engineers Site Supervisors
NVM20.	Non-tonal reversing alarms.	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted & used on all construction vehicles & mobile plant regularly used on site	D26 RT&A recommended measure	Construction Director Project Managers Project Engineers Site Supervisors

CDS No.	Action Required	Applies to	Details	Source	Responsibility
NVM21.	Reduced scale blast trials	Airblast overpressure & Vibration	Carry out noise and vibration measurements on a series of smaller test blasts to establish appropriate propagation characteristics for the site. Use results to more accurately predict noise & vibration once the proposed charge & blast configuration information is determined.	D31 RT&A recommended measure	Construction Director Project Manager Environment and Sustainability Manager
NVM22.	Limit blast detonation	Airblast overpressure & Vibration	Unless otherwise agreed by the EPA, blasts will be limited to an average of one single detonation per receiver group in any one day, and a maximum of six per week.	D30	Project Manager Senior Project Engineers Site Supervisors
Path Controls					
NVM23.	Shield sensitive receivers from noisy activities.	Airborne noise	<p>Where reasonable & feasible, use structures to shield residential receivers from noise such as:</p> <ul style="list-style-type: none"> • Site shed placement • Earth bunds • Hoarding • Enclosures to shield fixed noise sources such as pumps, compressors, fans etc. (where practicable) <p>Temporary noise walls identified in APPENDIX G have been determined in consultation with the community, as required by Condition D20, and presented in the Temporary Noise Barrier Strategy.</p>	CDS standard practice RT&A recommended measure	Project Managers Senior Project Engineers Project Engineers Site Supervisors
NVM24.	Operational noise mitigation measures or equivalent temporary measures		<p>Where reasonable & feasible, operational noise mitigation measures or equivalent temporary measures will be installed at the start of construction, and in areas identified as having high noise impacts (including at or adjacent to construction work sites or ancillary facilities), and where existing noise barriers are to be altered.</p> <p>Where this is not feasible and reasonable, a report will be submitted to the Secretary for approval providing justification as to why along with details of the temporary measures that would be implemented to reduce construction noise impacts until such time that the operational noise mitigation measures are implemented. The report will be provided to the Secretary prior to the commencement of construction works which would affect the identified receivers.</p>	D19	Construction Director Project Manager Site Supervisors Environment and Sustainability Manager

CDS No.	Action Required	Applies to	Details	Source	Responsibility
NVM25.	Roadside temporary noise wall (variable height)	Airborne noise	<p>Relocatable noise walls constructed concrete jersey barrier with plywood hoarding mounted above. Relocatable noise walls may require back propping to a second concrete barrier. The higher the noise wall the higher the rake of the back bracing, so the more space required.</p> <p>Temporary noise walls identified in APPENDIX G have been determined in consultation with the community, as required by Condition D20, and presented in the Temporary Noise Barrier Strategy.</p>	RT&A recommended measure D20	Project Manager Senior Project Engineers Site Supervisors Environment and Sustainability Manager
NVM26.	Establish buffer zones	Airblast overpressure Vibration	<p>Establish a zone of affectation around the site, whilst taking into account adverse meteorological conditions.</p> <p>Identify site specific minimum working distances for vibration generating plant and equipment (see NVM29)</p>	RT&A recommended measure D68(b)(viii)	Project Manager Project Engineers
Monitoring					
NVM27.	Monitoring	Airborne noise Ground-borne noise Vibration	<p>Air blast overpressure, noise & vibration monitoring will be monitored during construction:</p> <ul style="list-style-type: none"> As detailed in Section 7; As required by any EPL granted for this Project. <p>Any necessary adaptive management requirements will be identified and implemented where reasonable and feasible.</p>	CDS standard practice RT&A recommended measure EIS commitment	Environment and Sustainability Manager Environmental Advisors
NVM28.	Verification testing of plant and equipment	Airborne noise	<p>Regular noise emissions verification checks on all plant and machinery used for the Project would identify whether the noise emissions are higher than assumed in the EIS and the design. This process also identifies defective silencing equipment on items of plant.</p> <p>Verification monitoring would occur prior to the commencement of high noise generating activities during the night period, such as piling, rock hammering, jack hammering to accurately establish the L_{Aeq} to L_{A1} (1 minute) differential to assist in verifying noise modelling and confirm the number of sensitive receivers which may experience sleep disturbance as a result of construction of the SSI during the evening and night-time periods.</p>	EIS V2C_Appl Section 10.8.3	Site Supervisors Environment and Sustainability Manager Environmental Advisors
NVM29.	Site specific attended vibration measurements	Vibration	Representative attended vibration measurements prior to vibration generating activities commencing to confirm that vibration is within the acceptable range to prevent cosmetic building damage.	CDS standard practice EIS V2C_Appl Section 10.8.3	Environment and Sustainability Manager

CDS No.	Action Required	Applies to	Details	Source	Responsibility
EPL					
NVM30.	Implementation of any additional measures required by the EPL conditions	Airborne noise Vibration	Additional measures required by any EPL granted for this Project are to be implemented as required.	CDS standard practice	Construction Director Project Manager Environment and Sustainability Manager

6.3 Minimum working distance

As a guide, indicative minimum working distances for typical items of vibration intensive plant and equipment are provided in Table 6.3 below. The minimum working distances are quoted for the purpose of minimising:

- Cosmetic damage (referenced from British Standard BS 7385 Part 2-1993 and German Standard DIN 4150-1999); and
- Human response (referenced from Assessing Vibration: a technical guideline (DEC, 2006)).

The minimum working distances for 'cosmetic' damage nominated in Table 6.3 must be complied with at all times, unless additional assessment and/or monitoring is undertaken to determine site specific minimum working distances.

Table 6.3: Recommended Minimum Working Distances for Vibration Intensive Equipment

Plant item	Rating description	Minimum working distance, m			
		Cosmetic damage			Human Response
		Residential & Light Commercial ¹	Group 2 (Typical) ²	Group 3 (Structurally unsound) ²	
Vibratory Roller	< 50 kN (Typically 1-2t)	5	7	11	15-20
	< 100 kN (Typically 2-4t)	6	8	13	20
	< 200 kN (Typically 4-6t)	12	16	15	40
	< 300 kN (Typically 7-13t)	15	20	31	100
	> 300 kN (Typically 13-18t)	20	26	40	100
	> 300 kN (Typically > 18t)	25	33	50	100
Small Hydraulic Hammer	300 kg - 5 to 12t excavator	2	3	5	7
Medium Hydraulic Hammer	900 kg - 12 to 18t excavator	7	10	15	23
Large Hydraulic Hammer	1600 kg - 18 to 34t excavator	22	29	44	73
Vibratory Pile Driver	Sheet piles	2-20	3	5	20
Pile Boring	≤ 800 mm	2	3	5	N/A
Jackhammer	Hand held	1	2	3	Avoid contact with structure
Roadheader ⁴	Tunnelling	2	3	5	7
Truck traffic	over smooth surfaces	1	1	2	10
Truck traffic	over irregular surfaces	5	7	10	20
Blasting Operations ⁵		TBC	TBC	TBC	TBC

Note 1: Criteria referenced from British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2

Note 2: Criteria referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration (including heritage items)

Note 3: Criteria referenced from EPA's Assessing Vibration: a technical guideline (DEC, 2006)

Note 4: Measurement from RT&A database

Note 5: To be determined during test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions and confirmed in the Blast Management Strategy (APPENDIX I)

6.4 Property condition surveys

Property condition surveys fall into four subcategories: residential, commercial, roads and utilities. Each subcategory is being administered by a different subcontractor. Pre-construction ground and infrastructure condition surveys are undertaken with the agreement of the property owner and any occupier. Surveys must be carried out by an independent assessor, who is appropriately qualified and experienced for the specific element of ground or infrastructure being surveyed.

Property condition survey invitations are sent via mail – two letters, sent ten working days apart – and further contact is made via phone calls and/or doorknocks with those who do not respond. Letters are sent by the Property team. Direct community contact in the form of phone calls and doorknocks are conducted by the Community team. To date, contact has been made with all asset owners affected by surface construction. The Property team will begin contacting those impacted by substratum works, following written advice to those property owners by Sydney Motorway Corporation (SMC) commencing on 4 July 2016.

The subcontractors issue CDS JV with a hard copy report, and an electronic copy in pdf format; this must be completed within five working days of the completion of the survey. Reports must contain both a written summary and high resolution digital still photos. Written reports provide an indicative assessment of the overall condition of the building, in particular noting any defects or observable problem areas, and are reviewed by the subcontractor's appropriately qualified structural engineer. The interior and exterior of the properties are digitally photographed using a high resolution digital camera. All images are electronically stored and transferred to a CD, which is appended to each report. CDS JV prepares a detailed record that, at a minimum, includes dated photographs of the pre-construction conditions of all the ground and infrastructure that may be affected, and summary descriptions of the pre-construction condition of the ground and infrastructure.

Both written reports and CDs are mailed out to the asset owner. By agreement, electronic copies of reports are made available to the client (SMC) and the Independent Certifier via TeamBinder.

6.5 Additional noise and vibration mitigation measures

Table 6.4 below should be used to advise the appropriate additional noise mitigation, based on the TfNSW Construction Noise Strategy.

Table 6.4: Additional Airborne Noise Mitigation Measures

Construction hours	Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			Additional mitigation measures	Additional mitigation measure code
	Receiver perception	dB(A) above RBL	dB(A) above NML		
Standard Hours	Noticeable	5 to 10	0	-	-
	Clearly Audible	10 to 20	≤ 10	-	-
	Moderately intrusive	20 to 30	10 to 20	LB, V	AM2
	Highly intrusive	> 30	> 20	LB, V	AM2
	75dBA or greater	N/A	N/A	LB, SN, V	AM3

Construction hours	Predicted airborne $L_{Aeq}(15min)$ noise level at receiver			Additional mitigation measures	Additional mitigation measure code
	Receiver perception	dB(A) above RBL	dB(A) above NML		
OOHW Period 1	Noticeable	5 to 10	≤ 5	-	-
	Clearly Audible	10 to 20	5 to 15	LB	AM1
	Moderately intrusive	20 to 30	15 to 25	LB, V	AM2
	Highly intrusive	> 30	> 25	LB, SN, RO, V	AM4
OOHW Period 2	Noticeable	0 to 10	< 5	LB	AM1
	Clearly Audible	10 to 20	5 to 15	LB, V	AM2
	Moderately intrusive	20 to 30	15 to 25	LB, SN, V	AM3
	Highly intrusive	> 30	> 25	LB, SN, AA, V	AM5

Notes: LB = Letter box drops SN = Specific notification, Individual briefings, or Phone call RO = Project specific respite offer V = Verification of predicted noise level AA = Alternative accommodation

Table 6.5 should be used to advise the appropriate additional ground-borne noise mitigation, based on the TfNSW Construction Noise Strategy.

Table 6.5: Additional Ground-borne Noise Mitigation Measures

Construction hours	Predicted ground-borne $L_{Aeq}(15min)$ noise level at receiver		Additional mitigation measures	Additional mitigation measure code
	Receiver perception	dB(A) above GNML		
Standard Hours#	Noticeable	< 10	LB	GM1
	Moderately intrusive	10 to 20	LB, V	GM2
	Highly intrusive	>20	LB, SN, V	GM3
OOHW Period 1	Noticeable	< 10	LB, V	GM2
	Moderately intrusive	10 to 20	LB, SN, RO, V	GM4
	Highly intrusive	>20	LB, SN, RO, V	GM4
OOHW Period 2	Noticeable	< 10	LB, SN, V	GM3
	Moderately intrusive	10 to 20	LB, SN, RO, AA, V	GM5
	Highly intrusive	>20	LB, SN, RO, AA, V	GM5

Notes: LB = Letter box drops SN = Specific notification, Individual briefings, or Phone call RO = Project specific respite offer V = Verification of predicted GBN levels AA = Alternative accommodation

GBNML not applicable during standard hours, vibration goals apply. However, in the interest of ensuring adequate community consultation and management of impacts in relation to tunnelling GBN during the day period, guidance for receiver perception of GBN has been derived from AS2107:2000 and the ICNG

Table 6.6 should be used to advise the appropriate additional ground-borne vibration mitigation, based on the TfNSW Construction Noise Strategy.

Table 6.6: Additional Vibration Mitigation Measures

Construction hours	Predicted vibration at receiver	Additional mitigation measures	Additional mitigation measure code
Standard Hours	Vibration above VML	LB, RO, V	VM1

Construction hours	Predicted vibration at receiver	Additional mitigation measures	Additional mitigation measure code
OOHW Period 1	Vibration above VML	LB, SN, RO, V	VM2
OOHW Period 2	Vibration above VML	LB, SN, RO, AA, V	VM3
Notes:	LB = Letter box drops V = Verification of predicted GBN levels	SN = Specific notification, Individual briefings, or Phone call	RO = Project specific respite offer AA = Alternative accommodation

If the predicted ground-borne vibration levels exceed the structural damage objectives in Section 4.3.2, a different construction method with lower source vibration levels should be considered. Attended measurements should be undertaken at the commencement of all high vibration generating activities. If there is any risk of exceedance of the structural damage objective, a permanent vibration monitoring system should be installed, to warn plant operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching the structural damage objective.

6.6 Residual impacts

At some receiver locations, noise and/ or vibration may exceed the management levels even after all reasonable and feasible noise and vibration management measures have been considered and adopted, resulting in residual impacts. Residual impact management, including respite offers, alternative accommodation and at-property treatment, will be addressed on a site by site basis in each CNVIS prepared under this CNVMP. Furthermore, a negotiated agreement can be sought with the affected receivers in accordance with CoA D15(b).

Residual impacts identified in the CNVIS assessment will be verified once site access is gained and prior to the commencement of 24 hour operations. For example, on site testing of trucks entering, exiting and driving on site will be used to verify noise levels predicted by the airborne noise model.

Some of the considerations for residual impact management are outlined in the following sub-sections.

6.6.1 Exposure to high construction noise (standard hours)

Receivers exposed to airborne noise more than 30 dB(A) above the RBL will be located fairly close to the works area. This will typically be during high noise activities such as rockbreaking and piling associated with shaft/ portal/ decline excavation and receivers in close proximity to the civil and local road works. The CNVIS reports will clearly identify highly noise affected receivers (over 75 dB(A) in day). Under our CNVMP receivers exposed to over 75 dB(A) during the day require specific notification, which may include a phone call, letter or direct visit. This approach would provide the opportunity to confirm whether the residents may be sleep impacted during the day. Alternative arrangements can then be made on a case by case basis.

6.6.2 Short-term OOHW residual impacts

With the exception of the tunnel support sites, where 24 hour works are planned to support the tunnelling works, construction of the Project is anticipated to be largely carried out during standard construction hours. Exceptions to this would be out of hours work under CoA D15. Works that meet CoA D15(a), (b), (c) or (d) would not incur residual impacts. Works that fall under CoA D15 (e) or (f) may potentially cause residual impacts, where all reasonable and feasible noise mitigation has been exhausted. These works would require a CNVIS to identify impacts and recommend suitable mitigation and management measures to satisfy CoA D15, including how residual impacts are managed.

All reasonable and feasible mitigation must be explored for a work activity prior to addressing residual impacts. Residual impacts resulting from short term OOHW will be managed in accordance with the additional noise and vibration mitigation measures outlined in Section 6.5 Short term residual impacts are managed based on the level of exceedance of the management level, namely:

- Exceeds management level, but below the alternative accommodation trigger: consideration will be given to offering respite in the form of noise cancelling headphones, movie tickets, coffee vouchers or similar.
- Exceeds management level AND the alternative accommodation trigger: consideration will be given to offering alternative accommodation for the duration of the noise or vibration impact where this occurs over 2 or more consecutive nights.

6.6.3 Long-term OOHW residual impacts

Long term residual impacts during the OOHW period are associated with the 24-hour tunnel support sites, where trucks require 24-hour access to the site. Exceedance of the OOHW NMLs is predicted to occur at receivers near the:

- Kingsgrove Road north tunnel support construction compound (C1);
- Bexley Road North tunnel support construction compound (C4);
- Arncliffe tunnel support construction compound (C7); and
- SPI tunnel support construction compound (C10).

A conservative, worst-case list of properties that may experience long term exceedance of the NMLs during out of hours works, namely tunnel support works, are included in Table E.1 of APPENDIX E. Note that all reasonable and feasible noise mitigation measures have been incorporated into the design of the tunnel support sites (see APPENDIX G). Works have been scheduled to occur during standard construction hours as much as practicable. Out-of-hours tunnel support works allow the tunnelling works to progress 24 hours per day, 7 days per week in accordance with Condition D13.

These receivers may also potentially be exposed to noise levels that cause sleep disturbance from trucks arriving and exiting the site. The CNVIS reports outline the at-property treatment requirements to be considered for each tunnel support site.

The list presented in Table E.1 based on the current design and represents the conservative, worst-case list of properties that may require treatment. This will be confirmed once site access is gained and prior to the commencement of 24 hour works that are predicted to exceed the NML. Residual impact management measures will be implemented prior to the commencement of works that trigger exceedance of the NMLs, as outlined in Table E.1.

6.6.4 Properties eligible for consideration of operational at-property treatment

CoA D19 requires the CDS JV to implement, where feasible and reasonable, the operational noise mitigation measures (such as noise barriers or at-property architectural treatments) in areas where receivers would be subject to construction noise impacts as identified in:

- New M5 Environmental Impact Statement - Volumes 1A, 18, 1C, 2A, 28, 2C, 2D, 2E, 2F,2G and 2H prepared by AECOM Australia, dated November 2015; and
- New M5 Submissions and Preferred Infrastructure Report - Volumes 1A, 18 and 2 prepared by AECOM Australia, dated March 2016

Condition D19 also applies to areas where existing noise barriers are to be altered or removed prior to commencement of construction.

Where this is not feasible and reasonable, CDS JV will submit to the Secretary for approval a report providing justification as to why along with details of the temporary measures that would be implemented to reduce construction noise impacts until such time that the operational noise mitigation measures are implemented. The report will be provided to the Secretary prior to the commencement of construction works which would affect the identified receivers.

Table E.2 in APPENDIX E summarises the properties identified in the above referenced documents and outlines the timeframe for at-property treatment.

6.7 At-property treatment

Table 6.7 provides guidance on the level of treatment required in relation to the exceedance above the external NML. The type of treatment nominated for each receiver is presented in APPENDIX E.

Table 6.7: At-property treatment recommendations

Treatment type	Level of reduction	Description of treatment
Treatment 1A Mechanical ventilation only	<5dB(A) reduction	Where external noise levels are less than 5dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. If the internal noise goals can be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia. It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.

Treatment type	Level of reduction	Description of treatment
Treatment 1B Mechanical ventilation, sealing of wall vents and upgraded seals for windows and doors	5-10dB(A) reduction	<p>Where external noise levels are less than 10dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed and wall vents are sealed. Special acoustic grade seals may also need to be installed on windows and perimeter doors exposed to noise to enable the internal noise criteria to be achieved with windows and doors shut.</p> <p>If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.</p>
Treatment 2 Upgraded seals for windows and doors	> 10 dB(A) reduction	<p>Where the predicted external noise level exceeds the external assessment criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors would be required on the facades exposed to the noise, in addition to the mechanical ventilation, sealing of wall vents and acoustic seals for windows and doors described in Treatments 1A and 1B. Note that these upgrades are only suitable for masonry type buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.</p>

7 Monitoring and Reporting

7.1 Verification monitoring and Reporting

7.1.1 Noise monitoring (airborne and ground-borne)

The following noise monitoring will be undertaken:

- Monitoring will be undertaken periodically adjacent to construction compounds and permanent facility works to verify the noise model predictions of both day and OOHW in order to ensure effectiveness of mitigation measures;
- during initial high noise generating activities (such as piling, rock hammering, jack hammering) to accurately establish the L_{Aeq} to L_{A1} (1 minute) differential and confirm the number of sensitive receivers which may experience sleep disturbance, where these activities occur during night period (10pm to 7am);
- Monitoring in response to complaints as required by the EPL;
- Noise monitoring will be undertaken when predicted air-borne noise impacts are
 - more than 20dB(A) above the RBL during standard construction hours and Out of Hours Work Period 1 (see Table 6.4);
 - more than 10dB(A) above the RBL during Out of Hours Work Period 2 (see Table 6.4)
- Noise monitoring will be undertaken when predicted ground-borne noise impacts
 - more than 10dB(A) above the Ground-borne Noise Management Level (GNML) during Out of Hours Work Period 1 (see Table 6.5);
 - more than the GNML during standard construction hours and Out of Hours Work Period 2 (see Table 6.5);
- Monthly noise monitoring will occur for day and night work periods as appropriate at construction compounds and permanent facility works areas in order to ensure effectiveness of controls and verify compliance with NMLs;
- As required by EPL No 20772;
- In response to complaints in accordance with the requirements of the EPL; and
- Ongoing spot checks of noise intensive plant and equipment will be undertaken throughout construction to ensure compliance with the maximum noise level goals for construction equipment.

Specific monitoring requirements for construction sites associated with the Project will be identified in the CNVIS reports prepared for each construction worksite (see Section 5.2 for details).

7.1.2 Vibration monitoring

The following vibration monitoring will be undertaken:

- Monthly monitoring will occur adjacent to construction compounds and permanent facility works in order to verify compliance;
- Vibration monitoring will be carried out to test for both structural damage and human comfort where either the 'minimum working distances' in the CNVMP cannot be complied with or vibration levels are predicted to be greater than the maximum values for human comfort as a result of works;
- Vibration monitoring will be undertaken when predicted vibration impacts Vibration Management Level (VML);
- During initial vibration generating activities, prior to commencing vibration generating activities that have the potential to impact on heritage items, to identify minimum working distances to retained heritage items to prevent cosmetic damage to these items or where required to verify compliance as per the Construction Heritage Management Plan;
- As required by a CNVIS;
- As required by an EPL; and
- In response to complaints in accordance with the requirements of the EPL.

Specific monitoring requirements for construction sites associated with the Project will be identified in the CNVIS reports prepared for each construction worksite.

7.1.3 Reporting

Inspection results will be recorded on the Weekly Environmental Inspection Forms. Noise and vibration compliance monitoring will be carried out as determined by the CNVIS and recorded on Noise/Vibration Monitoring Forms. The results of noise and vibration monitoring will be documented and provided to the EPA in accordance with conditions of the EPL.

The Environmental Representative will inspect the site regularly and will inspect any noise and vibration control measures.

Typical Compliance records would consist of:

- Inspections undertaken in relation to noise and vibration management measures
- Weekly Environmental Inspection forms
- Toolbox training records
- Noise record sheets from plant and environmental noise monitoring

- Noise monitoring records by specialist consultants
- Vibration monitoring records, records of enquiries and complaints
- Records of noise and vibration monitoring results against appropriate noise and vibration objectives
- Records of community enquiries and complaints and CDS's response.
- Results and outcomes of inspections, monitoring and auditing will be reported internally on a monthly basis. Records are to include a comparison of measured noise and vibration monitoring results against the noise and vibration management levels. Six-monthly construction compliance reports will be prepared to report on compliance with the Project Approval.

Specific reports prepared in response to noise and vibration will include:

- Monitoring reports will be completed and provided to complainants in accordance with the EPL; and
- The posting of monthly noise and complaint data online in accordance with the EPL

Details within the reports are likely to contain the following information:

- The locations and description of monitoring undertaken;
- A tabulation of results (e.g. for noise including L_{Amax} and $L_{Aeq(15min)}$ noise levels) together with notes identifying the principle sources and operations;
- Summary of any measurements exceeding the nominated criteria, and descriptions of the plant or operations causing these exceedances; and
- Detail of any corrective actions and confirmation of their successful implementation.

7.2 Complaints Handling and Incident Response

CDS will handle enquiries/ complaints in a responsive manner. Throughout the works, the team will be making contact with multiple and varied internal and external stakeholders. The Community Involvement Plan details procedures to ensure that the process of dealing with New M5 Works enquiries and complaints by the CDS Works team is consistent and in line with the Project's enquiry and complaints handling management policies.

The Environmental and Sustainability Manager and Environment Coordinator will assist the Stakeholder and Community Relations Manager in responding to environmental complaints and maintain a register of Environmental Complaints for reporting to the EPA and other relevant agencies.

Sydney Motorway Corporation (SMC) operate a 24-hour construction complaints line (1800 660 248). Enquiries/ complaints may also be received through the Project email (info@westconnex.com.au).

In accordance with EPL condition M7.4, CDS will investigate noise and vibration complaints received via the telephone complaints line from the occupants of dwellings or the management of noise sensitive receivers, other than dwellings:

- within two hours of the complaint being made; or
- in accordance with any prior compliant management agreement CDS may have made with the complainant.

Where noise or vibration monitoring/ investigation is required, a Preliminary Investigation Report will be provided to the EPA following any noise or vibration monitoring. A Follow-up Investigation Report will also be provided.

In relation to construction hours, including for standard and out-of-hours activities, the SSI shall be constructed to comply with EPL No 20772 applying to the SSI, including all relevant noise mitigation and management measures. In the event of a dispute between the Proponent (including its contractors) and the EPA, in relation to construction hours, either party may refer the matter to the Director General for resolution.

8 Review and Improvement

This plan will be reviewed and updated as required in accordance with the CEMP (Element 12.3). Revisions of the CEMP and sub-plans must be endorsed by the Environmental and Sustainability Manager and approved internally by the Project Director.

8.1 Non-conformances

Non-conformances in general will be dealt with and documented in accordance with Part B: Section 5 of the CEMP.

Where monitored noise levels are found to be above predictions or vibration goals are exceeded, the following actions will be undertaken:

- Confirm that monitored levels are not being impacted by other noise or vibration sources;
- Implement other feasible and reasonable measures which may include reducing plant size, modify time of works, changing operational settings (such as turning off the vibratory function of the machine), and utilizing alternate construction methodology or a combination of these;
- Review work practices to ensure compliance with the ICNG;
- Confirm if the exceedance is due to an uncharacteristically loud piece of equipment;
- Identify if equipment can be swapped out for another piece of equipment or alternative equipment or plant;
- Confirm if the exceedance is due to an uncharacteristically vibratory piece of equipment;
- Confirm that the modelling reflects the actual activity being undertaken; and
- Ensure that learning's from the above are fed back into the noise modelling assessment process.

8.2 Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this sub plan, CoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in Part B: Section 5 of the CEMP.

8.3 Revision of this plan

Continual improvement is achieved through constant measurement and evaluation, audit and review of the effectiveness of the plan, and adjustment and improvement of the Construction Environmental Management Plan, project environmental outcomes and CDS Environmental Management System.

Monthly reviews undertaken by the Environmental Representative and quarterly management reviews provide specific opportunities to identify improvements in the environmental management system and/or this CNVMP.

This plan will be updated as required:

- to address exceedances or non-compliances if investigations determine changes are required to prevent reoccurrences;
- to take into account changes to the environment or generally accepted environmental management practices, new risks to the environment, any hazardous substances, contamination or changes in law;
- where requested or required by the NSW Department of Planning and Environment or any other Authority; or
- in response to internal or external audits or quarterly management reviews.

The updated plan must be endorsed by the Environment and Sustainability Manager and approved internally by the Project Director. Minor changes may be approved by the Environmental Representative. Minor changes would typically include those that:

- are editorial in nature (e.g. staff and agency/authority name changes)
- do not increase the magnitude of impacts on the environment when considered individually or cumulatively
- do not compromise the ability of the project to meet approval or legislative requirements.

Where the Environmental Representative deems it necessary, the CNVMP will be provided to relevant stakeholders for review and comment if required and forwarded to the Secretary of DP&E for approval.

References

1. Department of Environment and Climate Change 2009 NSW Interim Construction Noise Guideline (ICNG),
2. Environment Protection Authority 1999 NSW Environmental Criteria for Rd Traffic Noise
3. Department of Environment Conservation NSW 2006 Assessing Vibration; a technical guideline
4. British Standard BS 6472-2008, Evaluation of human exposure to vibration in buildings (1-80Hz)
5. German Standard DIN 4150-3 : 1999-02, Structural vibration - Effects of vibration on structures, February 1999
6. ASHRAE Applications Handbook (SI) 2003, Chapter 47 Sound and Vibration Control, pp47.39-47.40
7. Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration, p16
8. Australian Standard AS/NZS 2107:2000 *Acoustics - Recommended design sound levels and reverberation times for building interiors*
9. Australian Standard AS 2187.2 Explosives - Storage and use - Part 2 Use of explosives
10. Roads and Maritime Services 2014 QA Specification G36 Environmental Protection Edition 4 / Revision 3
11. AECOM Australia Pty Ltd 2015 WestConnex The New M5 project - Technical Working Paper: Noise and Vibration Revision 8 – 20-Nov-2015
12. Gordon CG 1991 Generic Vibration Criteria for Vibration Sensitive Equipment *Proceedings of International Society for Optical Engineering (SPIE)*, Vol. 1619, San Jose, CA, November 4-6, 1991, pp. 71-85
13. Transport for NSW Construction Noise Strategy (ref: 7TP-ST-157/2.0) April 2012
14. Australian Standard AS2187:2-1993 Explosives - Storage and use Part 2: Use of explosives (superseded by AS2187:2-2006)
15. Lee D 2012 *Constraints for tunnel construction in the urban environment and how to overcome them* <http://www.ats.org.au>

APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Absorption Coefficient α	The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective.
Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Active recreation	Active recreation area, characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion, e.g. school playground, golf course
Air-borne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
Alternate Solution	An Alternative Solution is a design that complies with the relevant Performance Requirements of the National Construction Code other than by using Deemed-to-Satisfy Provisions.
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Amenity	A desirable or useful feature or facility of a building or place.
AS	Australian Standard
Assessment period	The time period in which an assessment is made. e.g. Day 7am-6pm, Evening 6pm-10pm, Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
Audible Range	The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Berm	Earth or overburden mound.
Buffer	An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use.
Bund	A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound.
BS	British Standard
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)"

Decibel [dB]	<p>The units of sound measurement. The following are examples of the decibel readings of every day sounds:</p> <p>0dB The faintest sound we can hear, defined as 20 micro Pascal</p> <p>30dB A quiet library or in a quiet location in the country</p> <p>45dB Typical office space. Ambience in the city at night</p> <p>60dB CBD mall at lunch time</p> <p>70dB The sound of a car passing on the street</p> <p>80dB Loud music played at home</p> <p>90dB The sound of a truck passing on the street</p> <p>100dB The sound of a rock band</p> <p>115dB Limit of sound permitted in industry</p> <p>120dB Deafening</p>
dB(A)	<p>A-weighted decibel. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter is denoted as dB(A). Practically all noise is measured using the A filter.</p>
dB(C)	<p>C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies. The dB(C) level is not widely used but has some applications.</p>
Diffraction	<p>The distortion of sound waves caused when passing tangentially around solid objects.</p>
DIN	<p>German Standard</p>
DnT,w	<p>Weighted Standardised Field Level Difference</p> <p>A measure of sound insulation performance of a building element. It is characterised by the difference in noise level on each side of a wall or floor. It is measured in-situ.</p> <p>It is a field measurement that relates to the Rw laboratory measured value but is not equal to it because an in-situ space is not of the same quality as a laboratory space.</p> <p>The value is indicative of the level of speech privacy between spaces. The higher its value the better the insulation performance.</p>
ECRTN	<p>Environmental Criteria for Road Traffic Noise, NSW, 1999</p>
EPA	<p>Environment Protection Authority</p>
Field Test	<p>A test of the sound insulation performance in-situ. See also 'Laboratory Test'</p> <p>The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion.</p> <p>A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.</p>
Fluctuating Noise	<p>Noise that varies continuously to an appreciable extent over the period of observation.</p>
Free-field	<p>An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.</p>
Frequency	<p>Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.</p>
Ground-borne noise	<p>Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.</p>

Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
Impact Noise	The noise in a room, caused by impact or collision of an object onto the walls or the floor. Typical sources of impact noise are footsteps on the floor above a tenancy and the slamming of doors on cupboards mounted on the common wall between tenancies.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
INP	NSW Industrial Noise Policy, EPA 1999
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).
ISEPP	State Environmental Planning Policy (Infrastructure), NSW, 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008
L ₁	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L ₁₀	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L _{10(1hr)}	The L ₁₀ level measured over a 1 hour period.
L _{10(18hr)}	The arithmetic average of the L _{10(1hr)} levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L ₉₀	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L ₉₀ noise level expressed in units of dB(A).
L _{Aeq} or L _{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the L _{Aeq} .
L _{Aeq(1hr)}	The L _{Aeq} noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted L _{eq} during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
L _{Aeq(8hr)}	The L _{Aeq} noise level for the period 10pm to 6am.
L _{Aeq(9hr)}	The L _{Aeq} noise level for the period 10pm to 7am.
L _{Aeq(15hr)}	The L _{Aeq} noise level for the period 7am to 10pm.
L _{Aeq(24hr)}	The L _{Aeq} noise level during a 24 hour period, usually from midnight to midnight.
L _{max}	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the L _{Amax} .
L _{min}	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the L _{Amin} .
Ln,w	Weighted Normalised Impact Sound Pressure Level A measure of the sound level transmitted from impacts on a floor to a tenancy below. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from a standard tapping machine. A lower value indicates a better performing floor.

LnT,w	<p>Weighted Standardised Field Impact Sound Pressure Level</p> <p>As for Ln,w but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement.</p> <p>The equivalent measurement in a laboratory is the Ln,w.</p> <p>A lower value indicates a better performing floor.</p>
Laboratory Test	<p>The performance of a building element when measured in a laboratory. The sound insulation performance of a building element installed in a building however can differ from its laboratory performance for many reasons including the quality of workmanship, the size and shape of the space in which the measurement is conducted, flanking paths and the specific characteristics of the material used which may vary from batch to batch.</p>
Loudness	<p>A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.</p>
Microphone	<p>An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.</p>
MOC	<p>Motorway Operations Complex</p>
NCA	<p>Noise Catchment Area. An area of study within which the noise environment is substantially constant.</p>
Noise	<p>Unwanted sound</p>
NRC	<p>Noise Reduction Coefficient.</p> <p>A measure of the ability of a material to absorb sound. The NRC is generally a number between 0 and 1 but in some circumstances can be slightly greater than 1 because of absorption at the edges of the material. A material with an NRC rating of 1 absorbs 100% of incoming sound, that is, no sound is reflected back from the material.</p> <p>The NRS is the average of the absorption coefficient measured in the octave bands 250Hz, 500Hz, 1kHz & 2kHz which correspond to the predominant frequencies associated with the human voice.</p>
Passive recreation	<p>Area specifically reserved for passive recreation, characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion e.g. reading, meditation</p>
Reflection	<p>Sound wave reflected from a solid object obscuring its path.</p>
Reverberation Time	<p>The time (in seconds) it takes for a noise signal within a confined space to decay by 60dB. The longer the reverberation time (usually denoted as RT60), the more echoic a room. Longer reverberation times generally result in higher noise levels within spaces.</p>
RMS	<p>Root Mean Square value representing the average value of a signal.</p>
Rw	<p>Weighted Sound Reduction Index</p> <p>A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory.</p> <p>The term supersedes the value STC which was used in older versions of the Building Code of Australia. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w.</p> <p>The higher the value the better the acoustic performance of the building element.</p>
R'w	<p>Weighted Apparent Sound Reduction Index.</p> <p>As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement.</p> <p>The higher the value the better the acoustic performance of the building element.</p>
RNP	<p>Road Noise Policy, NSW, March 2011</p>
SEL	<p>Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.</p>

Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the R_w and the sound insulation between two rooms can be described by the $D_{nT,w}$.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 micro Pascal.
Spoil	Soil or materials arising from excavation activities.
Standardised	<p>A method of adjusting the measured noise indices in-situ so that they are independent of the measuring space.</p> <p>The noise level in a room is affected by reverberation in the room. For example, the $L'_{n,w}$ impact sound pressure level measured in a room is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the reverberation time in the receiving room is set at 0.5 seconds. This enables the same value to be reported independent of whether the room contains carpet and furnishings and the like. See also 'Normalised'.</p>
STC	<p>Sound Transmission Class</p> <p>A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory.</p> <p>The term has been superseded by R_w.</p>
Structure-borne Noise	<p>Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine.</p> <p>Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example).</p> <p>Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.</p>
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	<p>The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another.</p> <p>For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the R_w or $R'w$ or $D_{nT,w}$.</p>

APPENDIX B Land Use Survey



Building Type		
Education	Industrial	Commercial
Under construction	Hotel	Church
Residential	Fire Station	Aged care
Recreational	Empty Lot	Heritage
Mixed Use	Community Centre	NCA

Client:

WestConnex STAGE 2 M5

Project:
WestConnex Stage 2 M5

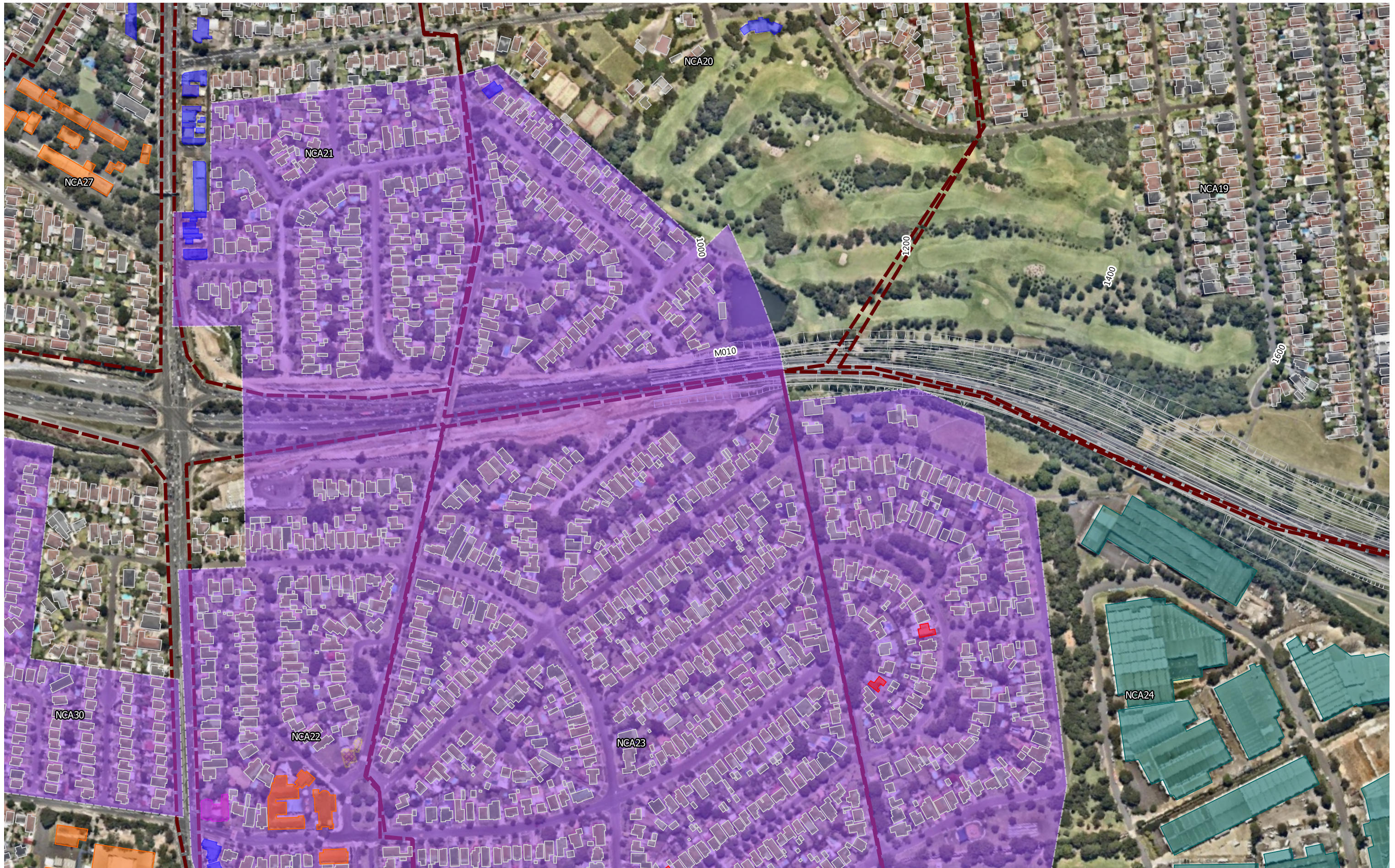
Description:
Noise catchment areas & Sensitive Receivers



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 P: 02 8218 0500 F: 02 8218 0501

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Building Type

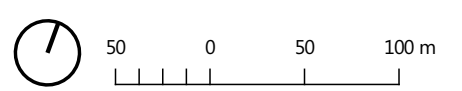
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Under construction	Hotel	Church
Residential	Fire Station	Aged care
Recreational	Empty Lot	Heritage
Mixed Use	Community Centre	NCA

Client:

WestConnex STAGE 2 M5

Project:
WestConnex Stage 2 M5

Description:
Noise catchment areas & Sensitive Receivers

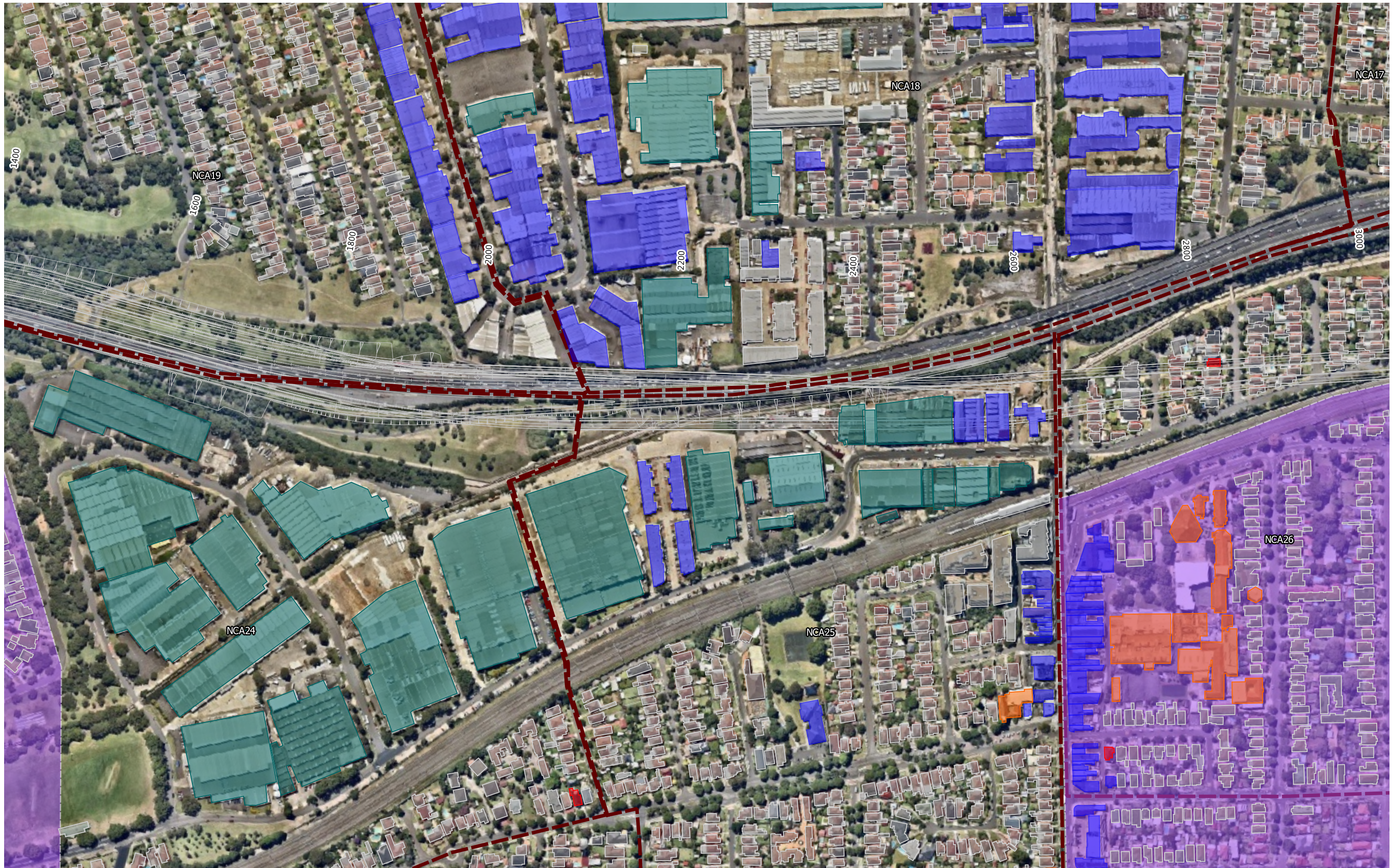


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Building Type

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Under construction	Hotel	Church
Residential	Fire Station	Aged care
Recreational	Empty Lot	Heritage
Mixed Use	Community Centre	NCA

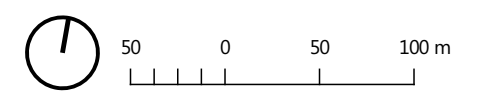
Client:

Project:

WestConnex Stage 2 M5

Project:
WestConnex Stage 2 M5

Description:
Noise catchment areas & Sensitive Receivers

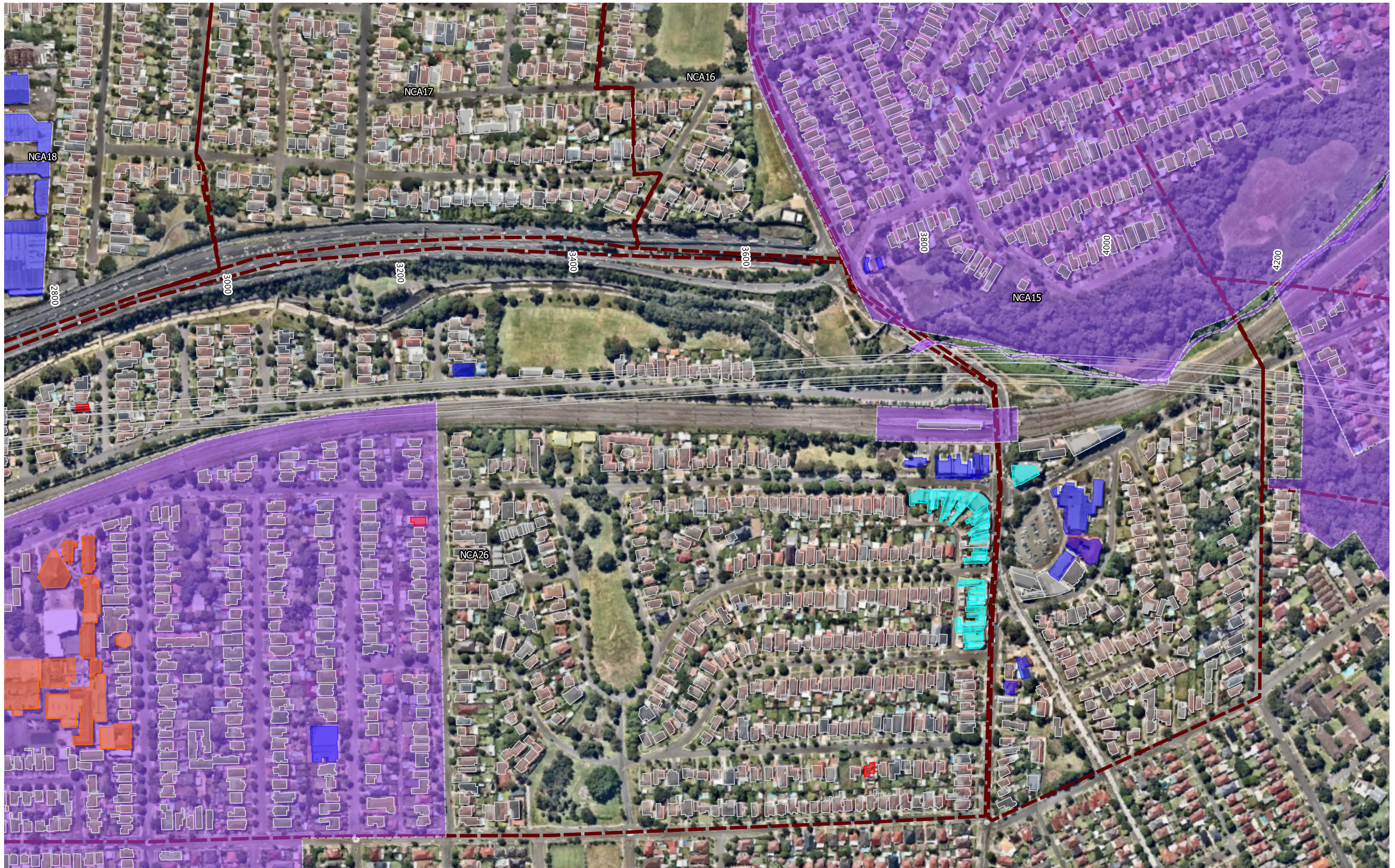


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Date: 28.04.2016
Scale: 1:4,000



Building Type

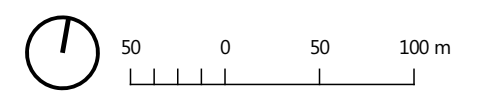
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Under construction	Hotel	Church
Residential	Fire Station	Aged care
Recreational	Empty Lot	Heritage
Mixed Use	Community Centre	NCA

Client:

WestConnex STAGE 2 M5

Project:
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Description:
Noise catchment areas & Sensitive Receivers



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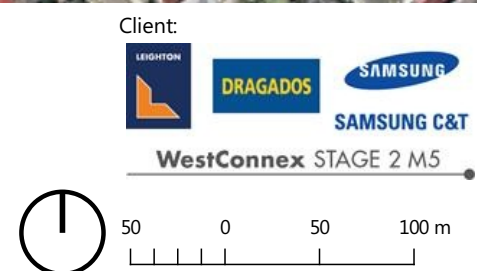
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Figure No: TH014-05 6 0 1 005 (r1)
Date: 28.04.2016
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Building Type

Education	Industrial	Commercial
Under construction	Hotel	Church
Residential	Fire Station	Aged care
Recreational	Empty Lot	Heritage
Mixed Use	Community Centre	NCA



Client: LEIGHTON DRAGADOS SAMSUNG SAMSUNG C&T

Project: WestConnex Stage 2 M5

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Description: Noise catchment areas & Sensitive Receivers

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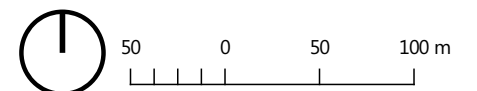
Building Type

Education	Industrial	Commercial
Under construction	Hotel	Church
Residential	Fire Station	Aged care
Recreational	Empty Lot	Heritage
Mixed Use	Community Centre	NCA

Client:

Project:
WestConnex Stage 2 M5

Description:
Noise catchment areas & Sensitive Receivers



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Building Type

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Under construction	Hotel	Church
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Client:

Project: WestConnex STAGE 2 M5

Description: Noise catchment areas & Sensitive Receivers

WestConnex STAGE 2 M5

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Under construction	Hotel	Church
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Client:

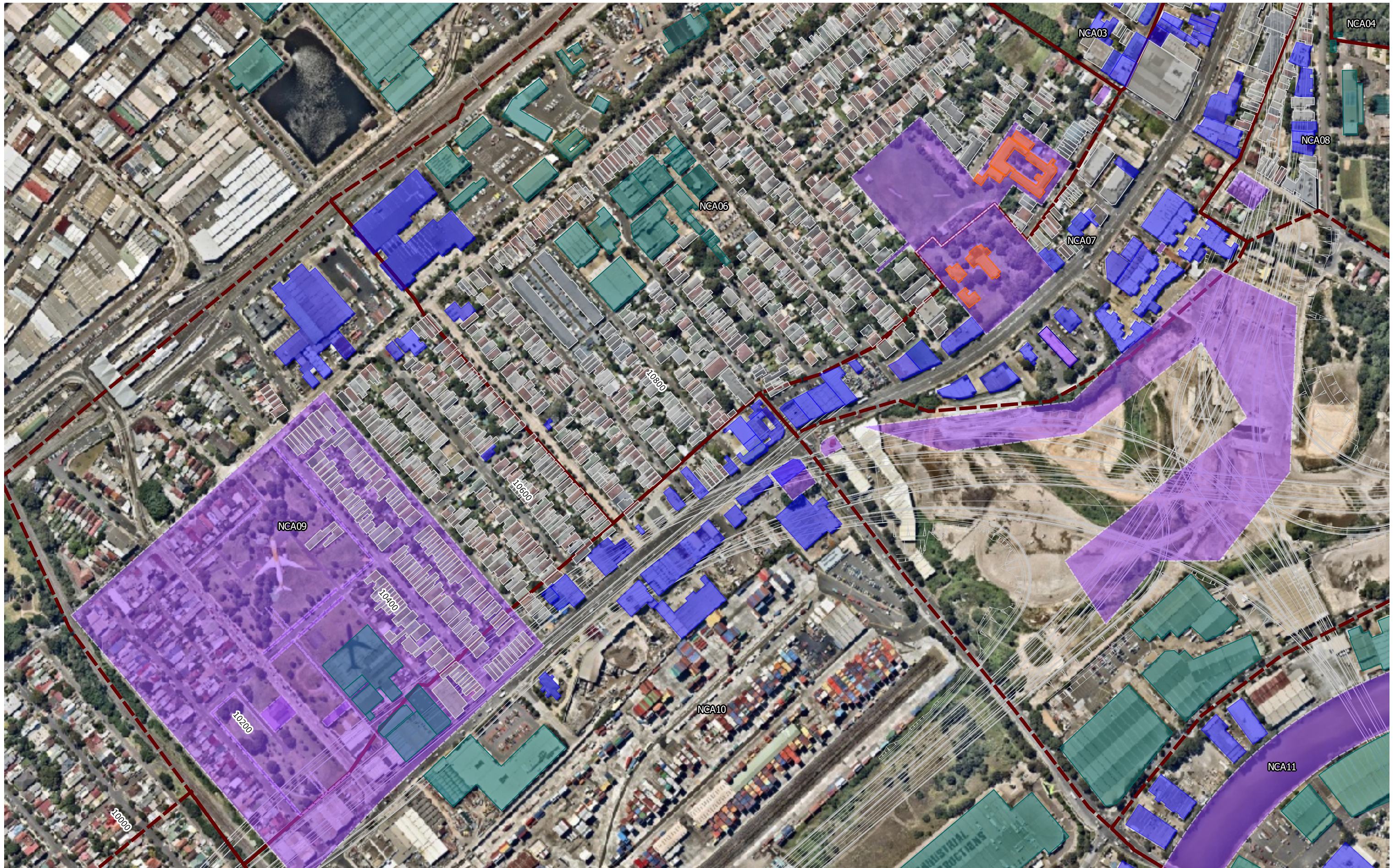
Project: WestConnex Stage 2 M5

Description: Noise catchment areas & Sensitive Receivers

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Under construction	Hotel	Church
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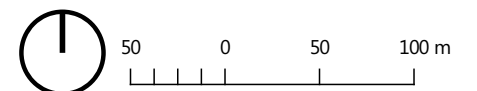
Client:

Project:

WestConnex Stage 2 M5

Project:
WestConnex Stage 2 M5

Description:
Noise catchment areas & Sensitive Receivers



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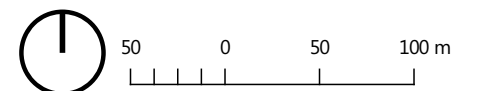
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Under construction	Hotel	Church
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Building Type

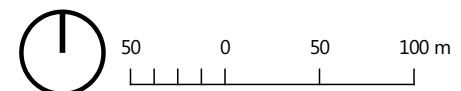
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WestConnex STAGE 2 M5

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Noise catchment areas & Sensitive Receivers



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Date: 28.04.2016
Scale: 1:4,000

APPENDIX C **Nearest residential receivers and construction Noise Management Levels**

Table 8.1 Nearest Noise and Vibration Sensitive Residential Receivers and Construction Noise Management Levels

NCA	Receiver Type	Nearest construction work area ²	Rating Background Level (RBL) LA90	Airborne NML									Ground-borne NML	
				Rating Background Level (RBL)			L _{Aeq(15min)} ¹			L _{A1(1min)}			L _{Aeq(15min)} ²	
				Logger ID	Day	Evening	Night	Standard Hours (RBL+10dB)			Out of Hours Work (OOHW) (RBL+5dB)			Sleep Disturbance (RBL+15dB)
St Peters Interchange and local roads														
NCA01	Residential	Sydney Park Road and Euston Road local road works	EISL01	57	51	40	67	62	56	45	55	40	35	
NCA02	Residential	Local Road works	EISL02	50	46	39	60	55	51	44	54	40	35	
NCA03	Residential Commercial (May Street Studios)	Campbell and May Street local road works	EISL02	50	46	39	60	55	51	44	54	40	35	
NCA04	Residential (Campbell Rd terraces) Recreation Commercial	SPI and Campbell Street works	EISL03	54	45	40	64	59	50	45	55	40	35	
NCA05	Commercial/ Industrial	SPI and Euston Road works	EISL01	57	51	40	67	62	56	45	55	-	-	
NCA06A	Residential Commercial	SPI and Campbell Road works	EISL02	50	46	39	60	55	51	44	54	40	35	
NCA06B	Residential Educational Facility Commercial	SPI and Campbell Road works	DD NL01	42	41	36	52	47	46	41	61	40	35	
NCA07	Residential Place of worship Commercial	SPI	EISL05	52	50	44	62	57	55	49	59	40	35	

NCA	Receiver Type	Nearest construction work area ²	Rating Background Level (RBL) LA90	Airborne NML									Ground-borne NML	
				Standard Hours (RBL+10dB)			Out of Hours Work (OOHW) (RBL+5dB)			Sleep Disturbance (RBL+15dB)			LAeq(15min) ²	
				Logger ID	Day	Evening	Night	Day	Day	Evening	Night	Night	Evening	Night
NCA08	Residential	SPI and Campbell Street works	EISL03	54	45	40	64	59	50	45	55	40	35	
NCA09	Residential	SPI	EISL19	60	54	43	70	65	59	48	58	40	35	
NCA10	Residential (NW of Princes Hwy) Industrial	SPI	EISL06	58	56	49	68	63	61	54	64	40	35	
NCA11	Residential Commercial/ Industrial	Gardeners and Bourke Road local works	EISL04	58	52	42	68	63	57	47	57	40	35	
NCA T3	Residential, Heritage, Commercial/ Industrial	Tunnelling	-	-	-	-	-	-	-	-	-	40	35	
Arncliffe Compound														
NCA12	Residential	Arncliffe compound	EISL20	55	55	45	65	60	60	50	60	40	35	
NCA13	Residential	Arncliffe compound	EISL21	49	48	42	59	54	53	47	57	40	35	
NCA14	Residential	Arncliffe compound	EISL22	47	47	39	57	52	52	44	54	40	35	
NCA T2	Residential, Heritage, Commercial/ Industrial	Tunnelling	-	-	-	-	-	-	-	-	-	40	35	
NCA T1	Residential, Heritage	Tunnelling	-	-	-	-	-	-	-	-	-	40	35	
Bexley Road Compounds														
NCA15	Residential Recreation	Bexley Road east compound	EISL23	51	51	43	61	56	56	48	58	40	35	
NCA16A	Residential Recreation	Bexley Road north compound	EISL09	48	48	43	58	53	53	48	58	40	35	

NCA	Receiver Type	Nearest construction work area ²	Rating Background Level (RBL) LA90	Airborne NML									Ground-borne NML	
				Standard Hours (RBL+10dB)			Out of Hours Work (OOHW) (RBL+5dB)			Sleep Disturbance (RBL+15dB)			LAeq(15min) ²	
				Day	Evening	Night	Day	Day	Evening	Night	Night	Evening	Night	
NCA16B NCA16D	Residential Recreation	Bexley Road north compound	DD NL03	49	48	36	59	54	53	41	61	40	35	
NCA16C	Residential Recreation	Bexley Road north compound	EISL07	54	54	40	64	59	59	45	55	40	35	
NCA17	Residential Recreation	Bexley Road compounds	EISL09	48	48	43	58	53	53	48	58	40	35	
NCA26A	Residential Recreation	Bexley Road compounds	DD NL04	47	47	41	57	52	52	46	56	40	35	
NCA26B	Residential Recreation	Local road works, Bexley Road compounds	EISL08	50	49	40	60	55	54	45	55	40	35	
NCA26C	Residential Place of worship Educational facility Recreation	Local road works, Bexley Road compounds	EISL24	47	47	41	57	52	52	46	56	40	35	
Kingsgrove portals and surface works														
NCA18	Residential Commercial/ Industrial	M5 East surface works	DD NL05	51	50	44	61	56	55	49	59	40	35	
NCA19	Residential Active recreation	M5 East tunnel portals, Kingsgrove compound	EISL12	45	45	43	55	50	50	48	58	40	35	
NCA20	Residential Active Recreation	M5 East surface works	EISL18	50	49	40	60	55	54	45	55	40	35	
NCA21	Residential	M5 East surface works	EISL16	47	46	40	57	52	51	45	55	40	35	

NCA	Receiver Type	Nearest construction work area ²	Rating Background Level (RBL) LA90	Airborne NML									Ground-borne NML	
				Standard Hours (RBL+10dB)			Out of Hours Work (OOHW) (RBL+5dB)			Sleep Disturbance (RBL+15dB)			LAeq(15min) ²	
				Logger ID	Day	Evening	Night	Day	Day	Evening	Night	Night	Evening	Night
NCA22	Residential	M5 East surface works	EISL16	47	46	40	57	52	51	45	55	40	35	
NCA23	Residential Active recreation	M5 East surface works	EISL17	49	49	42	59	54	54	57	67	40	35	
NCA24	Residential Active recreation	M5 East tunnel portals and surface works	EISL14	50	50	42	60	55	55	57	67	40	35	
NCA25	Residential Commercial/ Industrial	M5 East tunnel portals and surface works	DD NL06	42	42	37	52	47	47	42	52	40	35	
NCA27	Residential Recreation	Local road works	EISL25	60	58	46	70	65	63	51	61	40	35	
NCA28	Residential Recreation	Local works	EISL27	52	51	39	62	57	56	44	54	40	35	
NCA29	Residential Recreation	Local works	EISL24	47	47	41	57	52	52	46	56	40	35	
NCA30	Residential Recreation	Local road works	EISL26	53	52	44	63	58	57	49	54	40	35	

Notes:

- Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.
- Where 'GBN' is identified, nearest construction activity is likely to be tunnelling. Ground-borne NMLs, which apply inside the habitable room, are provided as airborne NMLs are not applicable.

'TBC' denotes that additional noise monitoring is required to describe the noise environment in this location. Noise monitoring will be carried out in early October, once school returns from holidays and the noise environment returns to 'normal'

APPENDIX D Construction noise and vibration impact statement outcomes

D.1 Construction noise and vibration activities

Table D.1.1 below summarises the construction activities and estimated timeframe for construction works to be completed. The likelihood for works to be completed during standard hours or as OOHW is also identified.

Table D.1.1: Construction activities and indicative timeframe of works

Location	Construction Scenarios	Approx. duration of works at any locality (over three years)	Construction hours of work Standard/ OOHW
Civil works - Surface earthworks, bridges and structures			
Kingsgrove North compound (C1)	Site establishment	4 to 5 months	Standard
Kingsgrove South compound (C2)	Surface earthworks: piling	4 to 5 months	Standard
Canal Road compound (C8)	Surface earthworks: bulk earthworks	12 to 18 months	Standard
Campbell Road compound (C9)			
Landfill closure compound (C10)	Concrete Works (cut & cover and ramp pavements)	Up to 18 months	Standard
Burrows Road compound (C11)			
Alexandra Canal compound (C12)	Roadworks	Up to 12 months	Standard & OOHW for road tie ins
Gardeners Road bridge compound (C13)			
Sydney Park compound (C14)	Mechanical and electrical fitout	Up to 18 months	Standard
Western surface works			
Toll infrastructure works	Construction of permanent operational facilities	Up to 15 months	Standard
St Peters Interchange works			
Local roadworks	Establishment of tolling infrastructure	Up to 12 months	Standard
Tunnel support			
Kingsgrove North compound (C1)	Site establishment	14 to 18 weeks	Standard
Commercial Road compound (C3)	Decline/ Shaft excavation & support	Up to 3 months	Standard
Bexley Road North compound (C4)			
Bexley Road South compound (C5)	Tunnel construction support	Up to 30 months	Standard & OOHW to support 24-hour tunnelling
Bexley Road East compound (C6)			
Arncliffe compound (C7)			
Landfill closure compound (C10)			
Tunnelling			
Kingsgrove to Bexley	Mainline tunnels: Heading	Up to 30 months	24-hour
Bexley to Arncliffe	Mainline tunnels: Benching		Up to 24-hour
Arncliffe to St Peters	Cross passages		Up to 24-hour
	Mechanical and electrical fitout		24-hour

D.2 Construction noise and vibration sources

D.2.1 Airborne noise sources

Noise generated from construction activities associated with the Project will vary depending on the level and specific type of activity carried out. Table D.2.1 provides a summary of the likely construction scenarios and associated Sound Power Levels in relation to airborne noise from construction activity. More detail regarding specific construction activities undertaken at each location is provided in the CNVIS reports prepared for each site under this CNVMP.

Table D.2.1 Construction airborne noise sources

Construction Scenarios	Plant/ Equipment	Scenario sound power level dB(A)
Civil works - Surface earthworks, bridges and structures		
Site establishment	Franna Crane, Small Truck, Excavator (w bucket/ rock hammer), Truck & dog, Chainsaw, Tub grinder/ mulcher, Elevated Work Platform (EWP), Mobile crane, Road saw, Vibratory roller, Bobcat, Line marking truck	125
Surface earthworks: piling	Piling Rig (bored piles), Crawler Crane, Excavator w bucket, Concrete Agi, Concrete pump, Concrete saw, Jackhammers	119
Surface earthworks: bulk earthworks	Excavator (w bucket/ rockhammer/ rock saw/ rock grinder head), Surface Miner / profiler, Drilling machine, Pneumatic Hammer, Bulldozer D7-D11, Grader, Truck & Dog (spoil haulage), Shotcrete Rig Pump & Compressor, Concrete Agitator, Water Pump, High pressure water blasting, Ultra High pressure water blasting	125
Concrete Works (cut & cover and ramp pavements)	Concrete agitator, concrete pump, Crawler Crane, Mobile Crane	109
Roadworks	Slipform Paver, Slipform Barrier, Slipform or Extruder Kerb & Gutter Machine, Road truck, Asphalt paving machine, Asphalt truck & sprayer, Roller, Concrete saw / Road saw, Line marking truck	121
Road tie-in works	Paver, Road profiler, Semi-trailer Truck (spoil haulage), Truck & Dog (spoil haulage), Road Sweepers, Road truck, Bobcat, Daymakers, Asphalt truck & sprayer, Roller, Water cart	120
Kerbing & drainage	Concrete saw, Line marking truck, Hiab truck, Concrete Vibrators, Curbing truck mould, Concrete Agitator	114
Bridges	Excavator, Concrete saw / Demo Saw, 5kva Generator, Piling Rig (driven), Mobile Crane, Concrete Vibrators, Franna Crane, Concrete pump	119
Utility works	Excavator (20t, 12t) w bucket, Excavator (20t) w rock hammer, Pneumatic Hammer, Concrete saw, Roller, Wacker rammer, Road profiler, Semi-trailer Truck (spoil haulage), Truck & Dog (spoil haulage), 5kva Generator, Road Sweepers	125
Mechanical and electrical fitout	Franna Crane, Small Truck, Excavator (w bucket/ rock hammer), Truck & dog, Elevated Work Platform (EWP), Mobile crane, Road saw, Vibratory roller, Bobcat, Concrete agitator	120
Construction of operational fixed facilities/ tolling infrastructure	Crane – wheeled, Saw Cutting Reo, Saw Cutting Formwork, Concrete agitator, Concrete pump, Concrete Vibrator, Concrete Grinding Machine	119
Tunnel support		
Site establishment	Franna Crane, Small Truck, Excavator (w bucket/ rock hammer), Truck & dog, Chainsaw, Tub grinder/ mulcher, Elevated Work Platform (EWP), Mobile crane, Road saw, Vibratory roller, Bobcat, Line marking truck	125
Decline/ Shaft excavation & support	Road Header (underground), Moxie (inside tunnel/ spoil shed), Truck & Dog (spoil haulage), FE Loader (in spoil shed), Concrete truck, Concrete pump (in tunnel), Pneumatic vibrator (in tunnel), Compressor (inside container), tunnel support (dust scrubber and ventilation fan)	111
Tunnel excavation support	Road Header (underground), Moxie (inside tunnel/ spoil shed), Truck & Dog (spoil haulage), FE Loader (in spoil shed), Concrete truck, Concrete pump (in tunnel), Pneumatic vibrator (in tunnel), Compressor (inside container), tunnel support (dust scrubber and ventilation fan)	111

Note: A 5 dB(A) penalty has been applied to predicted noise levels from 'particularly annoying' activities, such as rock breaking, jack hammering and piling, in accordance with the ICNG

D.2.2 Ground-borne Noise

Noise generated from tunnelling activities associated with the Project will vary depending on the excavation methodology used. Table D.2.2 provides a summary of the likely tunnelling methods. More detail regarding specific construction activities undertaken at each location is provided in the Tunnelling CNVIS report prepared under this CNVMP.

Table D.2.2 Construction ground-borne noise sources

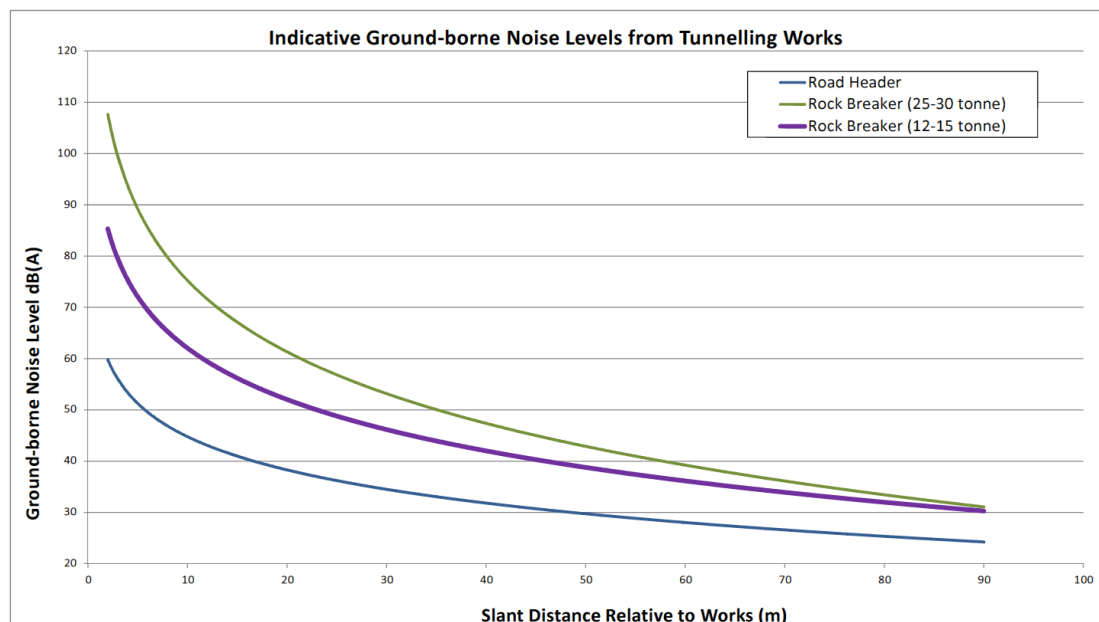
Construction Scenarios	Plant/ Equipment	Scenario sound power level dB(A)
Tunnelling		
Mainline tunnels: Heading	2 road headers per tunnel in each direction	GBN, see Figure 9
Mainline tunnels: Benching	2 road headers per tunnel in each direction AND/ OR Excavators with rock breaker attachment AND/ OR Drill and blast (to be confirmed)	GBN, see Figure 9
Cross passages	1 road header per cross passage in each direction AND/ OR Excavators with rock breaker attachment AND/ OR Drill and blast (to be confirmed)	GBN, see Figure 9

Note: A 5 dB(A) penalty has been applied to predicted noise levels from 'particularly annoying' activities, namely rock breaking, in accordance with the ICNG

The algorithms used in ground-borne noise (GBN) modelling have been developed from measurement data obtained from various Sydney projects, including the Cross City Tunnel (CCT), Lane Cove Tunnel (LCT), Epping to Chatswood Rail Link (ECRL) and North West Rail Link (NWRL).

Roadheader progress is estimated to be approximately 30 metres per week.

Figure 9: Indicative Ground-borne Noise Levels from Tunnelling



Source: GBN taken from recent Sydney tunnel projects, including CCT, LCT, ECRL and NWRL

D.2.3 Vibration

The vibration generated from construction activities at each work area/ site will vary depending on the level and type of activity carried out at during each construction stage. Typical plant and equipment in use at the construction worksite have been identified in Section D.2.

Table D.2.3 below identifies the dominant vibration generating plant and equipment. Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. Indicative levels of ground vibration from these sources are shown in the Table below.

Table D.2.3 Indicative Construction Plant Vibration Levels

Plant Noise Source	Typical PPV Vibration (mm/s) at distance from plant							
	5m	10m	15m	20m	30m	40m	50m	100m
Bobcat (Mustang 2054)	<1	-	-	-	-	-	-	-
Compactor (7 t)	-	6	-	2.5	0.3	-	-	-
Dozer (D810) (with ripper)	<2	-	-	-	-	-	-	-
Drilling machine – Pneumatic (Atlas Copco (ROC 812HC 20T)	3.2	1	-	-	<0.1	-	<0.1	-
Drilling Rig – Air Trac Rotary (Ingersoll/Rand CM350)	4.4	1.4	-	-	0.6	0.1	<0.1	-
Drilling Rig – Tracked (Samsung SE 240 LC3 18T)	<2	-	-	-	-	-	-	-
Excavator ≤30T (travelling)	8.0	3.4	1.6	-	-	-	-	-
Excavator ≤30T (digging)	5.8	4.0	0.0	-	-	-	-	-
Excavator & Rock Hammer (5 t)	1.5	0.3	-	0.1	<0.1	-	-	-
Excavator & Rock Hammer (20 t)	4.5	1.3	-	0.4	0.2	0.15	0.02	-
Excavator & Rock Hammer (30 t)	10.5	2.5	-	0.5	0.2	0.12	<0.1	-
Excavator & Rock Hammer (50 t) [^]	20	5	-	3	1	<1	-	-
Grader (20 t)	2.0	-	0.2	-	-	-	-	-
Jack hammer	2.0	1.0	0.2	0.1	0.0	0.1	-	-
Piling Rig - impact	26	20	14	10	7	-	4	2
Piling Rig - vibratory	12	6	4	3	1.5	-	1.2	<0.1
Piling Rig – Bored (Soilmec 60T) *	2.4	0.2	0.2	-	-	-	-	-
Ripping (in Sydney sandstone)	0.7	0.15	-	<0.1	-	-	-	-
Rocksaw (Komatsu AVANCE PC300)	1.5	0.5	-	0.3	-	-	-	-
Truck traffic (over normal (smooth) road surfaces)	1	0.2	-	0.05	-	0.02	-	-
Truck traffic (over irregular surfaces)	-	2.0	-	0.1	-	-	-	-
Vibratory Roller – medium (10 t)	-	3.6	-	2	1.5	1	-	-
Vibratory Roller - large (20 t)	7	4.5	-	3	2.3	2	1.7	-
Wacka packer on backfill	0.6	0.3	-	-	-	-	-	-
Wacka packer on asphalt	1.2	0.8	-	-	-	-	-	-

Notes: Source – Renzo Tonin & Associates database

* data based on sand/clay soil conditions

[^] Vibration data not available. Vibration levels approximated. Vibration monitoring recommended when plant on site.

D.3 Western civil surface works and tunnel support sites - Kingsgrove Road North (C1), Kingsgrove Road South (C2) and Commercial Road (C3)

Airborne noise and vibration impact from the Western civil surface works and tunnel support sites - Kingsgrove Road North (C1), Kingsgrove Road South (C2) and Commercial Road (C3) were determined by modelling the noise/ vibration sources, receiver locations, and operating activities, based on the information presented in Section D.2. Predicted noise levels at each receiver from the prescribed construction activities were assessed against the relevant NMLs for each NCA. The predictions are representative of noise levels during the site establishment and the construction phase of the works. Consistent with the requirements of ICNG, the construction noise impacts are based on a conservative but realistic worst case assessment. It is expected that the construction noise levels would be lower than have been predicted.

The C1 and C2 sites are approaching back end works which entail a concrete batch plant to be operating on the surface at C1 as well as general construction works and back-end works at both C1 and C3. Predicted noise levels at each receiver from this prescribed works was assessed against relevant NMLs for each NCA. These levels are all predicted to be within 5dBA of the NMLs.

It is noted that in relation to Kingsgrove North (C1), Condition of Approval D46 states that heavy vehicle movements associated with the SSI are not permitted to use Wirega Avenue and Garema Circuit at Kingsgrove, unless approved by the DPE Secretary. Following a traffic noise assessment which outcomes showed that there would be no noticeable increase in traffic noise compared to the existing noise, an application to justify the use of these roads was submitted for final approval September 2016 with approval given in October 2016. The assessment presented below includes an assessment for this access route.

Temporary noise walls included in this assessment have been determined in consultation with the community, as required by Condition D20, and presented in the Temporary Noise Barrier Strategy for the Western civil surface works and tunnel support sites [ref: TH014-05 01F08 WCX_NM5 Temp Barrier Nse Rep_WEST (r5)].

D.3.1 Noise/vibration assessment assumptions

The stages/operations considered in the noise model and vibration assessment for the Western civil surface works and tunnel support sites are summarised in the table below.

Table D.3.1 Noise modelling assumptions - Kingsgrove Road civil and tunnelling support sites

Activity/ Work Area	Aspect	Includes OOHW?	Approx. timing	Modelled construction stage									
				V01	V02	V03	V04	V05	V06	V07	V08		
				Site establishment			Civil works		TS				
Kingsgrove Road Civil compound C2	Power Generator	No	07-09 2016	■	■	■							
	Installation of enviro controls	No	07-09 2016	■									
Civil Works Site Establishment	Demolition of existing structures	No	07-09 2016	■									
	Crushing & Screening	No	07-09 2016	■									
	Vegetation Clearing	No	07-09 2016	■									
	Establishment of construction facilities	No	07-09 2016		■								
	Road and intersection modifications and installation of traffic controls	Yes	07-09 2016			■							
	Removal of earth mound on northern side of M5	No	09-10 2016					■					
	Portal surface site (piling)	No	10-12 2016						■				
	Portal surface site (earthworks)	No	2017-2018							■			
	Portal surface site (roadworks)	No	2017-2018								■		
	Western surface site (earthworks)	No	2017-2018									■	
	Western surface site (roadworks)	No	2017-2018									■	
	Kingsgrove Road and Commercial Road Tunnel Support Site Compounds C1 & C3	Installation of enviro controls	No	07-09 2016	■								
		Demolition of existing structures	No	07-09 2016	■								
Vegetation Clearing		No	07-09 2016	■									
Establishment of construction facilities		No	07-09 2016		■								
Road and intersection modifications and installation of traffic controls		No	07-09 2016			■							
Piling; Excavation of shaft		No	08-09 2016					■					

Activity/ Work Area	Aspect	Includes OOHW?	Approx. timing	Modelled construction stage									
				V01	V02	V03	V04	V05	V06	V07	V08		
Establishment	Shaft Excavation & Construction (acoustic shed in place)	No	08-09 2016										
	Tunnel support works	Yes	2016-2018										
	Back end works	Yes	2018-2020										

Note: TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week. TS has been modelled concurrent with other civil works activities (V05-V07), as well as in isolation (V08)

Sections D.3.2 and D.3.2.2 below summarise the impacts for each construction stage in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. The colours in the table indicate whether or not receivers in the NCA comply with the NML and, where exceedance of the NML occurs, the perceived impact of the exceedance.

D.3.2 Construction airborne noise impacts

D.3.2.1 Predicted noise levels for standard hours works

The impacts presented are as follows for **Standard Hours**:





















































-  Complies with NML
-  Exceeds NML by less than 10 dB(A) – noise affected
-  Exceeds NML by more than 10 dB(A) – noise affected
-  > 75 dB(A) – highly noise affected

Table D.3.2 Summary of noise construction noise impacts (standard hours)

NCA	Level of compliance with NML for construction stage							
	V01	V02	V03	V04	V05	V06	V07	V08
	Site establishment				Civil works (& TS)			TS
NCA18								
NCA19								
NCA20								
NCA23								
NCA24								
NCA25								

Notes All works to be undertaken during Standard construction hours (7am to 6pm Monday to Friday; 8am to 1pm Saturday)
 OSR = Other sensitive receiver surrounding work area. Worst affected OSR noted.
 TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week. TS has been modelled concurrent with other civil works activities (V05-V07), as well as in isolation (V08)

When site establishment construction works are underway at the Kingsgrove Road compounds, the nearest affected receivers in NCA 18, 19 and 25 (including adjacent commercial/ industrial premises) closest to the site will be noise affected during the site establishment works. Some receivers in NCA 19 will be highly noise affected as a result of vegetation clearing and demolition of structures during site establishment. Vegetation clearing will generate higher noise impact, mainly because these works need to be completed to enable the installation of environmental controls, including noise walls and

construction hoardings. It is not possible to install noise walls or construction hoarding prior to these activities being completed. High noise generating works will be managed through offering respite as noted in Section 4.1.3.

The early stages of the excavation works associated with the tunnelling support shafts will also generate noise levels that will be clearly audible to highly intrusive, again to the nearest receivers in NCA 19 (including adjacent commercial/ industrial premises). Activities such as rock hammering during excavation works and piling works are likely to cause receivers in NCA 19 to be highly noise affected. Noise from these activities may also be clearly audible at the nearest affected receivers in only NCA 18 and 25. It is noted that construction noise barriers will be installed prior to the commencement of shaft excavation works. Where high noise generating works still occur after implementation of all reasonable and feasible noise mitigation, high noise will be managed through offering respite as noted in Section 4.1.3.

During the early stages of the Kingsgrove civil works, including earthworks and removal of the earth mound, the nearest receivers in NCA 19 will be highly noise affected. Noise walls and construction hoarding will be installed as outlined in APPENDIX G to reduce noise levels during the construction phase. Piling works and excavation to the portal will also generate noise levels that will be clearly audible to moderately intrusive until earthworks are well below surface level. Noise walls and construction hoardings will be in place to assist in reducing impacts to receivers. Nonetheless activities such as piling works, jackhammering to trim the tops of piles, rock hammering during excavation works and surface excavation (in particular surface mining), are likely to cause highly intrusive noise levels to the nearest affected receivers.

Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during standard construction hours.

Measures for managing the noise impacts outlined in Section 6 and APPENDIX G.

D.3.2.2 Predicted noise levels for OOHW

The impacts presented are as follows for **OOHW Evening and Night**:
















-  Complies with NML
-  < 5 dB(A) above NML - construction noise noticeable
-  5 to 15 dB(A) above NML - construction noise clearly audible
-  > 15 to 25 dB(A) above NML - construction noise moderately intrusive
-  > 25 dB(A) above NML - construction noise highly intrusive

Table D.3.3 Summary of noise construction noise impacts (OOHW)

NCA	Level of compliance with NML for construction stage							
	V01	V02	V03	V04	V05	V06	V07	V08
	Site establishment			Civil works				TS
NCA18	-	-		-	-	-	-	
NCA19	-	-		-	-	-	-	
NCA20	-	-		-	-	-	-	
NCA23	-	-		-	-	-	-	
NCA24	-	-		-	-	-	-	

NCA	Level of compliance with NML for construction stage							
	V01	V02	V03	V04	V05	V06	V07	V08
NCA25	-	-	▲	-	-	-	-	▲

Notes All works to be undertaken during OOHW Evening 6pm to 10pm Monday to Sunday; or OOHW Night 10pm to 7am Monday to Friday and 10pm to 8am Saturday, Sunday and public holidays; OOHW Day 1pm to 6pm Saturday and 8am to 6pm Sundays and public holidays.
 Level of compliance reported is based on worst case impact for OOHW period (typically night period)
 - indicates that OOHW is not anticipated for this construction stage
 OSR = Other sensitive receiver surrounding work area. Worst affected OSR noted.
 TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week.

The OOHW site establishment works include the installation of traffic barriers on the existing M5 Motorway. Predicted noise levels from these activities were found to comply in NCA18 and NCA25 and at other sensitive receivers. Noise levels may be clearly audible [within 15 dB(A) of the NML] at the nearest receivers in NCA19, NCA20, NCA23 and NCA24.

Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during the OOHW period. There is a marginal exceedance [within 2 dB(A)] at 1 receiver in NCA19 during the night period, caused by spoil haul trucks moving on site.

Measures for managing the noise impacts outlined in Section 6 and APPENDIX G.

Measures for managing the noise impacts are provided in detail in the CNVIS prepared for the site, including the use of respite periods for high noise impact activities such as rock breaking and piling works.

D.3.3 Construction vibration impacts

Vibration generated by site establishment and construction of the western civil and surface works and tunnel support works was estimated at various distances and the risk of structural damage from construction vibration are shown in the top half of Table D.3.4 below. The risk of human disturbance from construction vibration are shown in the bottom half of Table D.3.4.

Table D.3.4 Assessment of vibration impact for residential/commercial properties

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
Risk of structural or cosmetic damage					
NCA18	<5m (Adjacent)	Industrial	Very high risk	Very low risk	Very low risk
NCA19	<5m (Adjacent)	Residential	Very high risk	Very low risk	Very low risk
NCA20	450m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA23	430m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA24	150m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA25	140m	Residential	Negligible risk	Negligible risk	Negligible risk
Risk of disturbance to building occupants					
NCA18	<5m (Adjacent)	Industrial	Very high risk	Medium risk	Low risk
NCA19	<5m (Adjacent)	Residential	Very high risk	Medium risk	Low risk
NCA20	450m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA23	430m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA24	150m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA25	140m	Residential	Negligible risk	Negligible risk	Negligible risk

Analysis of the risk of vibration impact finds that during site establishment, construction activities are potentially close to industrial and residential buildings in NCA18 and 19 respectively, mainly due to building demolition works. These activities have a very high risk of generating vibration above the limits for structural damage and/ or human disturbance due to the close proximity of the works – one industrial building is immediately adjacent to the building demolition works. Building occupants at risk of vibration impact will be notified in accordance with Table 6.6 in Section 6.4 of this CNVMP to satisfy conditions of approval D11. Site specific minimum working distances shall be determined prior to commencement of the regular use of plant and equipment on site to satisfy condition of approval D22. Site specific minimum working distances will be maintained in order to comply with relevant vibration limits. Where minimum working distances are unable to be maintained, alternative construction methodology will be adopted in order to meet the vibration objectives.

Once site establishment is complete, substantial construction activities are further removed from receivers, thereby reducing the risk of vibration impact. There is a very low risk of structural damage. Disturbance to building occupants may occur during civil works depending on the type of activity. Activities like vibratory compaction may be noticeable inside residential and industrial premises closest to the works. Where plant is likely to be used within the minimum working distances described in Section 6.3 of this CNVMP, site specific minimum working distances shall be determined and maintained as noted above.

For more detailed predictions see the detailed CNVIS report prepared for the western civil and surface works and tunnel support works prepared under this NVMP. Each CNVIS report manages vibration impact in detail on a site by site basis. Receivers where vibration monitoring is required are identified and measures to reduce the risk of vibration impact are discussed.

D.4 Bexley Road and Arncliffe tunnel support sites

Airborne noise and vibration impact from the Bexley Road and Arncliffe tunnel support sites - Bexley Road North (C4), Bexley Road South (C5), Bexley Road East (C6) and Arncliffe (C7) were determined by modelling the noise/ vibration sources, receiver locations, and operating activities, based on the information presented in Section D.2. Predicted noise levels at each receiver from the prescribed construction activities were assessed against the relevant NMLs for each NCA. The predictions are representative of noise levels during the site establishment and the construction phase of the works. Consistent with the requirements of ICNG, the construction noise impacts are based on a conservative but realistic worst case assessment. It is expected that the construction noise levels would be lower than have been predicted.

Bexley Road South has been assessed for noise and vibration impacts during the construction of the Motorway Operations Complex (MOC). This work will generally have a high number of NMLs exceeding at various receivers. These predictions assume all plant and equipment is operating concurrently at any given time which is likely conservative and as such the actual levels are expected to be lower than predicted.

Temporary noise walls included in this assessment have been determined in consultation with the community, as required by Condition D20, and presented in the Temporary Noise Barrier Strategy for the Bexley Road and Arncliffe tunnel support sites [ref: TH014-05 01F14 WXC_M5N Temp Barrier Nse Rep_BXR-ARN].

D.4.1 Noise/vibration assessment assumptions

The stages/operations considered in the noise model and vibration assessment for the Bexley Road and Arncliffe tunnel support sites are summarised in the table below.

Table D.4.1 Noise modelling assumptions - Bexley Road and Arncliffe tunnelling support sites

Activity/ Work Area	Aspect	Includes OOHW?	Approx. timing	Modelled construction stage													
				V01	V02	V03	V04	V05	V06	V07	V08	V09	V10				
Bexley compounds				Site establishment													
Bexley Road North (C4) and South (C5) Tunnelling Support Sites and Bexley Road East Compound (C6)	Installation of enviro controls	No	07-09 2016	█													
	Demolition of existing structures	No	07-09 2016	█													
	Vegetation Clearing	No	07-09 2016	█													
	Establishment of construction facilities	No	07-09 2016		█												
	Road and intersection modifications and installation of traffic controls	Yes	07-09 2016			█											
	Piling (shaft and buildings)	No	08-09 2016				█										
	Shaft Excavation & Construction (acoustic shed in place)	No	08-09 2016					█									
	Tunnel support works	Yes	2016-2018							█							
	Civil Works (MOC)	Yes	2019-2020														█
Arncliffe compound				Site establishment TS													
Arncliffe compound (C7), including - Arncliffe to Bexley tunnelling support shaft - Arncliffe to SPI tunnelling support decline	Installation of enviro controls	No	07-09 2016	█													
	Demolition of existing structures	No	07-09 2016	█													
	Vegetation Clearing	No	07-09 2016	█													
	Establishment of construction facilities	No	07-09 2016		█												
	Road and intersection modifications and installation of traffic controls	Yes	07-09 2016			█											
	Piling of building (decline spoil shed)	No	08-09 2016				█										
	Piling of shaft and decline	No	09-10 2016					█									
	Excavation and construction of shaft and decline (acoustic shed in place)	No	10-12 2017						█								
	Tunnel support works	Yes	2017-2020														█

Note TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week.

Sections D.4.2.1 and D.4.2.2 below summarise the impacts associated with the Bexley Road and Arncliffe tunnel support sites for each construction stage in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. The colours in the table indicate whether or not receivers in the NCA comply with the NML and, where exceedance of the NML occurs, the perceived impact of the exceedance.

D.4.2 Construction airborne noise impacts

D.4.2.1 Predicted noise levels for standard hours works

The impacts presented are as follows for **Standard Hours**:

- █ Complies with NML
- █ Exceeds NML by less than 10 dB(A) – noise affected
- █ Exceeds NML by more than 10 dB(A) – noise affected

◆ > 75 dB(A) – highly noise affected

Table D.4.2a Summary of construction noise impacts (standard hours) at Arncliffe compound

NCA	Level of compliance with NML for construction stage									
	V01	V02	V03	V04	V05	V06	V07	V08	V09	V10
Arncliffe compound	Site establishment					TS				
NCA12	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA13	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA14	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

Notes All works to be undertaken during Standard construction hours (7am to 6pm Monday to Friday; 8am to 1pm Saturday)
 TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week.

Table D.4.2b Summary of construction noise impacts (standard hours) at Bexley compound

NCA	Level of compliance with NML									
	V01	V02	V03	V04	V05	V06	V07	V08	V09	V10
	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day
NCA15	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA16A	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA16B	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA16C	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA17	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA26A	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA26C	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
OSR	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

Noise impacts associated with the standard hours works at the **Bexley Road compounds** include:

- Site establishment works at the Bexley Road compounds will have high noise impacts due to the close proximity of residential receivers to the three compound sites. The nearest affected receivers in NCA 15, 16, 17 and 26 will be noise affected during the site establishment works.
- Some receivers in NCAs 15 and 16 will be highly noise affected as a result of vegetation clearing and demolition of structures during site establishment. These activities will generate higher noise impact; however, the extent of demolition and vegetation clearing on each site is minimal.
- Noise generated by the establishment of construction facilities and the road modification works are likely to be clearly audible at the nearest receivers in NCA 15 and 16. It is noted that throughout the bulk of site establishment works the temporary noise barriers outlined in APPENDIX G will not be in place. This is because the bulk of the tunnel support sites will be taken up by the acoustic spoil shed, which will act as both an acoustic enclosure for works carried out inside the shed as well as a noise wall for external activities once the tunnelling site becomes operational.
- The spoil sheds (which form part of the noise wall at Bexley North and South) will not be in place when piling for the shaft and spoil shed building commences. The piling works are therefore predicted to generate noise levels that will cause receivers to be highly noise affected in NCA 16. Noise from these activities may also be clearly audible at the nearest affected receivers in NCAs 15 and 26. The use of temporary noise screens around the shaft

area will reduce noise to the nearest affected receivers by 5 to 10 dB(A) thereby reducing impact from piling to below the 'highly noise affected' level. Where practicable, relocatable noise screens will be installed around the piling rig to reduce noise impacts to NCA 15 and 16.

- Excavation of the shaft will commence once the shed is partly constructed, thereby forming a noise wall around the excavation works. The shed will provide 15-20 dB(A) noise reduction even without the roof in place, thereby keeping noise levels below the 'highly noise affected' level during the excavation works. Airborne noise from shaft excavation is predicted to lessen as the shaft depth increases. The use of alternative construction methods is also being investigated, such as eccentric rippers in place of rock hammers. These have been found to be approximately 5 dB(A) less than rock hammers and the impulsive character of the noise is removed.
- Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during standard construction hours, with the exception of 1 receiver in NCA15 where noise levels may exceed the NML by up to 2 dB(A).
- The construction of the MOC will during V07 will have only 3 exceedances of the NML greater than 10dBA and only increasing to 7 exceedances once in V08. Construction activities during V09 and V10 will include impulsive equipment predicting one highly affected resident and one highly affected OSR. This work will be undertaken during daytime hours.

Noise impacts associated with the works at the **Arncliffe compound** include:

- Receivers are generally further away from the Arncliffe compounds, such that receivers in NCA 13 and 14 will not be noise affected during the early site establishment works. Receivers in NCA 12 will be noise affected and construction noise may be clearly audible during the early site establishment works. Site establishment works in total will be short term in duration (i.e. less than three months).
- The piling works associated with the spoil shed for the Arncliffe – SPI decline will also generate noise levels that will be clearly audible to the nearest receivers in NCA 12, 13 and 14 and to the commercial Hotel in NCA 12. Installation of the construction hoarding around the site prior to the commencement of this stage of site establishment will reduce noise levels to single and double storey receivers by 5 to 10 dB(A). The multi-storey apartments and the hotel in NCA 12 overlooking the site will remain noise affected even after the noise wall is installed.
- The early stages of the excavation works associated with the tunnelling support shaft for the Arncliffe - Bexley compound and the decline excavation or the Arncliffe – SPI compound will also generate noise levels that will be clearly audible to highly intrusive, again to the nearest receivers in NCA 12 and to the commercial Hotel in NCA 12. Activities such as rock hammering during excavation works and piling works are likely to cause receivers in NCA 12 to be highly noise affected. Noise from these activities may also be clearly audible at the nearest affected receivers in only NCA 13 and 14.
- Installation of the temporary noise barriers in APPENDIX G prior to the commencement of this site establishment stage will reduce noise levels to single and double storey receivers by 5 to 10 dB(A). The multi-storey apartments and the hotel in NCA 12 overlooking the site will remain high noise affected even after the noise wall is installed.
- Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during standard construction hours.

Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during standard construction hours.

Measures for managing the noise impacts outlined in Section 6 and APPENDIX G.

D.4.2.2 Predicted noise levels for OOHW

The impacts presented are as follows for **OOHW Evening and Night**:












































-  Complies with NML
-  < 5 dB(A) above NML - construction noise noticeable
-  5 to 15 dB(A) above NML - construction noise clearly audible
-  > 15 to 25 dB(A) above NML - construction noise moderately intrusive
-  > 25 dB(A) above NML - construction noise highly intrusive

Table D.4.3 Summary of noise construction noise impacts (OOHW)

NCA	Level of compliance with NML for construction stage									
	V01	V02	V03	V04	V05	V06	V07	V08	V09	V10
Bexley compounds	Site establishment				TS					
NCA15	-	-		-		-	-	-	-	-
NCA16	-	-		-		-	-	-	-	-
NCA17	-	-		-		-	-	-	-	-
NCA26	-	-		-		-	-	-	-	-
Arncliffe compound										
NCA12										
NCA13										
NCA14										

Notes All works to be undertaken during OOHW Evening 6pm to 10pm Monday to Sunday; or OOHW Night 10pm to 7am Monday to Friday and 10pm to 8am Saturday, Sunday and public holidays; OOHW Day 1pm to 6pm Saturday and 8am to 6pm Sundays and public holidays.
 Level of compliance reported is based on worst case impact for OOHW period (typically night period)
 TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week.

Noise impacts associated with the OOHW at the Bexley Road compounds include:

- The site establishment road and intersection modifications and installation of traffic controls (V03) require a Road Occupancy Licence and will therefore need to be completed as OOHW. Receivers in NCA15 and NCA16 will be impacted by noise levels 15 to 25dB(A) above the NML. Noise from these activities may be moderately intrusive to residents in these NCAs. Note that there is potential for short duration concrete saw cutting to impact the receivers nearest to the works in NCA15 by noise levels greater than 25dB(A) above the NML, which is considered to be highly intrusive. These works will be managed by using relocatable noise screening to shield the works and by completing the works before 10 pm where practicable, with no saw cutting beyond midnight.
- Receivers in NCA17 and NCA26 will be impacted by noise levels 5 to 15dB(A) above the NML during the site establishment OOHW. Noise from these activities may be clearly audible to residents in these NCAs.

- Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during the OOHW period. There is a marginal exceedance [within 2 dB(A)] at 3 receivers in NCA15 during the night period, caused by spoil haul trucks moving on site.

Noise impacts associated with OOHW at the Arncliffe compound include:

- Some receivers in NCA12 are expected to be affected by noise between 5 to 15dB(A) above the NML during site establishment works, namely the stormwater service installation. This noise is likely to be clearly audible. Receivers in NCA13 and NCA14 will be unaffected by noise for the duration of the works.
- Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during the OOHW period in NCA14. There is a marginal exceedance [within 2 dB(A)] at 2 receivers in NCA13 during the night period, caused by spoil haul trucks moving on site. Predicted noise levels comply with the NMLs at all receivers during the evening period.
- The site access for the Arncliffe compound is located on Marsh Street, directly opposite Flora Street and NCA12. The entrance cannot be further mitigated by noise wall or gates due to the high volume of trucks entering and leaving the site rendering this impractical. As a consequence, there are up to 35 residences in NCA12 that may be exposed to noise levels up to 10 dB(A) above the NML at night. 15 receivers are predicted to be exposed to noise levels within 5 dB(A) of the NML. 10 receivers are predicted to be exposed to noise between 5 and 10 dB(A) above the NML. These receivers may also be exposed to noise that may cause sleep disturbance impacts.
- A number of on-site mitigation measures have been considered, which are further outlined in the CNVIS for the Arncliffe site. These include, but are not limited to:
 - relocation of the acoustic sheds and changing spoil haulage routes on site;
 - secondary noise walls within the site.

These measures were found to have limited effectiveness in reducing the number of properties affected by noise. At property treatment has been recommended for consideration at these receivers following verification of the noise model.

Measures for managing the noise impacts outlined in Section 6 and APPENDIX G.

Measures for managing the noise impacts are provided in detail in the CNVIS prepared for the site, including the use of respite periods for high noise impact activities such as rock breaking and piling works.

D.4.3 Construction vibration impacts

Vibration generated by site establishment and construction of the Bexley and Arncliffe tunnel support sites was estimated at various distances and the risk of structural damage from construction vibration are shown in the top half of Table D12 below. The risk of human disturbance from construction vibration are shown in the bottom half of Table D.12.

Table D.4.4 Assessment of vibration impact for residential/commercial properties

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
Risk of structural or cosmetic damage					
NCA15	< 10m (Adjacent)	Residential	Low risk	Low risk	Low risk
NCA16	< 10m (Adjacent)	Residential	Low risk	Medium risk	Low risk

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
NCA17	130m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA26	45m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA12	40m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA13	250m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	300m	Residential	Negligible risk	Negligible risk	Negligible risk
Risk of disturbance to building occupants					
NCA15	<5m (Adjacent)	Residential	Medium risk	Very high risk	Low risk
NCA16	<5m (Adjacent)	Residential	Medium risk	Very high risk	Low risk
NCA17	130m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA26	45m	Residential	Very low risk	Low risk	Negligible risk
NCA12	40m	Residential	Low risk	Low risk	Negligible risk
NCA13	250m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	300m	Residential	Negligible risk	Negligible risk	Negligible risk

Analysis of the risk of vibration impact during site establishment, construction activities are potentially close to residential buildings in NCA15 and 16. Nonetheless, there is sufficient distance for the activities to be assessed as low risk of vibration impact, largely due to the limited surface works required to prepare the site. Piling will be completed using bored piles, which are of low vibration impact at distances of 10 m or more.

During the civil works on the site, mainly the excavation of the shaft, there is a medium risk of structural damage, as the shaft/ decline location for all sites is more 15 m from the nearest residential buildings in NCA 15. Building occupants at risk of vibration impact will be notified in accordance with Section 6.4 of this CNVMP to satisfy conditions of approval D11. Site specific minimum working distances shall be determined prior to commencement of the regular use of plant and equipment on site to satisfy condition of approval D22. Site specific minimum working distances will be maintained in order to comply with relevant vibration limits. Where minimum working distances are unable to be maintained, alternative construction methodology will be adopted in order to meet the vibration objectives.

Vibration impact during the tunnel support phase of the works is assessed as low to negligible.

D.5 SPI civil and tunnel support sites

Airborne noise and vibration impact from the SPI civil surface works and tunnel support site was determined by modelling the noise/ vibration sources, receiver locations, and operating activities, based on the information presented in Section D.2. Predicted noise levels at each receiver from the prescribed construction activities were assessed against the relevant NMLs for each NCA. The predictions are representative of noise levels during the site establishment and the construction phase of the works. Consistent with the requirements of ICNG, the construction noise impacts are based on a conservative but realistic worst case assessment. It is expected that the construction noise levels would be lower than have been predicted.

Temporary noise walls included in this assessment have been determined in consultation with the community, as required by Condition D20, and presented in the Temporary Noise Barrier Strategy for the SPI civil and tunnel support sites [ref: TH014-05 01F18 WXC_M5N Temp Barrier Nse Rep_SPI].

D.5.1 Noise/vibration assessment assumptions

The stages/operations considered in the noise model and vibration assessment for the SPI civil surface works and tunnel support sites are summarised in the table below.

Table D.5.1 Noise modelling assumptions - SPI civil and tunnelling support sites

Activity/ Work Area	Aspect	Includes OOHW?	Approx. timing	Modelled construction stage							
				V01	V02	V03	V04	V05	V06	V07	V08
				Site establishment			TS	Civil works			
Canal Road compound (C8) Civil works site establishment	Power Generator	No	07-09 2016	■	■	■	■				
	Installation of enviro controls	No	07-09 2016	■							
	Demolition of existing structures	Yes	07-09 2016	■							
	Crushing & Screening	No	07-09 2016	■							
	Vegetation Clearing	Yes	07-09 2016	■	■						
	Establishment of construction facilities and access roads	No	07-09 2016		■	■	■	■			
	Road and intersection modifications and traffic controls	Yes	07-09 2016		■	■	■				
	Installation of Site Hoarding	Yes	07-09 2016	■	■	■					
Burrows Road compound (C11) Local roads site establishment	Installation of enviro controls	No	08-12 2016	■							
	Demolition of existing structures (minor)	No	08-12 2016	■							
	Vegetation Clearing	No	08-12 2016	■							
	Establishment of construction facilities	No	08-12 2016	■	■						
Campbell Road Civil and Local Roads compound (C9) Civil works and local roads site establishment	Power Generator	No	08-12 2016	■	■	■	■				
	Installation of enviro controls	No	08-12 2016		■						
	Demolition of existing structures (major)	No	08-12 2016	■	■	■	■				
	Vegetation Clearing	No	08-12 2016		■						
	Establishment of construction facilities (local roads/ civil works)	No	08-12 2016			■	■				
	Road and intersection modifications traffic controls	Yes	08-12 2016		■	■					
SPI Tunnelling support compound (C8) Tunnelling Support Site Establishment	Installation of enviro controls	No	07-09 2016		■						
	Demolition of existing structures	No	07-09 2016		■						
	Vegetation Clearing	No	07-09 2016		■						
	Establishment of construction facilities	No	07-09 2016			■	■				
	Road and intersection modifications and traffic controls	Yes	07-09 2016		■	■					
	Piling (shed)	No	08-09 2016				■				
	Tunnel support works	Yes	2016-2018					■	■	■	■
SPI Portal civil and surface works	Piling; Excavation of decline	No	2016-2018						■		
	Earthworks	No	2016-2018							■	
	Road tie-in works	No	2016-2018								■
	Earthworks	No	2016-2018						■		
	Dynamic compaction & Piling	No	2016-2018							■	

Activity/ Work Area	Aspect	Includes OOHW?	Approx. timing	Modelled construction stage									
				V01	V02	V03	V04	V05	V06	V07	V08		
SPI Northern Ramps civil and surface works	Road tie-in works	No	2016-2018										

Note: TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week. TS has been modelled concurrent with other civil works activities (V06-V08), as well as in isolation (V05).

Sections D.3.2 and D.3.2.2 below summarise the impacts for each construction stage in each NCA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. The colours in the table indicate whether or not receivers in the NCA comply with the NML and, where exceedance of the NML occurs, the perceived impact of the exceedance.

D.5.2 Construction airborne noise impacts

D.5.2.1 Predicted noise levels for standard hours works

The impacts presented are as follows for **Standard Hours**:





-  Complies with NML
-  Exceeds NML by less than 10 dB(A) – noise affected
-  Exceeds NML by more than 10 dB(A) – noise affected
-  > 75 dB(A) – highly noise affected

Table D.5.2 Summary of noise construction noise impacts (standard hours)

NCA	Level of compliance with NML for construction stage							
	V01	V02	V03	V04	V05	V06	V07	V08
	Site establishment				TS	Civil works (& TS)		
NCA01								
NCA02								
NCA03								
NCA04								
NCA06								
NCA07								
NCA08								
NCA09								
NCA10								
NCA11								

Notes All works to be undertaken during Standard construction hours (7am to 6pm Monday to Friday; 8am to 1pm Saturday)
 TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week. TS has been modelled concurrent with other civil works activities (V06-V08), as well as in isolation (V05).

The SPI site is generally further away from residential receivers, with the exception of Campbell Road residences in NCA 04, NCA 06, NCA 07 and NCA 08. NCA 01, 02, 03, 09 and 11 will not be noise affected during the site establishment works.

The site establishment of the Canal Road and the Burrows Road compounds will be of minimal noise impact – some receivers in NCAs 06, 07 and 10 will be noise affected during these works, mainly as a result of vegetation clearing and demolition works on these sites.

The demolition works along Campbell Road associated with the Civil works and Local Roads compounds will have higher noise impact to receivers in NCA 04, in particular the row of terraces opposite the compound site on Campbell Road. Vegetation clearing and demolition will generate higher noise impact, mainly because these works need to be completed to enable the installation of environmental controls, including noise walls and construction hoardings. It is not possible to install noise walls or construction hoarding prior to these activities being completed. Noise walls and hoardings will be installed as early as practicable. As demolition of buildings along Campbell Road progresses towards Princes Highway, the highly noise affected properties will change. Receivers in NCA 04 will be less impacted and receivers in NCA 08 will be more impacted. High noise generating works will be managed through offering respite as noted in Section 4.1.3.

Excavation works associated with the SPI portal at the SPI compound may generate noise levels that will be clearly audible to highly intrusive, again to the nearest receivers in NCA 08 and to the commercial properties backing onto the site in NCA 07. Activities such as rock hammering during excavation works and piling works are likely to cause receivers in NCA 07 to be highly noise affected. Noise from these activities may also be clearly audible at the nearest affected receivers in only NCA 04, 06 and 07.

Measures for managing the noise impacts are provided in Section 6.2, including the use of respite periods for high noise impact activities such as rock breaking and piling works, in accordance with D14.

During the earthworks, piling and compaction associated with the SPI Northern Ramps the nearest receivers in in NCA 04, NCA 07 and NVA08 may be highly noise affected. Noise walls and construction hoarding will be installed as outlined in APPENDIX G to reduce noise levels during the construction phase.

The SPI site is generally further away from residential receivers, with the exception of Campbell Road residences. NCA 01, 02, 03, 09 and 11 will not be noise affected during the site establishment or tunnel support works.

Some receivers in NCAs 06 and 10 may be noise affected during site establishment works, though not once tunnelling support is underway.

The site establishment works, including demolition and vegetation clearing along Campbell Road associated with the Civil works and Local Roads compounds will have higher noise impact to receivers in NCA04, 07 and 08 in particular the row of terraces opposite the compound site on Campbell Road. It is not possible to install noise walls or construction hoarding prior to these activities being completed. Noise walls and hoardings will be installed as early as practicable.

Excavation works associated with the tunnelling support portal, in particular as rock hammering may generate noise levels that will be clearly audible to highly intrusive to the nearest receivers in NCAs 04, 06, and 08 and to the commercial properties backing onto the site in NCA 07. Activities such during excavation works and piling works are likely to cause receivers in NCA 08 to be highly noise affected.

Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during standard construction hours.

Noise impacts associated from civil works have been assessed based on the details available to date. Construction impacts will be updated as the design progresses, with the aim to reduce impacts presented above.

Measures for managing the noise impacts are provided in detail in the CNVIS prepared for the site, including the use of respite periods for high noise impact activities such as rock breaking and piling. The operational at-property treatments will also be installed as early as practicable during the site establishment works to ensure receivers highly noise affected as well as noise affected during OOHW receive the benefit of at-property treatment during the construction phase.

Measures for managing the noise impacts outlined in Section 6 and APPENDIX G.

D.5.2.2 Predicted noise levels for OOHW

The impacts presented are as follows for OOHW Evening and Night:


































































-  Complies with NML
-  < 5 dB(A) above NML - construction noise noticeable
-  5 to 15 dB(A) above NML - construction noise clearly audible
-  > 15 to 25 dB(A) above NML - construction noise moderately intrusive
-  > 25 dB(A) above NML - construction noise highly intrusive

Table D.5.3 Summary of noise construction noise impacts (OOHW)

NCA	Level of compliance with NML for construction stage							
	V01	V02	V03	V04	V05	V06	V07	V08
	Site establishment				TS			
NCA01	-			-				
NCA02	-			-				
NCA03	-			-				
NCA04	-			-				
NCA06	-			-				
NCA07	-			-				
NCA08	-			-				
NCA09	-			-				
NCA10	-			-				
NCA11	-			-				

Notes All works to be undertaken during OOHW Evening 6pm to 10pm Monday to Sunday; or OOHW Night 10pm to 7am Monday to Friday and 10pm to 8am Saturday, Sunday and public holidays; OOHW Day 1pm to 6pm Saturday and 8am to 6pm Sundays and public holidays.
 Level of compliance reported is based on worst case impact for OOHW period (typically night period)
 - indicates that OOHW is not anticipated for this construction stage
 TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week.

Receivers in NCA01, NCA02, NCA03, NCA09, and NCA11 will be unaffected by all of the St Peters Interchange site establishment out-of-hours works

For the various combinations of hoarding installation and tree removal along Canal Road, as well as high voltage power crossing and power pad installation, the worst impacts are when all of those activities are occurring simultaneously. The nearest receivers in NCA06 and NCA07 will be affected by moderately to highly intrusive noise levels during the works.

Noise may be clearly audible at the closest receivers in NCA04 and NCA10. Temporary, relocatable screens will be used during these OOHW to reduce noise impacts. Where practicable, higher noise impact activities, in particular use of the concrete saw will be limited to before midnight (note that works cannot commence until 10:00 pm due to Road Occupancy Licence requirements). In addition to this, respite offers and alternative accommodation will be offered in accordance with the OOHW protocol.

A CNVIS has been prepared for the OOHW site establishment works, with detailed assessment and recommendations to limit impacts to receivers, in accordance with the EPL, ICNG, CNS and the OOHW Protocol for this Project.

Construction noise impacts from the tunnelling support operations are predicted to comply with the NMLs during the OOHW period, with the exception of NCA04, NCA07 and NCA08. The location of the truck haulage route on site results in up to residual impact 28 properties. At property treatment has been recommended for these sites, and is further detailed in the CNVIS for this site.

Measures for managing the noise impacts, including residual impact properties requiring at-property treatment, are outlined in Section 6 and APPENDIX G.

Measures for managing the noise impacts are provided in detail in the CNVIS prepared for the site, including the use of respite periods for high noise impact activities such as rock breaking and piling works.

D.5.3 Construction vibration impacts

Vibration generated by site establishment and construction of the SPI civil and surface works and tunnel support works was estimated at various distances and the risk of structural damage from construction vibration are shown in the top half of Table D10 below. The risk of human disturbance from construction vibration are shown in the bottom half of Table D.10.

Table D.5.4 Assessment of vibration impact for residential/commercial properties

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
Risk of structural or cosmetic damage					
NCA01	750m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA02	700m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA03	230m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA04	20m	Residential	Low risk	Low risk	Negligible risk
NCA05	80m	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA06	75m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA07	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Very low risk
NCA08	12m	Residential	Low risk	Low risk	Negligible risk
NCA09	260m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	25m	Commercial	Negligible risk	Negligible risk	Negligible risk
Risk of disturbance to building occupants					
NCA01	750m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA02	700m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA03	230m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA04	20m	Residential	Very high risk	Very high risk	Very low risk
NCA05	80m	Industrial	Negligible risk	Negligible risk	Negligible risk

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
NCA06	75m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA07	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Low risk
NCA08	12m	Residential	Very high risk	Very high risk	Very low risk
NCA09	260m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	25m	Commercial	Low risk	Low risk	Negligible risk
NCA11	25m	Industrial	Low Risk	Low Risk	Negligible risk

Analysis of the risk of vibration impact during site establishment and civil works, construction activities are potentially close to industrial buildings in NCA07 respectively, mainly due to works associated with the tunnel support site. These activities have a very high risk of generating vibration above the limits for structural damage and/ or human disturbance due to the close proximity of the works. Occupants of residential buildings on Campbell Road/ Campbell Street opposite the site in NCA04 and NCA08 are at risk of human disturbance from vibration generated during the site establishment and civil works.

Activities like vibratory compaction may be noticeable inside residential and industrial premises closest to the works. Where plant is likely to be used within the minimum working distances described in Section 6.3 of this CNVMP, site specific minimum working distances shall be determined and maintained as noted above. Building occupants at risk of vibration impact will be notified in accordance with Table 6.6 in Section 6.4 of this CNVMP to satisfy conditions of approval D11.

Site specific minimum working distances shall be determined prior to commencement of the regular use of plant and equipment on site to satisfy condition of approval D22. Site specific minimum working distances will be maintained in order to comply with relevant vibration limits. Where minimum working distances are unable to be maintained, alternative construction methodology will be adopted in order to meet the vibration objectives.

During tunnel support works there is a very low risk of structural damage. Disturbance to building occupants may occur is also low to very low risk.

For more detailed predictions see the detailed CNVIS report prepared for the western civil and surface works and tunnel support works prepared under this NVMP. Each CNVIS report manages vibration impact in detail on a site by site basis. Receivers where vibration monitoring is required are identified and measures to reduce the risk of vibration impact are discussed.

D.6 Local roadworks sites

Airborne noise and vibration impact from the local road works on Euston Road, Campbell Road/ Campbell Street, Bedwin Road, Bourke Road/ Bourke Street, Gardeners Road, construction of new and upgrades/ modifications to existing bridges including the pedestrian bridges to Campbell Street and the Alexandra Canal., were determined by modelling the noise/ vibration sources, receiver locations, and operating activities, based on the information presented in Section D.2. Predicted noise levels at each receiver from the prescribed construction activities were assessed against the relevant NMLs for each NCA. The predictions are representative of noise levels during the local roads construction phase of the works. Note that the local roads compound establishment is addressed under the SPI site.

Consistent with the requirements of ICNG, the construction noise impacts are based on a conservative but realistic worst case assessment. It is expected that the construction noise levels would be lower than have been predicted. Some noise impact assessment works are still based on the preliminary design. The design is still in progress, particularly in relation to local roads.

Temporary noise walls included in this assessment have been determined in consultation with the community, as required by Condition D20, and presented in the Temporary Noise Barrier Strategy for the Campbell Street and Road [ref: M5N-ES-PLN-LRW-0006].

Noise walls/ construction hoarding will be installed as soon as practicable and where possible (i.e. where no existing structure/ vegetation obstructs the noise wall/ hoarding construction) will be constructed prior to vegetation clearing and building demolition.

D.6.1 Noise/vibration assessment assumptions

The stages/operations considered in the noise model and vibration assessment for the local road works sites are summarised in the table below.

Table D.5.1 Noise modelling assumptions - Local roadworks sites

Activity/ Work Area	Aspect	Includes OOHW?	Approx. timing	Modelled construction stage												
				V01	V02	V03	V04	V05	V06	V07	V08	V09	V10	V11		
				Roadworks			Bridges			UW						
Roadworks	Demolition of existing structures	No	01-03 2017	Green												
	Earthworks	No	02-08 2017		Purple											
	Road tie-in works	Yes	2017-2018			Cyan										
	Kerbing & drainage	No	2017-2018				Yellow									
Bridgeworks	Pedestrian Bridges to Campbell Road	Yes	2017-2018					Orange								
	Alexandra Canal Bridge	No	2017-2018						Red							
Utility works	Utility works	Yes	2016-2018													Blue

Notes UW refers to Utility works

Sections D.6.2.1 and **Error! Reference source not found.** below summarise the impacts for each construction stage in each CA in terms of compliance with the NMLs during standard construction hours and for OOHW respectively. The colours in the table indicate whether or not receivers in the NCA comply with the NML and, where exceedance of the NML occurs, the perceived impact of the exceedance.

D.6.2 Construction airborne noise impacts

D.6.2.1 Predicted noise levels for standard hours works

The impacts presented are as follows for **Standard Hours**:

- ◆ Complies with NML
- ◆ Exceeds NML by less than 10 dB(A) – noise affected
- ◆ Exceeds NML by more than 10 dB(A) – noise affected
- ◆ > 75 dB(A) – highly noise affected

Table D.5.2 Summary of noise construction noise impacts (standard hours)

Level of compliance with NML																						
NCA	V01		V02		V03		V04		V05		V06		V07		V08		V09		V10		V11	
	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²	D ¹	D ²
NCA01	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA02	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA03	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA04	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCA06A	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA06B	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA07	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA08	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA10	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
NCA11	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

Notes: 1. WITHOUT Sawing and/or Hammering
 2. WITH Sawing and/or Hammering
 NCA05 does not contain any residential receivers

The local road works will be close to residential and other sensitive receivers along the road corridors where the works are being carried out. Receivers in NCA02, NCA09, and NCA11 are generally further away from and will not be noise affected during the site establishment works.

Predictions show that compliance will be achieved for receivers within NCA10 throughout the construction works. Furthermore, with temporary hoardings in place and no high noise activities (sawing/ rock hammering), compliance will also be achieved for NCA02 throughout the construction works. For receivers within NCA02 exceedances of 10 dB(A) above the NML are predicted to occur during sawing/rock hammering activity. The exception will be during V10 (Q1 2019), when construction activities are closer to NCA02 and higher noise impacts are anticipated.

Receivers within all NCAs except for NCA02 and NCA10 will be noise affected throughout the construction works. Receivers are typically highly noise affected during high noise activities (sawing/ rock hammering), requiring the use of respite periods to manage noise impacts during standard hours. Receivers in NCA03 and NCA07 that are closest to the works will be highly noise affected whenever construction activity is in close proximity. Note that the same receiver will not be highly noise affected for the duration of the works nor for the duration of each construction activity as equipment will shift/relocate as the works progress.

High noise generating works will be managed through offering respite as noted in Section 4.1.3. Measures for managing the noise impacts are provided in Section 6.2, including the use of respite periods for high noise impact activities such as rock breaking and piling works, in accordance with D14. The operational at-property treatments will also be installed as early as practicable during the site establishment works to ensure receivers highly noise affected as well as noise affected during OOHW receive the benefit of at-property treatment during the construction phase to satisfy D68(b)x, as noted in Section 6.5 of this CNVMP.

During the piling and concreting works associated with the Campbell Road pedestrian bridges and the Alexandra Canal bridge the nearest receivers in in NCA 04, NCA 07 and NVA08 may be moderately to highly noise affected. Noise walls and construction hoarding will be installed as outlined in APPENDIX G to reduce noise levels during the construction phase. Works will be scheduled to the standard hours period as much as practicable to minimise impacts during the OOHW period when people are more likely to be disturbed at home.

OOHW associated with local roadworks will be short term in duration. The works will be required to be completed out of standard hours, when access to roads is permitted by RMS Traffic Management Centre. Works will be completed during standard hours as much as practicable. If OOHW is needed it will be conducted in accordance with the EPL, ICNG, CNS and the OOHW Protocol for this Project. Measures for managing the noise impacts are provided in detail in the CNVIS prepared for the site, including the use of respite periods for high noise impact activities such as rock breaking and piling.

Measures for managing the noise impacts outlined in Section 6 and APPENDIX G.

D.6.3 Construction vibration impacts

Vibration generated by site establishment and construction of the SPI civil and surface works and tunnel support works was estimated at various distances and the risk of structural damage from construction vibration are shown in the top half of Table D.10 below. The risk of human disturbance from construction vibration are shown in the bottom half of Table D.10.

Table D.5.4 Assessment of vibration impact for residential/commercial properties

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Bridge works
Risk of structural or cosmetic damage					
NCA01	10m	Residential	Low risk	Low risk	Negligible risk
NCA02	20 m	Residential	Very low risk	Very low risk	Negligible risk
NCA03	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA04	<5m (Adjacent)	Residential	Very high risk	Very high risk	Very low risk
NCA05	5m	Industrial	Low Risk	Low Risk	Negligible risk
NCA06	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA07	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Negligible risk
NCA08	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA09	800m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	800m	Commercial	Negligible risk	Negligible risk	Negligible risk
NCA11	<5m	Industrial	Low Risk	Low Risk	Low Risk
Risk of disturbance to building occupants					
NCA01	10m	Residential	High risk	High risk	Negligible risk
NCA02	20 m	Residential	Very low risk	Very low risk	Negligible risk
NCA03	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA04	<5m (Adjacent)	Residential	Very high risk	Very high risk	Medium risk
NCA05	5m	Industrial	High risk	High risk	Negligible risk
NCA06	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA07	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Negligible risk
NCA08	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA09	800m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	800m	Commercial	Negligible risk	Negligible risk	Negligible risk
NCA11	<5m	Industrial	Low Risk	Low Risk	Medium risk

There are 117 buildings that are located within the buffer distance established for cosmetic damage during piling, jackhammering, rock hammering, rolling, drilling, and compacting

These activities have a very high risk of generating vibration above the limits for structural damage and/ or human disturbance due to the close proximity of the works. Activities like vibratory compaction may be noticeable inside residential and industrial premises closest to the works. Where plant is likely to be used within the minimum working distances described in Section 6.3 of this CNVMP, site specific minimum working distances shall be determined and maintained as noted above. Building occupants at risk of vibration impact will be notified in accordance with Table 6.6 in Section 6.4 of this CNVMP to satisfy conditions of approval D11.

There are 132 commercial buildings and 2 school buildings that may be exposed to vibration above the limit for human annoyance. However, due to the limited time the above plant will be operating in close proximity of these commercial properties, the risk of annoyance is also considered very low.

Site specific minimum working distances shall be determined prior to commencement of the regular use of plant and equipment on site to satisfy condition of approval D22. Site specific minimum working distances will be maintained in order to comply with relevant vibration limits. Where minimum working distances are unable to be maintained, alternative construction methodology will be adopted in order to meet the vibration objectives.

For more detailed predictions see the detailed CNVIS for Local Roads works prepared under this NVMP. Each CNVIS report manages vibration impact in detail on a site by site basis. Receivers where vibration monitoring is required are identified and measures to reduce the risk of vibration impact are discussed.

D.7 Ground-borne noise impacts (tunnelling)

D.7.1 Noise/vibration assessment assumptions

Ground-borne noise is typically not assessable during standard hours as airborne noise levels are usually higher and have the effect of masking ground borne noise. Higher noise impact excavation methods such as rock hammering may generate ground-borne noise that is audible inside occupied premises during standard hours.

The tunnelling design is still in progress and consequently noise and vibration impact from tunnelling is presented in terms of preliminary modelling completed to date. The CNVMP will be updated when details become available. More detailed results are presented in the Tunnelling CNVIS report.

The stages/operations considered in the noise model and vibration assessment for the tunnelling works are summarised in the table below.

- Roadheader tunnelling – two (2) Roadheaders to excavate the two main road tunnel heading (and bench TBC), ramp tunnels heading (and bench TBC), cross passages and ventilation tunnels
- Rock hammer tunnelling – two (2) Rock hammers bench clearing, cross passages and drainage excavation
- Blasting – cross passages. Under investigation, details to be confirmed. CNVMP will be updated if blasting is confirmed as a tunnel excavation method.

D.7.2 Tunnelling ground-borne noise impacts

The impacts presented are as follows for **Standard Hours**:

- ◆ Complies with GNML
- ◆ Exceeds GNML by less than 10 dB(A) – noise affected

Exceeds GNML by more than 10 dB(A) – noise affected

Predicted impacts will be provided in a later version of the document once OOHW are approved.

Table D.7.1 Summary of noise construction noise impacts – Tunnelling

NCA	Level of compliance with NML for construction stage								
	Roadheader tunnelling (heading/ bench)			Rock hammer tunnelling (bench only)			Rock hammer tunnelling (cross passages)		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
St Peters Interchange to Arncliffe tunnel support site									
NCA06	Green	Green	Light Green	Green	-*	-*	Green	-*	-*
NCA09	Green	Green	Light Green	Green	-*	-*	Green	-*	-*
NCA10	Green	Green	Light Green	Green - Blue	-*	-*	Green - Blue	-*	-*
NCAT3	Green	Green	Green	Green - Blue	-*	-*	Green - Blue	-*	-*
Arncliffe tunnel support site to Bexley tunnel support site									
NCA12	Green	Green	Green	Green - Blue	-*	-*	Green - Blue	-*	-*
NCA13	Green	Green	Green	Green - Blue	-*	-*	Green - Blue	-*	-*
NCA14	Green	Green	Green	Green - Blue	-*	-*	Green - Blue	-*	-*
NCAT2	Green	Green	Light Green	Green - Blue	-*	-*	Green - Blue	-*	-*
NCAT1	Green	Green	Light Green	Green - Blue	-*	-*	Green - Blue	-*	-*
NCA15	Green	Green	Light Green	Green - Blue	-*	-*	Green - Blue	-*	-*
Bexley tunnel support site to Western Portal									
NCA26	Green	Light Green	Yellow	Green - Blue	-*	-*	Green - Blue	-*	-*
NCA18	Green	Green	Light Green	Green	-*	-*	Green	-*	-*
NCA25	Green	Green	Green	Green	-*	-*	Green	-*	-*
NCA19	Green	Green	Green	Green	-*	-*	Green	-*	-*
NCA24	Green	Green	Green	Green	-*	-*	Green	-*	-*

Notes: - indicates that OOHW is not anticipated for this construction stage

* GBN from rock hammer excavation will be managed by restricting this activity to standard construction hours where tunnelling is below residential areas

The extent of mitigation and management required to limit potential GBN impacts to receivers is determined by looking not only at the level of noise impact, but also the duration that receivers are likely to be exposed to GBN levels above the strictest annoyance trigger level [i.e. night-time 35 dB(A)]. Furthermore, the duration receivers are exposed to GBN levels more than 10 dB(A) above the strictest annoyance trigger level [i.e. 45 dB(A)] is also determined.

GBN from rock hammer excavation will be managed by restricting this activity to standard construction hours. The predicted noise levels and land use survey indicate that some areas may be able to be excavated during the OOHW period, namely areas of NCA10, NCAT3, NCA12, NCAT1, NCA18 and NCA25, where the tunnel is located under mostly commercial/ industrial properties which would benefit from 24-hour excavation or recreational areas which won't be impacted by GBN. This would reduce the time of exposure to high noise levels during business hours. Furthermore, if verification monitoring conducted during the rock hammer tunnelling works finds that ground-borne noise levels inside residential properties are below the predicted noise levels and comply with the GNMLs, the rock hammer tunnel excavation may be extended into the OOHW period.

During standard construction hours, residential properties in the NCAs identified in Table D.7.1 above will be GBN affected. No residential properties will be 'highly noise affected' from GBN as a result of rock hammer tunnelling.

Measures for managing GBN impacts are provided in general in Section 6 of this CNVMP. Detailed noise mitigation and management measures are provided in the Tunnelling CNVIS.

D.7.3 Tunnelling vibration noise impacts

Vibration generated by tunnelling was estimated based on the tunnel depth and excavation methodology and the risk of structural damage from tunnelling vibration are shown in the top half of Table D7.2 below. The risk of human disturbance from tunnelling vibration are shown in the bottom half of Table D.7.2.

Table D.7.2 Assessment of vibration impact for residential/commercial properties

NCA	Type of Buildings	Risk of vibration impact		
		Roadheader tunnelling (heading/ bench)	Rock hammer tunnelling (bench only)	Rock hammer tunnelling (cross passages)
Risk of structural or cosmetic damage				
NCA06	Residential	Negligible risk	Negligible risk	Negligible risk
NCA09	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	Commercial/ Residential	Negligible risk	Negligible risk	Negligible risk
NCAT3	Residential/ Commercial	Negligible risk	Negligible risk	Negligible risk
NCA12	Residential	Negligible risk	Negligible risk	Negligible risk
NCA13	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	Residential	Negligible risk	Negligible risk	Negligible risk
NCAT2	Residential	Negligible risk	Negligible risk	Negligible risk
NCAT1	Residential	Negligible risk	Negligible risk	Negligible risk
NCA15	Residential/ Industrial	Negligible risk	Negligible risk	Negligible risk
NCA26	Residential/ Industrial	Negligible risk	Negligible risk	Negligible risk
NCA18	Industrial/ Residential	Negligible risk	Negligible risk	Negligible risk
NCA25	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA19	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA24	Industrial	Negligible risk	Negligible risk	Negligible risk
Risk of disturbance to building occupants				
NCA06	Residential	Negligible risk	Negligible risk	Negligible risk
NCA09	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	Commercial/ Residential	Negligible risk	Negligible risk	Negligible risk
NCAT3	Residential/ Commercial	Negligible risk	Negligible risk	Negligible risk
NCA12	Residential	Negligible risk	Negligible risk	Negligible risk
NCA13	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	Residential	Negligible risk	Negligible risk	Negligible risk
NCAT2	Residential	Negligible risk	Low risk	Low risk
NCAT1	Residential	Negligible risk	Low risk	Low risk
NCA15	Residential/ Industrial	Negligible risk	Low risk	Low risk
NCA26	Residential/ Industrial	Negligible risk	Medium Risk	Medium risk
NCA18	Industrial/ Residential	Negligible risk	Low risk	Low risk
NCA25	Industrial	Negligible risk	Very low risk	Very low risk
NCA19	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA24	Industrial	Negligible risk	Negligible risk	Negligible risk

Vibration from tunnelling was determined by modelling the vibration source, tunnel location and receiver locations, based on the information presented in Section D.7.1.

The assessment found vibration from road header excavation of the tunnels was below the vibration limit for human disturbance and the below the limit for sensitive equipment. Vibration from roadheader tunnelling was assessed as negligible risk of impact.

Vibration from rock hammer excavation of the tunnels may be noticeable inside residential and industrial premises in the NCAs identified in Table D.7.2 above. Building occupants at risk of vibration impact will be notified in accordance with Table 6.6 in Section 6.4 of this CNVMP to satisfy conditions of approval D11.

The tunnel runs adjacent to the two aboriginal heritage sites, WC-OVRH1 in Earlwood and RC-OVRH1 in Bardwell Park. Vibration from Roadheader and Rock hammer activity at the nearest location along the tunnel alignment to the heritage sites is predicted to be less than 1 mm/s ppv. This is within the structural damage limit for heritage sites. There is a very low risk of structural damage to the aboriginal heritage sites WC-OVRH1 and RC-OVRH1 as a result of the tunnelling works.

APPENDIX E **Properties eligible for consideration of at-property treatment**

E.1 Properties identified as eligible for consideration of at-property treatment in construction design

Table E.1: Predicted receivers with long-term residual OOHW noise impacts from 24-hour tunnel support sites - eligible for consideration of at-property treatment

NCA	Address	EIS Outcomes		Construction design outcomes			Date for treatment to be installed	Treatment type	Satisfies Condition D19?
		Identified for operational noise treatment?	Treatment type	Exceeds NML?		Source of noise that triggers treatment			
				Std Hours	OOHW				
Kingsgrove compounds (C1, C2 and C3)									
NCA19	99 Glamis Street, Kingsgrove	No	N/A	No (V08)	Yes	OOHW concrete trucks at Kingsgrove North compound (C1)	Mar-17	Type 1A	N/A
Bexley Road compounds (C4, C5, C6)									
NCA15	258 Bexley Road Earlwood	No	N/A	Yes (V06)	Yes	OOHW concrete trucks at Bexley Road North compound (C4)	Mar-17	Type 1A	N/A
NCA15	264 Bexley Road Earlwood	No	N/A	Yes (V06)	Yes		Mar-17	Type 1A	N/A
NCA15	94 Wolli Avenue Earlwood	No	N/A	Yes (V06)	Yes		Mar-17	Type 1A	N/A
Arncliffe compound (C7)									
NCA12	31 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	39 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	41 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	43 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	24a Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	24 Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	32 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	34 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	36 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	30 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	28 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	26 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	24 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	22 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	20 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	29 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	27 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	25 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	20-26 Innesdale Road Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	35 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	37 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	39 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	41 Flora Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	30 Valda Avenue Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	32 Valda Avenue Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA12	22a Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A

NCA	Address	EIS Outcomes		Construction design outcomes				Satisfies Condition D19?	
		Identified for operational noise treatment?	Treatment type	Exceeds NML?		Source of noise that triggers treatment	Date for treatment to be installed		Treatment type
				Std Hours	OOHW				
NCA12	11 Valda Avenue Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	15 Valda Avenue Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	19 Valda Avenue Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	22 Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	20 Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	18a Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	18 Marsh Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	24 Levey Street Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA12	26-32 Marsh Street Wolli Creek	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1B	N/A
NCA13	33 West Botany Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA13	37 West Botany Street Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
NCA14	20 Brennans Road Arncliffe	No	N/A	No (V06)	Yes	Night haulage noise	Jan-17	Type 1A	N/A
SPI Tunnel Support compound (C10)									
NCA04	2 Campbell Road Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA04	4 Campbell Road Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA04	6 Campbell Road Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA04	8 Campbell Road Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA04	10 Campbell Road Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA04	12 Campbell Road Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	19 Campbell Street Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	21 Campbell Street Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	23 Campbell Street Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	25 Campbell Street Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	27 Campbell Street Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	29 Campbell Street Alexandria	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1A	Yes
NCA08	53 Barwon Park Road St Peters	Yes	Type 2	No (V05)	Yes	Night haulage noise	Mar-17	Type 1B	Yes

Notes: 'N/A' refers to properties where Condition D19 is not applicable as this property has not been identified as eligible for consideration of operation at-property treatment.

E.2 Properties identified in the EIS as eligible for consideration of at-property treatment

Table E.2: Properties identified as eligible for consideration of operational at-property treatment in the EIS and affected by construction noise

NCA	Address	EIS Outcomes		Construction design outcomes					
		Identified for operational noise treatment?	Treatment type	Exceeds NML?		Source of construction noise	Date for treatment to be installed	Treatment type (TBC)	Condition D19 satisfied?
				Std Hours	OOHW				
NCA01	93-103 Euston Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA01	125 Euston Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA01	220-230 Lawrence St Alexandria	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA01	288-302 Lawrence St Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA03	58 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	71 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	73 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	77 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	79 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	81 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	83 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	85 Hutchinson Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA03	87 Hutchinson Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA03	101 Hutchinson Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA03	60-68 Hutchinson Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	19 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	21 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	23 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	25 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	27 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	29 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	31 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	33 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	35 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	37 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	39 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	41 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	43 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	45 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	47 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	49 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	51 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	53 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA03	55 Lackey Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary

NCA	Address	EIS Outcomes		Construction design outcomes					
		Identified for operational noise treatment?	Treatment type	Exceeds NML?		Source of construction noise	Date for treatment to be installed	Treatment type (TBC)	Condition D19 satisfied?
				Std Hours	OOHW				
NCA03	63-65 Campbell Street Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA03	67 Campbell Street Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	2 Campbell Road Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA04	4 Campbell Road Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA04	6 Campbell Road Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA04	8 Campbell Road Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA04	10 Campbell Road Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA04	12 Campbell Road Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA04	14 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	16 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	18 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	20 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	22 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	24 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	26 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	28 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	30 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	32 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA04	34 Campbell Road Alexandria	Yes	Type 2	Yes	TBC	Local roadworks	Mar-17	Type 2	Yes ¹
NCA06	75 Church Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	77 Church Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	79 Church Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	81 Church Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	83 Church Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	85 Church Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	87 Church Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	89 Church Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	91A-D Church Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	1b St Peters Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	4 St Peters Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	5 St Peters Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	6 St Peters Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	7 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	8 St Peters Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	9 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	11 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	12 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary

NCA	Address	EIS Outcomes		Construction design outcomes					
		Identified for operational noise treatment?	Treatment type	Exceeds NML?		Source of construction noise	Date for treatment to be installed	Treatment type (TBC)	Condition D19 satisfied?
				Std Hours	OOHW				
NCA06	13 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	15 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	16 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	17 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	18 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	21 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	23 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	31 St Peters Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	4 Florence Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	6 Florence Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	7 Florence Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	8 Florence Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	9 Florence Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	10 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	11 Florence Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	12 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	13 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	14 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	15 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	16 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	17 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	18 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	19 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	20 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	21 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	24 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	26 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	29 Florence Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	3 Brown Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	5 Brown Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	7 Brown Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	9 Brown Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	10 Brown Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	12 Brown Street St Peters	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA06	11 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	13 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	15 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary

NCA	Address	EIS Outcomes		Construction design outcomes					Condition D19 satisfied?
		Identified for operational noise treatment?	Treatment type	Exceeds NML?		Source of construction noise	Date for treatment to be installed	Treatment type (TBC)	
				Std Hours	OOHW				
NCA06	16 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	17 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	19 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	21 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	22 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	23 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	24 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	25 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA06	30 Brown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA07	159 Princes Highway St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	19 Campbell Street Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	21 Campbell Street Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	23 Campbell Street Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	25 Campbell Street Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	27 Campbell Street Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	29 Campbell Street Alexandria	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	53 Barwon Park Road St Peters	Yes	Type 2	Yes	Yes	Local roadworks/ SPI Tunnel Support	Mar-17	Type 2	Yes ¹
NCA08	31 Barwon Park Road St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	35 Barwon Park Road St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	47 Barwon Park Road St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	49 Barwon Park Road St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	51 Barwon Park Road St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	38 Crown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	44 Crown Street St Peters	Yes	Type 1	No (currently construction site)		Local roadworks	TBD	None	Report to Secretary
NCA08	65 Crown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	67 Crown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	71 Crown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	73 Crown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA08	75 Crown Street St Peters	Yes	Type 1	Yes	TBC	Local roadworks	TBD	Type 1	Report to Secretary
NCA11	8/635 Gardeners Road Mascot	Yes	Type 2	Yes	TBC	Local roadworks	TBD	Type 2	Report to Secretary
NCA20	1 Kirrang Street, Beverley Hills	Yes	Type 1	TBC	TBC	TBC	TBD	None	Report to Secretary

Notes: 1. Subject to installation of at-property treatment

APPENDIX F Out of Hours Work Protocol

Out of Hours Work Protocol

Project Name: WestConnex New M5

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Document Approval

Rev.	Date	Prepared by	Reviewed by	Recommended by	Approved by	Remarks
00	19/09/16	CDS-JV				
01	27/09/16	CDS-JV				
02	4/10/16	CDS-JV				
Signature:						

Out of Hours Work Protocol



Details of Revision Amendments

Document Control

The Project Director is responsible for ensuring that this Plan is reviewed and approved. The Support Services Director (SSD) is responsible for updating this Plan to reflect changes to the Project, legal and other requirements, as required.

Amendments

Any revisions or amendments must be approved by the Project Director before being distributed or implemented.

Revision Details

Revision	Details
00	Prepared for DP&E Approval
01	Updated to address WCX M5 AT comments.
02	Updated to address DP&E comments.

Out of Hours Work Protocol



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Out of Hours Work Protocol



1. Introduction

1.1 Context

This Out of Hours Work (OOHW) Protocol forms part of the Construction Noise and Vibration Management Plan (CNVMP), which is a sub-plan to the Construction Environmental Management Plan (CEMP) developed for the construction of the Project. The OOHW Protocol describes how CDS-JV will assess, manage and approve out of hours works during construction of the Project.

This OOHW Protocol has been prepared in accordance with the conditions of approval (CoA) for the project and in consultation with the Environment Protection Authority (EPA).

1.2 Training

Specific training will be provided to personnel likely to participate in OOHW. CDS-JV will ensure that project personnel can competently perform their duties and meet environmental obligations. Toolbox / pre-start talks are to include relevant works restrictions, management measures and expected workforce behavior.

Out of Hours Work Protocol



2. Legal and other requirements

2.1 Guidelines

Guidelines that relate to this OOHW Protocol are listed in Table 1.

Table 1: Guidelines that apply to noise and vibration impacts for out of hours work

Guideline
Interim Construction Noise Guidelines (DECC 2009)
Assessing Vibration: a technical guideline (DEC 2006)
Roads and Maritime Specification D&C G36: Environmental Protection, Edition 2 (Roads and Maritime 2014)
Construction Noise Strategy 7TP-ST-157/2.0 (Transport for NSW 2012)
Environmental Noise Management Manual (Roads and Traffic Authority 2001)

2.2 Minister's Conditions of Approval

The conditions of approval (CoA) that relate to construction noise and vibration and how they are being addressed by the project are provided in the CNVMP. CoA that specifically relate to this OOHW Protocol are provided in Table 2. A cross-reference is included to indicate where each condition is addressed in this OOHW Protocol or other project management document.

Table 2: Minister's Conditions of Approval that address out of hours works

Reference	Relevant condition	Where addressed
D12	Construction activities associated with the SSI must be undertaken during the following standard construction 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.	Refer to the CNVMP
D13	Notwithstanding condition D12, tunnelling may be undertaken 24 hours, seven days per week. Other activities associated with tunnelling (such as spoil haulage if approved under the Spoil Management Plan, deliveries, work area establishment, temporary road and intersection modifications, roads/cut-and-cover/dive structures and approach roads and ramps, excavation and ground support, civil, mechanical, and electrical, and ventilation facilities construction) may be undertaken outside of the hours specified in condition D12 where allowed in accordance with condition D15.	Sections 2.3 and 4 Also refer to the CNVMP
D14	Except as permitted by an EPL, activities resulting in impulsive or tonal noise emissions 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 hours each with a minimum respite from those activities and works of not less than one hour between each block. For the purposes of this condition, 'continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing any of the work the subject of this condition.	Section 3.6 Also refer to the CNVMP

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Reference	Relevant condition	Where addressed
D15	Notwithstanding conditions D12 and D14, construction works associated with the SSI may be undertaken outside the hours specified under those conditions in the following circumstances:	
	a) construction works that cause $L_{Aeq(15\text{ minute})}$ noise levels that are – <ul style="list-style-type: none"> (i) no more than 5 dB(A) above rating background level at any residence in accordance with the Interim Construction Noise Guideline (DECC, 2009), and (ii) no more than the noise management levels specified in Table 3 of the Interim Construction Noise Guideline (DECC, 2009) at other sensitive land uses, and (iii) continuous or impulsive vibration values, measured at the most affected residence are no more than those for human exposure to vibration, specified in Table 2.2 of Assessing vibration: a technical guideline (DEC, 2006), and (iv) intermittent vibration values measured at the most affected residence are no more than those for human exposure to vibration, specified in Table 2.4 of Assessing vibration: a technical guideline (DEC, 2006); or 	Section 4.1
	b) where a negotiated agreement has been reached with affected receivers, where the prescribed noise and/or vibration levels cannot be achieved; or	Section 4.1
	c) for the delivery of materials required by the police or other authorities for safety reasons; or	Section 4.1
	d) where it is required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm; or	Section 4.1
	e) construction works approved through an Out-Of-Hours Work Protocol prepared as part of the Construction Noise and Vibration Management Plan required by condition D68(b), provided the relevant council, local residents and other affected stakeholders and sensitive receivers are informed of the timing and duration at least five days and no more than 14 days prior to the commencement of the works; or	Section 4.2
	f) construction works approved through an EPL.	Section 4.3
D68(b)	a Construction Noise and Vibration Management Plan to detail how construction noise and vibration impacts will be minimised and managed. The Plan must be consistent with the guidelines contained in the Interim Construction Noise Guidelines (DECC, 2009). The Construction Noise and Vibration Management Plan must include, but not be limited to -	Refer to the CNVMP
	vi. an Out-of-Hours Work Protocol for the assessment, management and approval of works outside of standard construction hours as defined in condition D12 of this approval, for the Secretary's approval. The Out-of-Hours Work Protocol must be prepared in consultation with the EPA and be consistent with the out-of-hours work procedure detailed in the Construction Noise Strategy (Transport Construction Authority, 2011) and -	This OOHW Protocol
	A. provide an assessment of out-of-hours works against the relevant noise and vibration criteria,	Section 3

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Reference	Relevant condition	Where addressed
	B. provide detailed mitigation measures for any residual impacts (that is, additional to general mitigation measures), including extent of at-receiver treatments,	Sections 3.7 and 3.8
	C. set out proposed notification arrangements;	Section 5

2.3 OOHW justification

Construction work associated with the project will be undertaken in accordance with the assessment and management approach outlined in the Interim Construction Noise Guidelines (ICNG) and the Transport for NSW Construction Noise Strategy (2012). The ICNG outlines the recommended standard construction hours and requires that work outside of these hours must be appropriately justified. In general, OOHW undertaken on public infrastructure projects such as road works that are necessary to sustain the operational integrity of roads, are considered justified in the ICNG.

A description and justification for OOHW will be outlined in the relevant OOHW assessment report. Generally works are considered justified as OOHW to:

- Maintain the functional integrity of the road network around the project site, in particular the existing M5 Motorway, M5 East tunnels and the Princes Highway, and particularly during times of high traffic volumes;
- Maintain the structural integrity of existing and new road infrastructure proposed as part of the project;
- Promote the safety of road users, construction personnel and the public in general; and
- Minimise potential services/utilities disruptions (e.g. businesses and residential areas).

Where it is reasonable and feasible to undertake an activity during standard construction hours, approval for the activity as OOHW will not be sought. The justification for any activities proposed as OOHW must be established to the satisfaction of the Environment and Sustainability Manager.

Tunnelling is permitted to be undertaken 24 hours, seven days per week, under CoA D13. Activities associated with tunnelling may also be undertaken 24 hours, seven days per week where permitted in accordance with CoA D15. Tunnelling and activities associated with tunnelling that are proposed to be conducted 24 hours, seven days per week, will be subject to justification and a variation to the project EPL as described in Section 4 of this OOHW Protocol.

2.4 Hold points

Hold points that apply to OOHW are identified in Table 3.

Table 3: OOHW hold points

Hold Point	Details	Responsibility	Timing
Out of hours works approval	No out of hours works to be undertaken without OOHW approval (M5N-ES-FRM-PWD-0008)	Project Manager	Construction phase

Out of Hours Work Protocol



3. OOHW Assessment Procedure

Noise and vibration impact assessment is required for all construction activities for the project. The process for assessing impacts, including those relating to OOHW, is described in Section 5 of the CNVMP.

A consolidated summary of the detailed CNVIS reports prepared for each site under the project is provided in Appendix D of the CNVMP, and includes a summary of the predicted construction noise and vibration impacts (including OOHW). The predicted impacts for OOHW are summarised for the purposes of this Protocol below.

3.1 OOHW airborne noise assessment

The table below summarises the impacts for each construction stage in each NCA in terms of compliance with the airborne NMLs. The colours in the table indicate whether or not receivers in the NCA comply with the NML and, where exceedance of the NML occurs, the perceived impact of the exceedance.

The impacts presented are as follows for OOHW Evening and Night:

- Complies with NML
- < 5 dB(A) above NML - construction noise noticeable
- 5 to 15 dB(A) above NML - construction noise clearly audible
- > 15 to 25 dB(A) above NML - construction noise moderately intrusive
- > 25 dB(A) above NML - construction noise highly intrusive

Refer to Appendix D of the CNVMP for additional details regarding levels of compliance with airborne NMLs.

Table 4: Assessed level of compliance with NML for construction stages in each work area.

NCA	Level of compliance with NML for construction stage							
	Site establishment				Civil works			TS
Western Surface Works and Tunnel Support (including C1, C2, C3 compounds)	V01	V02	V03	V04	V05	V06	V07	V08
NCA18	N/A	N/A		N/A	N/A	N/A	N/A	
NCA19	N/A	N/A		N/A	N/A	N/A	N/A	
NCA20	N/A	N/A		N/A	N/A	N/A	N/A	
NCA23	N/A	N/A		N/A	N/A	N/A	N/A	
NCA24	N/A	N/A		N/A	N/A	N/A	N/A	
NCA25	N/A	N/A		N/A	N/A	N/A	N/A	
Bexley compounds	Site establishment					TS		
	V01	V02	V03	V04	V05			
NCA15	N/A	N/A		N/A				
NCA16	N/A	N/A		N/A				
NCA17	N/A	N/A		N/A				
NCA26	N/A	N/A		N/A				

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NCA	Level of compliance with NML for construction stage							
Arncliffe compound	Site establishment						TS	
	V01	V02	V03	V04	V05			
NCA12	N/A	🟡	N/A	N/A	🟡			
NCA13	N/A	🟢	N/A	N/A	🟢			
NCA14	N/A	🟢	N/A	N/A	🟢			
SPI civil and tunnel support sites	Site establishment				TS			
	V01	V02	V03	V04	V05	V06	V07	V08
NCA01	N/A	🟢	🟢	N/A	🟢	🟢	🟢	🟢
NCA02	N/A	🟢	🟢	N/A	🟢	🟢	🟢	🟢
NCA03	N/A	🟢	🟢	N/A	🟢	🟢	🟢	🟢
NCA04	N/A	🟡	🟡	N/A	🟢	🟢	🟢	🟢
NCA06	N/A	🟠	🟠	N/A	🟢	🟢	🟢	🟢
NCA07	N/A	🟠	🟠	N/A	🟢	🟢	🟢	🟢
NCA08	N/A	🟢	🟢	N/A	🟡	🟡	🟡	🟡
NCA09	N/A	🟢	🟢	N/A	🟢	🟢	🟢	🟢
NCA10	N/A	🟡	🟢	N/A	🟢	🟢	🟢	🟢
NCA11	N/A	🟢	🟢	N/A	🟢	🟢	🟢	🟢
Local Roads	Roadworks			Bridges		UW		
	V01	V02	V03	V04	V05	V06	V07	
NCA01	N/A	N/A	🟡	N/A	🟠	N/A	🟠	
NCA02	N/A	N/A	🟢	N/A	🟢	N/A	🟢	
NCA03	N/A	N/A	🔴	N/A	🔴	N/A	🔴	
NCA04	N/A	N/A	🔴	N/A	🔴	N/A	🔴	
NCA05	N/A	N/A	🟢	N/A	🟢	N/A	🟢	
NCA06	N/A	N/A	🟠	N/A	🔴	N/A	🔴	
NCA07	N/A	N/A	🟢	N/A	🟡	N/A	🟡	
NCA08	N/A	N/A	🟠	N/A	🔴	N/A	🔴	
NCA09	N/A	N/A	🟢	N/A	🟢	N/A	🟢	
NCA10	N/A	N/A	🟠	N/A	🟠	N/A	🟠	
NCA11	N/A	N/A	🟢	N/A	🟢	N/A	🟢	

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NCA	Level of compliance with NML for construction stage
Notes	<p>Refer to Appendix D of the CNVMP for details regarding proposed activities during each stage (V01, V02, etc).</p> <p>All works to be undertaken during OOHW Evening 6pm to 10pm Monday to Sunday; or OOHW Night 10pm to 7am Monday to Friday and 10pm to 8am Saturday, Sunday and public holidays; OOHW Day 1pm to 6pm Saturday and 8am to 6pm Sundays and public holidays.</p> <p>Level of compliance reported is based on worst case impact for OOHW period (typically night period)</p> <p>N/A indicates that OOHW is not anticipated for this construction stage</p> <p>TS refers to tunnel support activities, which will be undertaken 24 hours per day, 7 days per week.</p> <p>UW refers to Utility works</p>

3.2 OOHW Ground-borne noise assessment

Ground-borne noise from tunnelling activities has been assessed and is summarised in Table 5 below. The colours in the table indicate whether or not receivers in the NCA comply with the NML as per key in Section Table 4. Refer to Appendix D of the CNVMP for additional details regarding levels of compliance with airborne NMLs.

Table 5: Summary of noise construction impacts - tunnelling

NCA	Level of compliance with NML for construction stage					
	Roadheader tunnelling (heading/ bench)		Rock hammer tunnelling (bench only)		Rock hammer tunnelling (cross passages)	
	Evening	Night	Evening	Night	Evening	Night
St Peters Interchange to Arncliffe tunnel support site						
NCA06	🟢	🟡	N/A*	N/A*	N/A*	N/A*
NCA09	🟢	🟡	N/A*	N/A*	N/A*	N/A*
NCA10	🟢	🟡	N/A*	N/A*	N/A*	N/A*
NCAT3	🟢	🟢	N/A*	N/A*	N/A*	N/A*
Arncliffe tunnel support site to Bexley tunnel support site						
NCA12	🟢	🟢	N/A*	N/A*	N/A*	N/A*
NCA13	🟢	🟢	N/A*	N/A*	N/A*	N/A*
NCA14	🟢	🟢	N/A*	N/A*	N/A*	N/A*
NCAT2	🟢	🟡	N/A*	N/A*	N/A*	N/A*
NCAT1	🟢	🟡	N/A*	N/A*	N/A*	N/A*
NCA15	🟢	🟡	N/A*	N/A*	N/A*	N/A*
Bexley tunnel support site to Western Portal						
NCA26	🟡	🟠	N/A*	N/A*	N/A*	N/A*
NCA18	🟢	🟡	N/A*	N/A*	N/A*	N/A*
NCA25	🟢	🟢	N/A*	N/A*	N/A*	N/A*
NCA19	🟢	🟢	N/A*	N/A*	N/A*	N/A*
NCA24	🟢	🟢	N/A*	N/A*	N/A*	N/A*
Notes:	<p>N/A indicates that OOHW is not anticipated for this construction stage</p> <p>* GBN from rock hammer excavation will be managed by restricting this activity to standard construction hours where tunnelling is below residential areas</p>					

3.3 Noise assessment for unassessed works

Any OOHW not previously assessed under the CNVMP (excluding those circumstances identified in CoA D15(c) and (d), will be assessed in accordance with the CNVMP to determine the magnitude and extent of the noise impact that the construction activity could potentially have upon the adjacent sensitive receivers. The level of assessment shall be commensurate with the potential magnitude and extent of the impact.

Out of Hours Work Protocol



Noise assessments will determine compliance with D15(a) and/or any potential exceedance of the relevant Noise Management Levels (NMLs) identified for the potentially affected areas. The potential for sleep disturbance as described in Sections 4.2.3 and 5.1 of the CNVMP will also be assessed.

For OOHW requiring an EPL variation a Construction Noise and Vibration Impact Statement (CNVIS) will be prepared to document the outcomes of the noise assessment as described in Section 5 of the CNVMP.

For OOHW that meet the criteria of D15(a), a simple noise calculation is appropriate to determine the potential magnitude and extent of the impact. The noise calculator may also be used to assess minor changes against a prepared CNVIS. Minor changes may include one to two pieces of additional plant or equipment or the identical plant/equipment list used in a different location. In these instances, the noise calculator would be validated against the predicted noise levels identified in the CNVIS prior to assessing the minor change.

3.4 OOHW vibration assessment

The vibration generated from construction activities at each work area/ site will vary depending on the level and type of activity carried out during each construction stage.

Appendix D.2.3 of the CNVMP identifies the dominant vibration generating plant and equipment for the project. Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. Indicative risk of structural or cosmetic damage from vibration for each construction area is provided in Table 6. Indicative risk of disturbance of building occupants is provided in Table 7. Indicative risk of vibration impacts (for both structural damage and human disturbance) resulting from tunnelling activities is shown in Table 8.

Table 6: Assessed risk of structural or cosmetic damage from vibration

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
Western Surface Works and Tunnel Support (including C1, C2, C3 compounds)					
NCA18*	<5m (Adjacent)	Industrial	Very high risk	Very low risk	Very low risk
NCA19	<5m (Adjacent)	Residential	Very high risk	Very low risk	Very low risk
NCA20	450m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA23	430m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA24*	150m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA25	140m	Residential	Negligible risk	Negligible risk	Negligible risk
Bexley Road and Arncliffe tunnel support sites					
NCA15	<10m (Adjacent)	Residential	Low risk	Low risk	Low risk
NCA16	<10m (Adjacent)	Residential	Low risk	Medium risk	Low risk
NCA17	130m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA26*	45m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA12*	40m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA13	250m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	300m	Residential	Negligible risk	Negligible risk	Negligible risk
SPI civil and tunnel support sites					
NCA01	750m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA02	700m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA03	230m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA04	20m	Residential	Low risk	Low risk	Negligible risk
NCA05	80m	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA06*	75m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA07*	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Very low risk
NCA08	12m	Residential	Low risk	Low risk	Negligible risk

Out of Hours Work Protocol



NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
NCA09	260m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10*	25m	Commercial	Negligible risk	Negligible risk	Negligible risk
Local Roads					
NCA01	10m	Residential	Low risk	Low risk	Negligible risk
NCA02	20 m	Residential	Very low risk	Very low risk	Negligible risk
NCA03	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA04	<5m (Adjacent)	Residential	Very high risk	Very high risk	Very low risk
NCA05	5m	Industrial	Low Risk	Low Risk	Negligible risk
NCA06	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA07	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Negligible risk
NCA08	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA09	800m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10	800m	Commercial	Negligible risk	Negligible risk	Negligible risk
NCA11	<5m	Industrial	Low Risk	Low Risk	Low Risk

Notes: * NCA includes 'other sensitive receiver' identified in CNVIS.

Table 7: Assessed risk of disturbance to building occupants from vibration

NCA	Approx. distance to nearest buildings from works	Type of Buildings	Risk of vibration impact		
			Site establishment	Civil works	Tunnel support
Western Surface Works and Tunnel Support (including C1, C2, C3 compounds)					
NCA18*	<5m (Adjacent)	Industrial	Very high risk	Medium risk	Low risk
NCA19	<5m (Adjacent)	Residential	Very high risk	Medium risk	Low risk
NCA20	450m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA23	430m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA24	150m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA25*	140m	Residential	Negligible risk	Negligible risk	Negligible risk
Bexley Road and Arncliffe tunnel support sites					
NCA15	<5m (Adjacent)	Residential	Medium risk	Very high risk	Low risk
NCA16	<5m (Adjacent)	Residential	Medium risk	Very high risk	Low risk
NCA17	130m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA26*	45m	Residential	Very low risk	Low risk	Negligible risk
NCA12	40m	Residential	Low risk	Low risk	Negligible risk
NCA13	250m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	300m	Residential	Negligible risk	Negligible risk	Negligible risk
SPI civil and tunnel support sites					
NCA01	750m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA02	700m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA03	230m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA04	20m	Residential	Very high risk	Very high risk	Very low risk
NCA05	80m	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA06	75m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA07*	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Low risk
NCA08	12m	Residential	Very high risk	Very high risk	Very low risk

Out of Hours Work Protocol



NCA09*	260m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10*	25m	Commercial	Low risk	Low risk	Negligible risk
NCA11	25m	Industrial	Low Risk	Low Risk	Negligible risk
Local Roads					
NCA01	10m	Residential	High risk	High risk	Negligible risk
NCA02	20 m	Residential	Very low risk	Very low risk	Negligible risk
NCA03	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA04	<5m (Adjacent)	Residential	Very high risk	Very high risk	Medium risk
NCA05	5m	Industrial	High risk	High risk	Negligible risk
NCA06	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA07*	<5m (Adjacent)	Industrial	Very high risk	Very high risk	Negligible risk
NCA08	<5m (Adjacent)	Residential	Very high risk	Very high risk	Negligible risk
NCA09*	800m	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10*	800m	Commercial	Negligible risk	Negligible risk	Negligible risk
NCA11	<5m	Industrial	Low Risk	Low Risk	Medium risk

Table 8: Assessed vibration impacts - tunnelling

NCA	Type of Buildings	Risk of vibration impact		
		Roadheader tunnelling (heading/ bench)	Rock hammer tunnelling (bench only)	Rock hammer tunnelling (cross passages)
Risk of structural or cosmetic damage				
NCA06	Residential	Negligible risk	Negligible risk	Negligible risk
NCA09*	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10*	Commercial/ Residential	Negligible risk	Negligible risk	Negligible risk
NCAT3*	Residential/ Commercial	Negligible risk	Negligible risk	Negligible risk
NCA12	Residential	Negligible risk	Negligible risk	Negligible risk
NCA13	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	Residential	Negligible risk	Negligible risk	Negligible risk
NCAT2*	Residential	Negligible risk	Negligible risk	Negligible risk
NCAT1	Residential	Negligible risk	Negligible risk	Negligible risk
NCA15	Residential/ Industrial	Negligible risk	Negligible risk	Negligible risk
NCA26*	Residential/ Industrial	Negligible risk	Negligible risk	Negligible risk
NCA18*	Industrial/ Residential	Negligible risk	Negligible risk	Negligible risk
NCA25*	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA19	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA24	Industrial	Negligible risk	Negligible risk	Negligible risk
Risk of disturbance to building occupants				
NCA06	Residential	Negligible risk	Negligible risk	Negligible risk
NCA09*	Residential	Negligible risk	Negligible risk	Negligible risk
NCA10*	Commercial/ Residential	Negligible risk	Negligible risk	Negligible risk
NCAT3*	Residential/ Commercial	Negligible risk	Negligible risk	Negligible risk
NCA12	Residential	Negligible risk	Negligible risk	Negligible risk

Out of Hours Work Protocol



NCA	Type of Buildings	Risk of vibration impact		
		Roadheader tunnelling (heading/ bench)	Rock hammer tunnelling (bench only)	Rock hammer tunnelling (cross passages)
NCA13	Residential	Negligible risk	Negligible risk	Negligible risk
NCA14	Residential	Negligible risk	Negligible risk	Negligible risk
NCAT2*	Residential	Negligible risk	Low risk	Low risk
NCAT1	Residential	Negligible risk	Low risk	Low risk
NCA15	Residential/ Industrial	Negligible risk	Low risk	Low risk
NCA26*	Residential/ Industrial	Negligible risk	Medium Risk	Medium risk
NCA18*	Industrial/ Residential	Negligible risk	Low risk	Low risk
NCA25*	Industrial	Negligible risk	Very low risk	Very low risk
NCA19	Industrial	Negligible risk	Negligible risk	Negligible risk
NCA24	Industrial	Negligible risk	Negligible risk	Negligible risk

3.5 Vibration assessment for unapproved works

Where activities with the potential for vibration impacts upon sensitive receivers or structures are proposed as OOHW, these shall also be assessed as described in Section 5 of the CNVMP. The assessment will include, as relevant, the potential for:

- cosmetic and/or structural impacts (including safe working distances);
- human comfort impacts; and
- in accordance with the minimum working distance guideline in Table 6.3 of the CNVMP.

For OOHW requiring an EPL variation, the outcomes of the vibration assessment will also be documented in the CNVIS for the proposed works.

3.6 High noise impact equipment use

Equipment that can generate high noise impacts include jackhammering, rock breaking or hammering, pile driving, concrete cutting, vibratory rolling and impact piling occurring on the surface and generating noise with impulsive, intermittent, tonal or low frequency characteristics. Where reasonable and feasible, these pieces of equipment will be used:

- Between 8am-6pm, Monday to Friday;
- Between 8am-1pm Saturdays; and
- In continuous blocks of no more than 3 hours with at least a one-hour respite between each block of work generating high noise impact, where the location of the work is likely to impact the same receivers.

Where the use of such equipment is proposed out of hours:

- The equipment will be used prior to 10pm where reasonable and feasible;
- Where the above cannot be achieved the equipment will be used prior to midnight where reasonable and feasible; and
- It is not proposed to apply a 3 hour on and a 1 hour off respite approach in an effort to ensure that the use of such equipment is completed as early in the night as possible.

3.7 Noise and vibration impact categories and selection of management measures

For OOHW (excluding those circumstances identified in CoA D15(c) and (d)), sensitive receivers predicted to experience noise levels above the relevant NML or VML will be managed in accordance with the categories outlined in Table 9, Table 10 and Table 11 below (extracted from Tables 6.4, 6.5 and 6.6 of the CNVMP). These categories are based on noise levels determined from the 'after mitigation' scenario in the noise assessment (derived from the TfNSW Construction Noise Strategy). Refer to Section 6 of the CNVMP for further details.

Out of Hours Work Protocol



Table 9: Additional airborne noise mitigation measures

Construction hours	Predicted airborne $L_{Aeq}(15min)$ noise level at receiver			Additional mitigation measures
	Receiver perception	dB(A) above RBL	dB(A) above NML	
OOHW Period 1	Noticeable	5 to 10	≤ 5	-
	Clearly Audible	10 to 20	5 to 15	LB
	Moderately intrusive	20 to 30	15 to 25	LB, V
	Highly intrusive	> 30	> 25	LB, SN, RO, V
OOHW Period 2	Noticeable	0 to 10	< 5	LB
	Clearly Audible	10 to 20	5 to 15	LB, V
	Moderately intrusive	20 to 30	15 to 25	LB, SN, V
	Highly intrusive	> 30	> 25	LB, SN, AA, V

Notes: LB = Letter box drops, V = Verification of predicted noise level, SN = Specific notification, Individual briefings, or Phone call, RO = Project specific respite offer, AA = Alternative accommodation
Refer to Table 4.1 of the CNVMP for a definition of OOHW Periods 1 and 2

Table 10: Additional ground-borne noise mitigation measures

Construction hours	Predicted ground-borne $L_{Aeq}(15min)$ noise level at receiver		Additional mitigation measures
	Receiver perception	dB(A) above GNML	
OOHW Period 1	Noticeable	< 10	LB, V
	Moderately intrusive	10 to 20	LB, SN, RO, V
	Highly intrusive	>20	LB, SN, RO, V
OOHW Period 2	Noticeable	< 10	LB, SN, V
	Moderately intrusive	10 to 20	LB, SN, RO, AA, V
	Highly intrusive	>20	LB, SN, RO, AA, V

Notes: LB = Letter box drops, V = Verification of predicted noise level, SN = Specific notification, Individual briefings, or Phone call, RO = Project specific respite offer, AA = Alternative accommodation
Refer to Table 4.1 of the CNVMP for a definition of OOHW Periods 1 and 2

Table 11: Additional vibration mitigation measures

Construction hours	Predicted vibration at receiver	Additional mitigation measures
OOHW Period 1	Vibration above VML	LB, SN, RO, V
OOHW Period 2	Vibration above VML	LB, SN, RO, AA, V

Notes: LB = Letter box drops, V = Verification of predicted noise level, SN = Specific notification, Individual briefings, or Phone call, RO = Project specific respite offer, AA = Alternative accommodation
Refer to Table 4.1 of the CNVMP for a definition of OOHW Periods 1 and 2

3.8 Management and mitigation measures

After the noise and vibration assessment has been completed as described above, the most appropriate management and mitigation measures are determined in accordance with the ICNG.

After implementation of all reasonable and feasible management and mitigation measures during the OOHW period, some residual impacts may remain at some receiver locations. Additional mitigation measures for residual impacts of OOHW will be guided by the categories of impact and corresponding mitigation measures outlined in Section 3.7 (extracted from Tables 6.4, 6.5 and 6.6 of the CNVMP).

Out of Hours Work Protocol



This may include respite offers, alternative accommodation and at-property treatment. Note that where vibration levels are predicted to be above the VML, verification of predicted vibration levels will be undertaken by way of vibration monitoring (refer to Section 7.1.2 of the CNVMP).

The requirement for residual impact management will be addressed in the CNVIS. Residual impact management may also include seeking a negotiated agreement with the affected receiver in accordance with CoA D15(b). Predicted residual impacts will be verified on site at the commencement of the relevant activity.

Out of Hours Work Protocol



4. Out of hours works approvals

4.1 Approvals criteria

OOHW must meet one or more of the following criteria (CoA D15):

- a) construction works that cause L_{Aeq} (15 minute) noise levels that are –
 - (i) no more than 5 dB(A) above rating background level at any residence in accordance with the Interim Construction Noise Guideline (DECC, 2009), and
 - (ii) no more than the noise management levels specified in Table 3 of the Interim Construction Noise Guideline (DECC, 2009) at other sensitive land uses, and
 - (iii) continuous or impulsive vibration values, measured at the most affected residence are no more than those for human exposure to vibration, specified in Table 2.2 of Assessing vibration: a technical guideline (DEC, 2006), and
 - (iv) intermittent vibration values measured at the most affected residence are no more than those for human exposure to vibration, specified in Table 2.4 of Assessing vibration: a technical guideline (DEC, 2006); or
- b) where a negotiated agreement has been reached with affected receivers, where the prescribed noise and/or vibration levels cannot be achieved; or
- c) for the delivery of materials required by the police or other authorities for safety reasons; or
- d) where it is required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm; or
- e) construction works approved through an Out-Of-Hours Work Protocol prepared as part of the Construction Noise and Vibration Management Plan required by condition D68(b), provided the relevant council, local residents and other affected stakeholders and sensitive receivers are informed of the timing and duration at least five days and no more than 14 days prior to the commencement of the works; or
- f) construction works approved through an EPL.

4.2 CDS-JV approval

When works are proposed to be conducted outside of standard construction hours for the project, an OOHW approval form (M5N-ES-FRM-PWD-0008) must be completed for the works as described in the Manage Environmental Noise Issues Procedure (M5N-ES-PRC-PWD-0043).

All OOHW (except any emergency works undertaken in accordance with CoA D15(c) or (d)), will require CDS-JV approval in accordance with the OOHW approval form (M5N-ES-FRM-PWD-0008). Approval is required from the following CDS-JV management:

- Environment and Sustainability Manager
- Safety Manager
- Community Relations Manager
- Project Manager.

CDS-JV may approve works that have been assessed in accordance with this OOHW Protocol and determined to be compliant with CoA D15 (a), (b), (c) or (d) as listed in Section 4.1 above. CDS-JV do not intend to seek approval for OOHW under this OOHW Protocol. Any works (including any high-risk works as described by the TfNSW Construction Noise Strategy) that are not compliant with CoA D15, would require an EPL variation issued by the EPA (refer Section 4.3).

4.3 EPL approval

Where the proposed works are not approved under the existing EPL and do not meet the criteria of CoA D15 (a)–(d) listed in Section 4.1 above, an EPL variation will be sought in accordance with the Manage Environmental Noise Issues Procedure (M5N-ES-PRC-PWD-0043).

Out of Hours Work Protocol



5. Community consultation

5.1 Consultation activities

The project will aim to conduct works during the day time period in the first instance and where this is not possible, look for opportunities to limit the level of impact during OOHW.

The community will be notified of proposed OOHW through the standard project procedures outlined in the Community Communication Strategy and as required by the relevant EPL. Notifications for OOHW will be completed by way of targeted letterbox drops, emails (where requested by community members) and updates to the project website (http://www.westconnex.com.au/explore_the_route/stage_2/new_m5_resources.html).

Additional notification and consultation will be undertaken as appropriate to the proposed activity, affected stakeholders and impacts predicted. This may include one on one briefings, advertisements/announcements by radio, print and website, as well as on-road signage and VMS.

Additional notifications specific to OOHW will be provided in accordance with the predicted level of noise and/or vibration impact as described in Section 3.7. These may include specific notifications, individual briefings, respite offers or offers of alternative accommodation.

5.2 Complaints management

All complaints in relation to OOHW will be handled according to the project's complaints management procedure outlined in the Community Communications Strategy.

The WestConnex telephone information line 1800 660 248 provides a 24 hour point of contact, seven days per week for the duration of the project. The project enquiries email address info@newm5.com.au is also available as a point of contact for the project and is checked daily by the team Monday to Friday.

All complaints relating to noise and vibration impacts must be investigated within 2 hours of the complaint being made unless otherwise agreed with the complainant, as required by the EPL.

Out of Hours Work Protocol



6. Monitoring and recording

All monitoring and recording will be conducted in accordance with Section 7 and Appendix H of the CNVMP as well as the relevant Australian Standards/guidelines and the EPL.

Non-conformances relating to OOHW will be dealt with in accordance with Elements 3 and 12, Part B of the CEMP. Non-conformances relating to noise and vibration issues will be dealt with as described in Section 8.1 of the CNVMP.

APPENDIX G **Site specific noise mitigation**

G.1 KINGSGROVE COMPOUNDS

G.1 KINGSGROVE COMPOUNDS



Building Type		Legend	
Education	Hotel	Place of worship	Compound Sites
Under construction	Fire Station	Heritage	Temporary 3m Barrier
Residential	Empty Lot	Temporary 4.5m Barrier	Permanent Noise Barriers
Mixed Use	Community Centre	NCA	
Industrial	Commercial		

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

25 0 25 50 75 100 m

Description:
Kingsgrove compound
Noise catchment areas & Sensitive Receivers
Temporary and permanent noise barrier locations

Created by: THW
Figure No: TH014-05 6 0 1 006 (r2)
Date: 29.07.2016
Scale: 1:3,000 @ A3

1/418A Elizabeth Street, SURRY HILLS NSW 2010
 P: 02 8218 0500 F: 02 8218 0501

Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.



Building Type		Legend	
Education	Hotel	Place of worship	Compound Sites
Under construction	Fire Station	Heritage	Temporary 3m Barrier
Residential	Empty Lot	Temporary 4.5m Barrier	Permanent Noise Barriers
Mixed Use	Community Centre	NCA	
Industrial	Commercial		

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

25 0 25 50 75 100 m

Description: Kingsgrove compound
Noise catchment areas & Sensitive Receivers
Temporary and permanent noise barrier locations

Created by: THW
Figure No: TH014-05 6 0 1 006 (r2)
Date: 29.07.2016
Scale: 1:3,000 @ A3

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

inspired to achieve

Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

Table C2: Construction Noise Management Schedule

Kingsgrove Civil and Tunnel Support Works

Area to be Managed	Mitigation/ Management Measure	Typical Details	Comments	
Tunnel and Civil site establishment				
1	Noise Barrier	NB01: 3m noise barrier NB02: 4.5m noise barrier NB03: 2-3m relocatable noise barrier NB04: 3-4m temporary noise barrier	see Table C3 for details see Table C3 for details see Table C3 for details see Table C3 for details	Noise walls to be constructed as early as practicable. Noise walls to be constructed as early as practicable. Noise walls to be constructed as early as practicable. Noise walls to be constructed as early as practicable.
2	At-property treatment (operational noise)	No noise barrier required around Kingsgrove South or Commercial Road compound Residences identified for at-property treatment as a result of operational noise (Project complete) should be treated ASAP during construction phase, where practicable	see Table C3 for details Details to be confirmed as part of ONMR and CNVMP	- Treatment installed as early as practicable
3	Work outside Standard Construction Hours	None		
4	High noise impact works	Respite periods for high noise activities.	Some 'Highly Noise Affected' Receivers during standard hours (initial excavation works).	
Tunnel shaft excavation				
1	Noise Barrier	As above		
2	Work outside Standard Construction Hours	No OOHW anticipated, with the exception of excavation support works, where required for safety (concrete lining - possibility of OOHW pours) or ongoing maintenance of site (water pumps).		
3	Truck movement restrictions for OOHW period	Evening: ≤ 4 concrete trucks per hour Night: 0 trucks per hour	Contingency concrete pour during tunnel lining works	
4	High noise impact works	Respite periods for high noise activities.	Some 'Highly Noise Affected' Receivers during standard hours (shaft excavation works).	
Tunnel RH Support, Spoil Handling and Tunnel Lining (Northern compound)				
1	Noise Barrier	As above		
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below NIGHT works (10 pm to 7 am): Restricted as outlined below		
3	Workshop	Partial acoustic enclosure: 3 walls + roof, open side oriented away from receivers	see Table C4 for details	
4	Spoil bin area	EVE/ NIGHT: 1 handtool only NIGHT: Limit use of franna crane Acoustic shed DAY/ EVE: 1 Front End Loaders (FEL); NIGHT: 1 FEL.	see Table C5 for performance requirements see Table C4 for details see Table C5 for performance requirements	
5	Water Treatment Plant Pumps	Partial acoustic enclosure	see Table C5 for performance requirements	
6	Compressors	Partial acoustic enclosure	see Table C5 for performance requirements	
7	Ventilation Fan	Ventilation fans with silencer + additional attenuation (duct lining/ inlet attenuator). Intake to be orientated away from receivers.	see Table C5 for performance requirements	
8	Concrete Truck restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: 0 trucks per hour		
9	Spoil Truck restrictions for OOHW period	EVE: ≤ 8 trucks per hour NIGHT: ≤ 4 trucks per hour		Compression braking and air brake release will be managed on site
10	Water Cart restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: 0 trucks per hour		
11	Residual impacts	Properties where (after application of the above) noise levels exceed NML DAY: NCA19 - N/A EVE: NCA19 - 1 property by up to 6 dB(A) NIGHT: NCA19 - 1 property by up to 5 dB(A)	At some receiver locations noise levels may exceed the NMLs and there are no physical mitigation measures that can be applied to achieve the NMLs. Therefore, after all reasonable and feasible noise mitigation measures have been applied, the way forward is to seek a negotiated agreement with the affected receiver	
Tunnel RH Support, Spoil Handling and Tunnel Lining (Southern compound)				
1	Noise Barrier	As above		
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below		
3	Workshop	Partial acoustic enclosure: 3 walls + roof EVE/ NIGHT: 1 handtool only NIGHT: Limit use of franna crane	see Table C4 for details see Table C5 for performance requirements	
4	Spoil bin area	Acoustic shed DAY/ EVE: 1 Front End Loaders (FEL);	see Table C4 for details	

Table C2: Construction Noise Management Schedule

Kingsgrove Civil and Tunnel Support Works

Area to be Managed	Mitigation/ Management Measure	Typical Details	Comments
	NIGHT: 1 FEL.	see Table C5 for performance requirements	
	Roller door to be partly closed during EVE/ NGT period to the minimum height required to allow trucks to access the shed		
5 Water Treatment Plant Pumps	Partial acoustic enclosure	see Table C5 for performance requirements	
6 Compressors	Partial acoustic enclosure	see Table C5 for performance requirements	
7 Ventilation Fan	-	see Table C5 for performance requirements	
8 Concrete Truck restrictions for OOHW period	EVE/ NIGHT: ≤ 4 trucks per hour		
9 Spoil Truck restrictions for OOHW period	EVE: ≤ 8 trucks per hour NIGHT: ≤ 4 trucks per hour		Compression braking and air brake release will be managed on site
10 Water Cart restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: 0 trucks per hour		
Civil and surface works (Portal Construction - Piling, Earthworks, Road Tie-In Works)			
1 Hoardings/ Noise Walls	As above		
2 Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below. NIGHT works (10 pm to 7 am): None		
3 Workshop	Partial acoustic enclosure: 3 walls + roof, open side oriented away from receivers EVE: 1 handtool only	see Table C4 for details	
4 Compressors	Partial acoustic enclosure	see Table C5 for performance requirements	
5 Truck movement restrictions for OOHW period	Evening: ≤ 4 trucks per hour		
6 Shotcreting for OOHW period	EVE: Shotcrete pump and compressor		
4 High noise impact works	Respite periods for high noise activities.	Some 'Highly Noise Affected' Receivers during standard hours (shaft excavation works).	
Civil Works Western Site - Earthworks, Road tie-in Works			
1 Hoardings	As above		
2 Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below.		EVE: over-run works as required (concreting etc.)
3 Workshop	Partial acoustic enclosure: 3 walls + roof, open side oriented away from receivers EVE: 1 handtool only	Type 1 Shed	see Table E.5 for details (TBC at detailed design)
4 Compressors	Partial acoustic enclosure	see Table C5 for performance requirements	see Table E.5 for details (TBC at detailed design)
5 Truck movement restrictions for OOHW period	Evening: ≤ 8 trucks per hour		
6 Shotcreting for OOHW period	EVE: Shotcrete pump and compressor NIGHT: None		
Ventilation Station Works			
1 Hoardings	As above		
2 Work outside Standard Construction Hours	None		
3 Workshop	As above		
4 Compressors	As above		

Table C3: Noise Barrier Design Specifications**Kingsgrove Civil and Tunnel Support Works**

Noise barrier reference	Location	Noise barrier height	Required Rw	Proposed Construction	Acoustic Rating of Construction*
NB01	Kingsgrove North compound Northern boundary	3m **	Rw 15-20	17 mm plywood hoarding	Rw 24
			Medium	Speedwall panel; OR 150mm Hebel	Rw 41 Rw 40
NB02	Kingsgrove North compound Section of northern boundary adjacent to bottom of Glamis St (Ref Site Layout)	4.5m	Rw 25	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); <u>OR</u>	Rw 28
			High	Speedwall panel; <u>OR</u> 150mm Hebel	Rw 41 Rw 40
NB03	Kingsgrove site - M5 Motorway along northern side of M5 eastbound carriageway (where feasible to do so)	2-3m#	Rw 15-20	17 mm plywood hoarding; OR	Rw 24
			Medium	17 mm plywood hoarding on top of concrete barrier (Type F or Jersey Kerb); OR Single skin sheet steel (colorbond) 0.48 mm sheet steel (no gaps)	Rw 22 Rw 22
NB04	Kingsgrove site - M5 Motorway along southern side of M5 westbound carriageway work area	3-4m#	Rw 15-20	17 mm plywood hoarding; OR	Rw 24
			Medium	17 mm plywood hoarding on top of concrete barrier (Type F or Jersey Kerb); OR Single skin sheet steel (colorbond) 0.48 mm sheet steel (no gaps)	Rw 22 Rw 22
	Kingsgrove South compound Commercial Road compound	0m	-	Chain mesh or equivalent	-

Notes:

Noise wall performance: Low - Rw 10-15; Medium - Rw 15-220; Medium-High - Rw 20-25; High - Rw 25; Very High - Rw 30

* estimated by calculations and/or reference to other similar wall type data

** Noise barrier may be constructed to a height similar to NB02 if there is community preference for a higher noise barrier in this area.

Subject to feasibility review. Barrier mounted hoarding does not comply with RMS Safety Barrier System Acceptance Conditions where there is insufficient clear zone / offset to the travel lane or where the hazard free deflection zone behind barrier does not provide space for a separate safety barrier and hoarding/ noise barrier. This is often the case for workzones where road widening is occurring, making barrier mounted hoard not feasible. This issue will require review by the construction design team for the relocatable roadside noise barrier on the northern side of the M5 East Motorway.

GENERAL

- The specified 'required rating' must be achieved by the product selected.
- By way of explanation, the Sound Insulation Rating Rw is a measure of the noise reduction property of the assembly, a higher rating implying a higher sound reduction performance.
- Note that the Rw rating of systems measured as built on site (R'w Field Test) may be up to 5 points lower than the laboratory result.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C4: Noise Shed / Enclosure Design Specifications

Kingsgrove Civil and Tunnel Support Works

Area to be Mitigated	Construction component	Acoustic element type
1. Northern Workshop	Walls	Form A
	Roof	Form A
	Acoustic lining	Underside of roof to be lined with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty
	Doors	Not required. Potentially open on one (or more) side/s.
	Ventilation Openings	Any openings should face away from neighbours so that noise walls can effectively shield them from neighbours.
2. Southern Workshop	Walls	Form A
	Roof	Form A
	Acoustic lining	Underside of roof to be lined with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty
	Doors	Not required. Potentially open on one (or more) side/s.
	Ventilation Openings	Any openings should face away from neighbours so that noise walls can effectively shield them from neighbours.
3. Northern Spoil Shed	Walls	Form B or Form C
	Roof	Form B or Form C
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed of: - upper section of south & west facing walls; - above 2.5 m of north facing & east facing walls; and - Underside of roof
	Doors	oversized roller door (larger than wall opening) and rubber seals side and bottom
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.
4. Southern Spoil Shed	Walls	Form A
	Roof	Form A
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed of: - upper section of south & west facing walls; - above 2.5 m of north facing & east facing walls; and - Underside of roof
	Doors	oversized roller door (larger than wall opening) and rubber seals side and bottom
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.

Notes:
 LEGEND * estimated by calculations and/or reference to other similar wall type data. The client is advised not to commit to materials which have not been tested in an approved laboratory or for which an opinion only is available. Testing materials is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions.

- GENERAL
- The underside of the roof and (where possible) internal walls should be lined with acoustic insulation to reduce the build-up of sound inside the shed
 - The specified performances must be achieved by the product selected.
 - The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
 - Check design of all junction details with acoustic consultant prior to construction.
 - Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
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 - The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C4a: Specification for acoustic elements of noise sheds/ acoustic enclosures

Wall/ roof type	Sound transmission loss per octave spectrum dB						
	63	125	250	500	1000	2000	4000
FORM A	8	10	14	18	18	21	25
FORM B	8	10	25	38	50	60	69
FORM C	16	20	24	29	33	35	41
FORM D	20	24	29	33	38	41	46

Table C5: Plant and Equipment Specifications

Kingsgrove Civil and Tunnel Support Works

Building/ Area to be Mitigated	Item	Acoustic Requirement	Octave spectrum dB								Lw dB(A)
			31.5	63	125	250	500	1000	2000	4000	
<i>Kingsgrove North compound</i>											
Tunnel ventilation	Ventilation fan #	Sound power level - surface inlet (includes fan + attenuation)	106	108	104	88	77	76	93	100	102
Plant item	Front end loader 25 t - Kingsgrove North + high grade muffler	Plant sound power level to be confirmed in accordance with CNVMP	110	102	101	100	99	97	97	88	105
Plant item	Workshop Franna Crane 20 t	Plant sound power level to be confirmed in accordance with CNVMP	112	105	97	94	95	91	91	85	98
Plant item	Water Treatment Plant Pumps	Plant sound power level to be confirmed in accordance with CNVMP	88	83	84	82	82	81	74	64	87
Plant item	Compressor inside container control room	Plant sound power level to be confirmed in accordance with CNVMP	51	63	52	57	66	67	59	61	70
<i>Kingsgrove South compound</i>											
Tunnel ventilation	Ventilation fan #	Sound power level - surface inlet (includes fan + attenuation)	106	108	104	88	77	76	93	100	102
Plant item	Front end loader 25 t	Plant sound power level to be confirmed in accordance with CNVMP	120	112	111	105	104	102	99	99	110
Plant item	Workshop Franna Crane 20 t	Plant sound power level to be confirmed in accordance with CNVMP	112	105	97	94	95	91	91	85	98
Plant item	Water Treatment Plant Pumps	Plant sound power level to be confirmed in accordance with CNVMP	98	93	94	92	92	91	84	74	97
Plant item	Compressor inside container control room	Plant sound power level to be confirmed in accordance with CNVMP	51	63	52	57	66	67	59	61	70

Notes:
 LEGEND * estimated by calculations and/or reference to other similar plant type data. The client is advised not to commit to fans which have not been tested in an approved laboratory. Testing plant is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions. The advice provided here is in respect of acoustics only.

Fans require detailed design once fan detail available.

GENERAL

- Sound power level of plant assumed based on sound power level of similar plant type, incorporating attenuation (acoustic attenuator/ muffler/ duct lining as required)
- The specified performances must be achieved by the product selected.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C6: Managing Residual Impacts during 'out of standard hours' work

Kingsgrove Civil and Tunnel Support Works

ID	Noise Mitigation/ Management Measure															
1	At some receiver locations noise levels may exceed the NMLs and there are no physical mitigation measures that can be applied to achieve the NMLs. Therefore, after all reasonable and feasible noise mitigation measures have been applied, the way forward is to seek a negotiated agreement with the affected receiver.															
2	The Construction Noise and Vibration Management Plan (CNVMP) identifies the management measures that can be applied to deal with residual impacts, including noise monitoring, letter box drops, phone calls, individual briefings, respite offers and alternative accommodation. Further mitigation measures may include changing operational procedures at night in order to reduce noise impacts, e.g. reduce the number of trucks on site during the night period (10 pm to 7am). The appropriate management measure would be determined by the degree of exceedance of the NML.															
3	Where, after the application of all reasonable and feasible mitigation measures, noise levels still exceed the NML, then at-property treatments may need to be considered. The following provides guidance on the level of treatment required in relation to the exceedance above the external NML.															
Treatment 1 Mechanical ventilation only																
<5dB(A) reduction	Where external noise levels are less than 5dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 15dB(A) from outside to inside when windows are closed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.															
Treatment 2 Mechanical ventilation and sealing of wall vents																
5-10 dB(A) reduction	Where external noise levels are less than 10dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside (ENMM p20) when windows are closed and wall vents are sealed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia. It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.															
Treatment 3 Upgraded seals for windows and doors																
10-12dB(A) reduction	Where external noise levels are only slightly greater than 10dB(A) above the external assessment criteria, then in addition to installing mechanical ventilation (Treatment 1) and sealing of wall vents (Treatment 2), special acoustic grade seals should be installed on windows and perimeter doors exposed to road traffic noise to enable the internal noise criteria to be achieved with windows and doors shut.															
Treatment 4 Upgraded windows, glazing and doors																
>12 dB(A) reduction	Where the predicted external noise level exceeds the external assessment criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors would be required on the facades exposed to the works, in addition to the mechanical ventilation, sealing of wall vents and acoustic seals for windows and doors described in Treatments 1, 2 and 3, respectively. Note that these upgrades are only suitable for masonry type buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.															
4	All reasonable and feasible mitigation has been explored for the site. Exceedance of the sleep disturbance NML is predicted to occur at up to 15 receivers in NCA 15 in the area opposite the driveway exit from the site. The following at-property treatment may be required to reduce noise impact from the site:															
<table border="1"> <thead> <tr> <th>Treatment Type</th> <th>No. Residences</th> <th>No. Apartment Blgs</th> </tr> </thead> <tbody> <tr> <td>Treatment 1</td> <td>1</td> <td>-</td> </tr> <tr> <td>Treatment 2</td> <td>1</td> <td>-</td> </tr> <tr> <td>Treatment 3</td> <td>-</td> <td>-</td> </tr> <tr> <td>Treatment 4</td> <td>-</td> <td>-</td> </tr> </tbody> </table>		Treatment Type	No. Residences	No. Apartment Blgs	Treatment 1	1	-	Treatment 2	1	-	Treatment 3	-	-	Treatment 4	-	-
Treatment Type	No. Residences	No. Apartment Blgs														
Treatment 1	1	-														
Treatment 2	1	-														
Treatment 3	-	-														
Treatment 4	-	-														
5	At property treatment requirements will be reviewed once site access is gained and prior to the commencement of 24 hour operations. The review will include on site testing of trucks driving on site and entering/exiting the site to verify noise levels predicted by the noise model. Once the noise model is verified, properties likely to exceed the OOHW (Night) NML and the sleep disturbance NML will be identified for consideration of at-property treatment.															

G.2 BEXLEY ROAD COMPOUNDS



Building Type		Legend	
Residential	Compound sites	Temporary 4.5m Barrier	Site Building
Mixed Use	NCAs	Temporary 3m Barrier	Acoustic Shed
Community Centre		Temporary 4.5m Awning	
Commercial		Temporary 2.4m Barrier	
Heritage		Chain-link fence	

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

25 0 25 50 75 100 m

Description: Bexley compound
Noise catchment areas & Sensitive Receivers
Temporary and permanent noise barrier locations

Created by: THW
Figure No: TH014-05 6 0 1 007 (r1)
Date: 29.07.2016
Scale: 1:3,000 @ A3

1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

RENZO TONIN & ASSOCIATES
inspired to achieve



- Legend
- Residential receiver
 - Other sensitive receiver
 - NCA

- Barrier Height (m)
- 1.8m hoarding
 - 2.4m noise wall
 - 3m noise wall
 - 4.5m noise wall



Consultant:
RENZO TONIN & ASSOCIATES
inspired to achieve
 Acoustics, Vibration & Structural Dynamics
 Sydney Melbourne Brisbane Gold Coast Kuwait
 1/418A Elizabeth Street, SURRY HILLS NSW 2010
 P: 02 8218 0500 F: 02 8218 0501

Client:

WestConnex New M5

CPB CONTRACTORS | **DRAGADOS** | **SAMSUNG SAMSUNG C&T**

Project:
WESTCONNEX STAGE 2 NEW M5

Noise levels are approximate due to interpolation of contours and should be used for reference only.
 For information only and not for construction.
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Description:
 BEXLEY ROAD COMPOUND
 NCAs, SENSITIVE RECEIVERS
 TEMPORARY NOISE BARRIER LOCATIONS

Project No.:	TH014-05	Created by:	rp
Fig Ref:	TH014-10.6.5.C4.5.01 (r1)		
Date:	2018.05.01	Scale:	1: 3500 A3

Table C2: Construction Noise Management Schedule**Bexley Road Compound Roadheader Support Works**

Area to be Managed	Mitigation/ Management Measure	Typical Details	Comments
Tunnel site establishment			
1	Noise Barriers	4.5m temporary noise barrier around Bexley North support site. 4.5m temporary noise barrier around southern side of Bexley South exit ramp from spoil shed to Bexley Road. 3m temporary noise barrier around northern side of Bexley South exit ramp from spoil shed to the Bexley Road. 2.4m temporary noise barrier around north and east sides of Bexley East compound.	see Table C3 for details see Table C3 for details see Table C3 for details see Table C3 for details
2	At-property treatment (operational noise)	N/A	
3	Work outside Standard Construction Hours	Limited (covered by OOHW CNVIS)	
4	High noise impact works	Some 'Highly Noise Affected' Receivers during standard hours (initial excavation works). Respite periods for high noise activities.	
Tunnel shaft excavation			
1	Hoardings/ Noise Walls	Temporary relocatable screens should be placed around the shaft during shaft excavation until noise barriers and acoustic shed in place or excavation is 15m below surface.	
2	Work outside Standard Construction Hours	No OOHW anticipated, with the exception of excavation support works, where required for safety (concrete lining - possibility of OOHW pours) or ongoing maintenance of site (water pumps).	
3	Truck movement restrictions for OOHW period	Evening: ≤ 4 concrete trucks per hour Night: ≤ 4 concrete trucks per hour	Contingency concrete pour during tunnel lining works Contingency concrete pour during tunnel lining works
Tunnel RH Support, Spoil Handling and Tunnel Lining (Northern)			
1	Hoardings/ Noise Walls	As above	
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below	
3	Workshop	Inside main shed. High noise generating activities to generally be conducted in tunnel	
4	Spoil bin area	Acoustic shed DAY/ EVE: 1 Front End Loader (FEL); NIGHT: 1 FEL. Roller door to be partly closed during EVE/ NGT period to the minimum height required to allow trucks to access the shed	see Table C4 for details see Table C5 for performance requirements
5	Water Treatment Plant Pumps	n/a	see Table C4 for performance requirements
6	Compressors	Inside main shed	
7	Ventilation Fan	Attenuator/ acoustic enclosure	see Table C5 for performance requirements
8	Concrete Truck restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: ≤ 4 trucks per hour	Up to 6 in total during OOHW period (i.e. 6 pm to 7 am) Sleep disturbance issues TBC during first 12 months on site - Compression braking and air brake release will be managed on site
9	Spoil Truck restrictions for OOHW period	EVE: ≤ 8 trucks per hour NIGHT: 0 trucks per hour	- Subject to on site verification testing during first 12 months on site
10	Water Cart restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: 0 trucks per hour	
11	Residual impacts	Properties where (after application of the above) noise levels exceed NML	DAY: none EVE: 1 NIGHT: 3 (See Table C6) Subject to on site verification testing during first 12 months on site
Tunnel RH Support, Spoil Handling and Tunnel Lining (Southern)			
1	Hoardings/ Noise Walls	As above	
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below	
3	Workshop	N/A	see Table C4 for details
4	Spoil bin area	Acoustic shed DAY/ EVE: 1 Front End Loader (FEL); NIGHT: 1 FEL. Roller door to be partly closed during EVE/ NGT period to the minimum height required to allow trucks to access the shed	see Table C4 for details see Table C5 for performance requirements
5	Water Treatment Plant Pumps	Attenuator/ acoustic enclosure	see Table C5 for performance requirements
6	Compressors	N/A	
7	Ventilation Fan	Attenuator/ acoustic enclosure	see Table C5 for performance requirements
8	Concrete Truck restrictions for OOHW period	EVE/ NIGHT: ≤ 4 trucks per hour	Compression braking and air brake release will be managed on site
9	Spoil Truck restrictions for OOHW period	EVE/ NIGHT: ≤ 8 trucks per hour	
10	Water Cart restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: 0 trucks per hour	
11	Residual impacts	Properties where (after application of the above) noise levels exceed NML	See above

Table C3: Noise Barrier Design Specifications**Bexley Road Compound Roadheader Support Works**

Noise barrier reference	Location	Noise barrier height	Required Rw	Proposed Construction	Acoustic Rating of Construction*
NB01	Northern site	4.5m	Rw 25	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); <u>OR</u> Speedwall panel; <u>OR</u> 150mm Hebel	Rw 28
	As shown on B1 Site Layout		High		Rw 41
					Rw 40
NB02	Southern site	4.5m	Rw 25	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); <u>OR</u> Speedwall panel; <u>OR</u> 150mm Hebel	Rw 28
	South side of spoil shed exit ramp		High		Rw 41
					Rw 40
NB03	Southern site	3m	Rw 15-20	17 mm plywood hoarding	Rw 24
	As shown on B1 Site Layout		Medium		
NB04	Compound Access area	2.4m	Rw 15-20	17 mm plywood hoarding	Rw 24
	North and east boundaries		Medium		

Notes:

Noise barrier performance: Low - Rw 10-15; Medium - Rw 15-220; Medium-High - Rw 20-25; High - Rw 25; Very High - Rw 30

* estimated by calculations and/or reference to other similar barrier type data

GENERAL

- The specified 'required rating' must be achieved by the product selected.
- By way of explanation, the Sound Insulation Rating Rw is a measure of the noise reduction property of the assembly, a higher rating implying a higher sound reduction performance.
- Note that the Rw rating of systems measured as built on site (R'w Field Test) may be up to 5 points lower than the laboratory result.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
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Table C4: Noise Shed / Enclosure Design Specifications

Bexley Road Compound Roadheader Support Works

Area to be Mitigated	Construction component	Acoustic element type
1. Northern Spoil Shed	North/east/south walls	Form B or Form C
	West wall	Form E
	Roof	Form B or Form C
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed of: - upper section of south & west facing walls; - above 2.5 m of north facing & east facing walls; and - Underside of roof
	Doors	oversized roller door (larger than wall opening) and rubber seals side and bottom
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.
2. Southern Spoil Shed	Walls	Form A
	Roof	Form A
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed of: - upper section of south & west facing walls; - above 2.5 m of north facing & east facing walls; and - Underside of roof
	Doors	oversized roller door (larger than wall opening) and rubber seals side and bottom
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.

Notes:

LEGEND * estimated by calculations and/or reference to other similar wall type data. The client is advised not to commit to materials which have not been tested in an approved laboratory or for which an opinion only is available. Testing materials is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions.

GENERAL

- The underside of the roof and (where possible) internal walls should be lined with acoustic insulation to reduce the build-up of sound inside the shed
- The specified performances must be achieved by the product selected.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
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Table C4a: Specification for acoustic elements of noise sheds/ acoustic enclosures

Wall/ roof type	Sound transmission loss per octave spectrum dB						
	63	125	250	500	1000	2000	4000
FORM A	8	10	14	18	18	21	25
FORM B	8	10	25	38	50	60	69
FORM C	16	20	24	29	33	35	41
FORM D	20	24	29	33	38	41	46
FORM E	20	30	36	44	51	63	72

Table C5: Plant and Equipment Specifications**Bexley Road Compound Roadheader Support Works**

Building/ Area to be Mitigated	Item	Acoustic Requirement	Octave spectrum dB								Lw dB(A)	
			31.5	63	125	250	500	1000	2000	4000		8000
Tunnel ventilation	North ventilation fan Drive 3 (with silencer)	Plant sound power level based on manufacturers specification		100	111	113	105	103	104	108	105	113
	+ Fantech Silencer. RT17G-337-280. 70 m3/s. 2.4m length + 5 dB enclosure ##	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		89	90	75	54	48	60	77	84	85
Tunnel ventilation	South ventilation fan Drive 1&2 (with silencer)	Plant sound power level based on manufacturers specification		110	116	119	113	108	104	111	113	118
	+ Fantech Silencer. RT17G-337-280. 70 m3/s. 2.4m length + 5 dB enclosure ##	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		95	96	81	60	54	66	83	90	91
Plant item	Front end loader 25 t + high grade muffler	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		110	102	101	100	99	97	97	88	105
Plant item	Workshop Franna Crane 20 t	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1	112	105	97	94	95	91	91	85	77	98
Plant item	Water Treatment Plant Pumps	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		83	78	79	77	77	76	69	59	82

Notes:

LEGEND * estimated by calculations and/or reference to other similar plant type data. The client is advised not to commit to fans which have not been tested in an approved laboratory. Testing plant is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions. The advice provided here is in respect of acoustics only.

GENERAL

- Sound power level of plant assumed based on sound power level of similar plant type, incorporating attenuation (acoustic attenuator/ muffler/ duct lining as required)
- The specified performances must be achieved by the product selected.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Fans need a detailed design completed once fan detail available.

Table C6: Managing Residual Impacts during 'out of standard hours' work

Bexley Road Compound Roadheader Support Works

ID	Noise Mitigation/ Management Measure																
1	At some receiver locations noise levels may exceed the NMLs and there are no physical mitigation measures that can be applied to achieve the NMLs Therefore, after all reasonable and feasible noise mitigation measures have been applied, the way forward is to seek a negotiated agreement with the affected receiver																
2	The Construction Noise and Vibration Management Plan (CNVMP) identifies the management measures that can be applied to deal with residual impacts, including noise monitoring, letter box drops, phone calls, individual briefings, respite offers and alternative accommodation. Further mitigation measures may include changing operational procedures at night in order to reduce noise impacts, e.g. reduce the number of trucks on site during the night period (10 pm to 7am). The appropriate management measure would be determined by the degree of exceedance of the NML.																
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A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside (ENMM p20) when windows are closed and wall vents are sealed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia. 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Note that these upgrades are only suitable for masonry type buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.</td> </tr> </tbody> </table>		Treatment 1	Mechanical ventilation only	<5dB(A) reduction	Where external noise levels are less than 5dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 15dB(A) from outside to inside when windows are closed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.	Treatment 2	Mechanical ventilation and sealing of wall vents	5-10 dB(A) reduction	Where external noise levels are less than 10dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside (ENMM p20) when windows are closed and wall vents are sealed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia. It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.	Treatment 3	Upgraded seals for windows and doors	10-12dB(A) reduction	Where external noise levels are only slightly greater than 10dB(A) above the external assessment criteria, then in addition to installing mechanical ventilation (Treatment 1) and sealing of wall vents (Treatment 2), special acoustic grade seals should be installed on windows and perimeter doors exposed to road traffic noise to enable the internal noise criteria to be achieved with windows and doors shut.	Treatment 4	Upgraded windows, glazing and doors	>12 dB(A) reduction	Where the predicted external noise level exceeds the external assessment criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors would be required on the facades exposed to the works, in addition to the mechanical ventilation, sealing of wall vents and acoustic seals for windows and doors described in Treatments 1, 2 and 3, respectively. 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4	All reasonable and feasible mitigation has been explored for the site. Exceedance of the sleep disturbance NML is predicted to occur at up to 15 receivers in NCA 15 in the area opposite the driveway exit from the site. The following at-property treatment may be required to reduce noise impact from the site:																
<table border="1"> <thead> <tr> <th>Treatment Type</th> <th>No. Residences</th> <th>No. Apartment Blgs</th> </tr> </thead> <tbody> <tr> <td>Treatment 1</td> <td>3</td> <td>-</td> </tr> <tr> <td>Treatment 2</td> <td>-</td> <td>-</td> </tr> <tr> <td>Treatment 3</td> <td>-</td> <td>-</td> </tr> <tr> <td>Treatment 4</td> <td>-</td> <td>-</td> </tr> </tbody> </table>		Treatment Type	No. Residences	No. Apartment Blgs	Treatment 1	3	-	Treatment 2	-	-	Treatment 3	-	-	Treatment 4	-	-	
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Treatment 1	3	-															
Treatment 2	-	-															
Treatment 3	-	-															
Treatment 4	-	-															
5	At property treatment requirements will be reviewed once site access is gained and prior to the commencement of 24 hour operations. The review will include on site testing of trucks driving on site and entering/existing the site to verify noise levels predicted by the noise model. Once the noise model is verified, properties likely to exceed the OOHW (NIght) NML and the sleep disturbance NML will be identified for consideration of at-property treatment.																

G.3 ARNCLIFFE COMPOUND



Building Type

Residential	NCA
Hotel	
Commercial	
Heritage	
Compound sites	

Legend

Temporary 5m Barrier	Site Building
Temporary 4m Barrier	Acoustic Shed

Client: **WestConnex** New M5

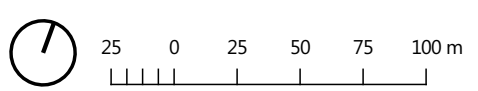


Project: **WestConnex Stage 2 M5**

Description:
 Arncliffe compound
 Noise catchment areas & Sensitive Receivers
 Temporary and permanent noise barrier locations



Created by: THW
 Figure No: TH014-05 6 0 1 008 (r1)
 Date: 29.07.2016
 Scale: 1:3,000 @ A3



Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

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Table C2: Construction Noise Management Schedule

Arncliffe Compound Roadheader Support Works

Area to be Managed	Mitigation/ Management Measure	Typical Details	Comments
Tunnel site establishment			
1	Noise barriers	4m temporary noise barrier along Marsh St from Innesdale Rd to northern boundary 5m temporary noise barrier along Marsh St from entry gate to Innesdale Rd 5m temporary noise barrier around perimeter from Marsh St boundary to the south past air compressors	see Table C3 for details see Table C3 for details see Table C3 for details
2	At-property treatment (operational noise)	N/A	
3	Work outside Standard Construction Hours	Limited (covered by OOHW CNVIS)	
4	High noise impact works	Some 'Highly Noise Affected' Receivers during standard hours (initial excavation works). Respite periods for high noise activities.	
Tunnel shaft excavation			
1	Noise barriers	As above	
2	Work outside Standard Construction Hours	No OOHW anticipated, with the exception of excavation support works, where required for safety (concrete lining - possibility of OOHW pours)	
3	Truck movement restrictions for OOHW period	Evening: ≤ 4 concrete trucks per hour Night: ≤ 4 concrete trucks per hour	Contingency concrete pour during tunnel lining works Contingency concrete pour during tunnel lining works
Tunnel RH Support, Spoil Handling and Tunnel Lining (decline)			
1	Noise barriers	As above	
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below	
3	Workshop	Partial acoustic enclosure: 3 walls + roof	
4	Spoil bin area	Acoustic shed DAY/ EVE: 2 Front End Loaders (FEL); NIGHT: 2 FELs. Roller door to be partly closed during EVE/ NGT period to the minimum height required to allow trucks to access the shed	see Table C4 for details see Table C5 for performance requirements
5	Water Treatment Plant Pumps	N/A	see Table C4 for performance requirements
6	Compressors	N/A	
7	Ventilation Fan	Attenuator/ acoustic enclosure	see Table C5 for performance requirements
8	Concrete Truck restrictions for OOHW period	EVE: ≤ 8 trucks per hour NIGHT: ≤ 8 trucks per hour	To be revised when fan details are known The following items are TBC during first 12 months on site: - truck noise levels on and off site (model verification) - Lmax noise levels/ sleep disturbance (model verification) Compression braking and air brake release will be managed on site throughh toolbox talks etc
9	Spoil Truck restrictions for OOHW period	EVE: ≤ 24 trucks per hour	
10	Water Cart restrictions for OOHW period	EVE: ≤ 24 trucks per hour NIGHT: 0 trucks per hour	
11	Residual impacts	Properties where (after application of the above) noise levels exceed NML	DAY: none EVE: none NIGHT: 38 (See Table C6 for additional details) Subject to verification testing during first 12 months on site
Tunnel RH Support, Spoil Handling and Tunnel Lining (shaft)			
1	Noise Barrier	As above	
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below	
3	Workshop	EVE/ NIGHT: 1 handtool only NIGHT: Limit use of franna crane	see Table C5 for performance requirements
4	Spoil bin area	Acoustic shed DAY/ EVE: 2 Front End Loaders (FEL); NIGHT: 2 FELs. Roller door to be partly closed during EVE/ NGT period to the minimum height required to allow trucks to access the shed	see Table C4 for details see Table C5 for performance requirements
5	Water Treatment Plant Pumps	As above	see Table C5 for performance requirements
6	Compressors	As above	see Table C5 for performance requirements
7	Ventilation Fan	Attenuator/ acoustic enclosure	see Table C5 for performance requirements
8	Concrete Truck restrictions for OOHW period	EVE/ NIGHT: ≤ 4 trucks per hour	To be revised when fan details are known Compression braking and air brake release will be managed on site
9	Spoil Truck restrictions for OOHW period	EVE: ≤ 8 trucks per hour NIGHT: ≤ 8 trucks per hour	
10	Water Cart restrictions for OOHW period	EVE: ≤ 4 trucks per hour NIGHT: 0 trucks per hour	
11	Residual impacts	Properties where (after application of the above) noise levels exceed NML	As above

Table C3: Noise Barrier Specifications**Arncliffe Compound Roadheader Support Works**

Noise barrier reference	Location	Noise barrier height	Required Rw	Proposed Construction	Acoustic Rating of Construction*
NB01	Northern perimeter Marsh St from Innesdale Rd to northern boundary	4m	Rw 15-20 Medium	17 mm plywood hoarding	Rw 24
NB02	Northern perimeter Marsh St from entry gate to Innesdale Rd	5m	Rw 25 High	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); QR	Rw 28
				Speedwall panel; QR	Rw 41
				150mm Hebel	Rw 40
NB03	Southern & western perimeter From Marsh St boundary to the south past air compressors	5m	Rw 25 High	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); QR	Rw 28
				Speedwall panel; QR	Rw 41
				150mm Hebel; QR	Rw 40
				'Frog' noise wall - requirement for top 3m of NB03 to be transparent plastic extends 28 m south east from Marsh St boundary	Rw 32
				PALGLAS 15mm; QR	Rw 31
LEXAN MARGARD® Soundglaze SC Sheet 8mm; QR	Rw 28				
				Plexiglas® sheet 6mm	Rw 28

Notes:

Noise barrier performance: Low - Rw 10-15; Medium - Rw 15-220; Medium-High - Rw 20-25; High - Rw 25; Very High - Rw 30

* estimated by calculations and/or reference to other similar barrier type data

GENERAL

- The specified 'required rating' must be achieved by the product selected.
- By way of explanation, the Sound Insulation Rating Rw is a measure of the noise reduction property of the assembly, a higher rating implying a higher sound reduction performance.
- Note that the Rw rating of systems measured as built on site (R'w Field Test) may be up to 5 points lower than the laboratory result.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C4: Noise Shed / Enclosure Design Specifications

Arncliffe Compound Roadheader Support Works

Area to be Mitigated	Construction component	Acoustic element type
1. Arncliffe to Bexley Shaft Spoil Shed (assumed shed height: 17 m)	North/west/south walls	Form B or Form C
	East wall	Form A
	Roof	Form B or Form C
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed of: - upper section of south & west facing walls; - above 2.5 m of north facing, south facing, & east facing walls; and - Underside of roof
	Doors	oversized roller door (larger than wall opening) and rubber seals side and bottom
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.
2. Arncliffe to SPI Decline Spoil Shed (assumed shed height: 10 m)	Walls	Form A
	Roof	Form A
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed of: - upper section of south & west facing walls; - above 2.5 m of north facing, south facing, & east facing walls; and - Underside of roof
	Doors	oversized roller door (larger than wall opening) and rubber seals side and bottom
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.

Notes:

LEGEND * estimated by calculations and/or reference to other similar wall type data. The client is advised not to commit to materials which have not been tested in an approved laboratory or for which an opinion only is available. Testing materials is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions.

GENERAL

- The underside of the roof and (where possible) internal walls should be lined with acoustic insulation to reduce the build-up of sound inside the shed
- The specified performances must be achieved by the product selected.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C4a: Specification for acoustic elements of noise sheds/ acoustic enclosures

Wall/ roof type	Sound transmission loss per octave spectrum dB						
	63	125	250	500	1000	2000	4000
FORM A	8	10	14	18	18	21	25
FORM B	8	10	25	38	50	60	69
FORM C	16	20	24	29	33	35	41
FORM D	20	24	29	33	38	41	46
FORM E	20	30	36	44	51	63	72

Table C5: Plant and Equipment Specifications

Arncliffe Compound Roadheader Support Works

Building/ Area to be Mitigated	Item	Acoustic Requirement	Octave spectrum dB								Lw dB(A)	
			31.5	63	125	250	500	1000	2000	4000		8000
Tunnel ventilation	Zitron 2xZVN 1-18-280/4. 108.75 m3/s. With silencers (D5)	Plant sound power level based on manufacturers specification		122	124	122	117	113	107	106	108	119
	+ additional attenuator, such as RT17G-337-280. 70 m3/s. 2.4m length. ##	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		116	108	89	71	63	68	80	92	96
Tunnel ventilation	Zitron 2xZVN 1-18-400/4. 108.75 m3/s. With silencers (D6)	Plant sound power level based on manufacturers specification		122	124	122	117	113	107	106	108	119
	+ additional attenuator, such as RT17G-337-280. 70 m3/s. 2.4m length. ##	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		116	108	89	71	63	68	80	92	96
Tunnel ventilation	Zitron 2xZVN 1-18-132/4. 68.25 m3/s. With silencers (D4)	Plant sound power level based on manufacturers specification		114	122	119	111	108	108	110	109	117
	+ additional attenuator, such as RT17G-337-280. 70 m3/s. 2.4m length. ##	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		108	106	86	65	58	69	84	93	95
Plant item	Front end loader 25 t + high grade muffler in both sheds	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		110	102	101	100	99	97	97	88	105
Plant item	Workshop Franna Crane 20 t	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1	112	105	97	94	95	91	91	85	77	98
Plant item	Water Treatment Plant Pumps	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		89	93	94	92	92	91	84	74	97

Notes:

LEGEND * estimated by calculations and/or reference to other similar plant type data. The client is advised not to commit to fans which have not been tested in an approved laboratory. Testing plant is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions. The advice provided here is in respect of acoustics only.

GENERAL

- Sound power level of plant assumed based on sound power level of similar plant type, incorporating attenuation (acoustic attenuator/ muffler/ duct lining as required)
- The specified performances must be achieved by the product selected.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Fans need a detailed design completed once fan detail available.

Table C6: Managing Residual Impacts during 'out of standard hours' work

Arncliffe Compound Roadheader Support Works

ID	Noise Mitigation/ Management Measure
1	At some receiver locations noise levels may exceed the NMLs and there are no physical mitigation measures that can be applied to achieve the NMLs. Therefore, after all reasonable and feasible noise mitigation measures have been applied, the way forward is to seek a negotiated agreement with the affected receiver
2	The Construction Noise and Vibration Management Plan (CNVMP) identifies the management measures that can be applied to deal with residual impacts, including noise monitoring, letter box drops, phone calls, individual briefings, respite offers and alternative accommodation. Further mitigation measures may include changing operational procedures at night in order to reduce noise impacts, e.g. reduce the number of trucks on site during the night period (10 pm to 7am). The appropriate management measure would be determined by the degree of exceedance of the NML.
3	Where, after the application of all reasonable and feasible mitigation measures, noise levels still exceed the NML, then at property treatments may need to be considered. The following provides guidance on the level of treatment required in relation to the exceedance above the external NML.

Treatment 1	Mechanical ventilation only
<5dB(A) reduction	Where external noise levels are less than 5dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 15dB(A) from outside to inside when windows are closed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.
Treatment 2	Mechanical ventilation and sealing of wall vents
5-10 dB(A) reduction	Where external noise levels are less than 10dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside (ENMM p20) when windows are closed and wall vents are sealed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia. It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.
Treatment 3	Upgraded seals for windows and doors
10-12dB(A) reduction	Where external noise levels are only slightly greater than 10dB(A) above the external assessment criteria, then in addition to installing mechanical ventilation (Treatment 1) and sealing of wall vents (Treatment 2), special acoustic grade seals should be installed on windows and perimeter doors exposed to road traffic noise to enable the internal noise criteria to be achieved with windows and doors shut.
Treatment 4	Upgraded windows, glazing and doors
>12 dB(A) reduction	Where the predicted external noise level exceeds the external assessment criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors would be required on the facades exposed to the works, in addition to the mechanical ventilation, sealing of wall vents and acoustic seals for windows and doors described in Treatments 1, 2 and 3, respectively. Note that these upgrades are only suitable for masonry type buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.

4 All reasonable and feasible mitigation has been explored for the site. Exceedance of the NML is predicted to occur at up to 27 receivers in NCA 12 in the area opposite the driveway access to the site. These receivers may also potentially be exposed to noise levels that cause sleep disturbance from trucks arriving and exiting the site. The following at-property treatment may be required to reduce noise impact from the site:

Treatment Type	No. Residences	No. Apartment Blqs
Treatment 1	27	1
Treatment 2	9	1
Treatment 3	-	-
Treatment 4	-	-

5 At property treatment requirements will be reviewed once site access is gained and prior to the commencement of 24 hour operations. The review will include on site testing of trucks driving on site and entering/exiting the site to verify noise levels predicted by the noise model. Once the noise model is verified, properties likely to exceed the OOHW (Night) NML and the sleep disturbance NML will be identified for consideration of at-property treatment.
[Additional long-term noise monitoring completed in May 2016 confirmed the NMLs in NCA 12.](#)

G.4 SPI COMPOUNDS



Building Type		Legend	
	Education		Compound sites
	Residential		NCAs
	Industrial		Temporary 2.4m Barrier
	Hotel		Temporary 3m Barrier
	Commercial		Acoustic Shed

Client: **WestConnex New M5**

Project: **WestConnex Stage 2 M5**

Scale: 0 25 50 75 100 m

Description:
 St Peter Intersection compound
 Noise catchment areas & Sensitive Receivers
 Temporary and permanent noise barrier locations

Noise Levels are approximate due to interpolation of contours and should be used for reference only. For information only and not for construction. This information is protected by copyright.

RENZO TONIN & ASSOCIATES
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 Figure No: TH014-05 6 0 1 010 (r1)
 Date: 29.07.2016
 Scale: 1:3,500 @ A3

Table C2: Construction Noise Management Schedule

St Peters Interchange Tunnel Support Works

Area to be Managed	Mitigation/ Management Measure	Typical Details	Comments
Tunnel site establishment			
1	Noise barriers	3m temporary barrier on northeast boundary from offices to earthmound 3m temporary barrier on northeast boundary from earthmound to warehouses 2.4m temporary barrier on northwest boundary from above decline to south of 1 Canal Rd	see Table C3 for details see Table C3 for details see Table C3 for details
2	At-property treatment (operational noise)	See SPI CNVIS	
3	Work outside Standard Construction Hours	Limited (covered by OOHW CNVIS)	
4	High noise impact works	Some 'Highly Noise Affected' Receivers during standard hours (site establishment/ initial excavation works). Respite periods for high noise activities.	Commercial receivers only.
Tunnel decline ramp excavation			
1	Noise barriers	As above	
2	Work outside Standard Construction Hours	EVE works (6pm to 10 pm): Restricted as outlined below; NIGHT works (10 pm to 7 am): None.	
3	Truck movement restrictions for OOHW period	Evening: ≤ 12 concrete trucks per hour; Night: 0 trucks per hour.	
Tunnel RH Support, Spoil Handling and Tunnel Lining			
1	Noise barriers	As above	
2	Work outside Standard Construction Hours	EVE works (6 pm to 10 pm): Restricted as outlined below NIGHT works (10 pm to 7 am): Restricted as outlined below	
3	Workshop	Partial acoustic enclosure: 3 walls + roof, open side oriented away from receivers EVE/ NIGHT: 1 handtool only	
4	Spoil bin area	Partial acoustic enclosure: part wall + roof, open on side facing away from Princes Hwy DAY/ EVE: ≤ 2 Front End Loaders (FELs); NIGHT: ≤ 1 FEL.	see Table C4 for details
5	Water Treatment Plant Pumps	Partial acoustic enclosure	see Table C5 for performance requirements
6	Compressors	Partial acoustic enclosure	see Table C5 for performance requirements
7	Ventilation Fan	Attenuator/ acoustic enclosure	see Table C5 for performance requirements
8	Concrete Truck restrictions for OOHW period	EVE/ NIGHT: ≤ 4 trucks per hour	Compression braking and air brake release will be managed on site
9	Spoil Truck restrictions for OOHW period	EVE: ≤ 16 trucks per hour NIGHT: ≤ 4 trucks per hour	Entry and Exit
10	Shotcreting for OOHW period	NIGHT: Shotcreting limited to bottom of decline	
11	Residual impacts	Properties where (after application of the above) noise levels exceed NML	Subject to verification testing during first 12 months on site
		DAY: none EVE: 6 (See Table C6 and Table C7 for additional details) NIGHT: 20 (See Table C6 and Table C7 for additional details)	

Table C3: Noise Barrier Design Specifications**St Peters Interchange Tunnel Support Works**

Noise barrier reference	Location	Noise barrier height	Required Rw	Proposed Construction	Acoustic Rating of Construction*
NB01	Campbell Road Compound Northeast boundary between 36 Albert St and large earth mound	3m	Rw 15-20 Medium	17 mm plywood hoarding	Rw 24
NB02	Campbell Road Compound Northeast boundary from south of large earth mound to 47-49 Campbell Rd	3m	Rw 15-20 Medium	17 mm plywood hoarding	Rw 24
NB03	Canal Road Compound From west of 310 Princes Highway, to south of 1 Canal Rd, with openings for vehicle access	2.4m	Rw 15-20 Medium	17 mm plywood hoarding	Rw 24

Notes:

Noise barrier performance: Low - Rw 10-15; Medium - Rw 15-220; Medium-High - Rw 20-25; High - Rw 25; Very High - Rw 30

* estimated by calculations and/or reference to other similar barrier type data

GENERAL

- The specified 'required rating' must be achieved by the product selected.
- By way of explanation, the Sound Insulation Rating Rw is a measure of the noise reduction property of the assembly, a higher rating implying a higher sound reduction performance.
- Note that the Rw rating of systems measured as built on site (R'w Field Test) may be up to 5 points lower than the laboratory result.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C4: Noise Shed / Enclosure Design Specifications

St Peters Interchange Tunnel Support Works

Area to be Mitigated	Construction component	Acoustic element type
Spoil Shed	North/east/west walls	Form A
	South wall	Open
	Roof	Form A
	Acoustic lining	Acoustic lining with roofing blanket with perforated foil e.g. Permastop building blanket 55mm Sisilation Light Duty on inner skin facing inside shed on underside of roof
	Doors	None
	Ventilation Openings	Any necessary ventilation openings should face away from neighbours, placed down low so that noise walls can effectively shield them from neighbours, and also fitted with acoustic louvres / attenuators.

Notes:

LEGEND * estimated by calculations and/or reference to other similar wall type data. The client is advised not to commit to materials which have not been tested in an approved laboratory or for which an opinion only is available. Testing materials is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions.

GENERAL

- The underside of the roof and (where possible) internal walls should be lined with acoustic insulation to reduce the build-up of sound inside the shed
- The specified performances must be achieved by the product selected.
- The sealing of all gaps is critical in a sound rated construction. Use only sealer approved by the acoustic consultant.
- Check design of all junction details with acoustic consultant prior to construction.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C4a: Specification for acoustic elements of noise sheds/ acoustic enclosures

Wall/ roof type	Sound transmission loss per octave spectrum dB						
	63	125	250	500	1000	2000	4000
FORM A	8	10	14	18	18	21	25
FORM B	8	10	25	38	50	60	69
FORM C	16	20	24	29	33	35	41
FORM D	20	24	29	33	38	41	46
FORM E	20	30	36	44	51	63	72

Table C5: Plant and Equipment Specifications

St Peters Interchange Tunnel Support Works

Building/ Area to be Mitigated	Item	Acoustic Requirement	Octave spectrum dB								Lw dB(A)	
			31.5	63	125	250	500	1000	2000	4000		8000
Tunnel ventilation	Ventilation Fan - ZVN 1-16-110/4	Sound power level at surface outlet after attenuator		93	106	104	96	92	91	97	96	103
Tunnel ventilation	Ventilation Fan - ZVN 1-16-220/4	Sound power level at surface outlet after attenuator		98	110	108	100	97	95	101	100	107
Plant item	Front end loader 25 t	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1		120	112	111	105	104	102	99	90	110
Plant item	Workshop Franna Crane 20 t	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.1	112	105	97	94	94	95	91	85	77	98
Plant item	Water Treatment Plant Pumps	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.2		98	93	94	92	92	91	84	74	97
Plant item	Compressor inside container control room	Plant sound power level to be confirmed in accordance with CNVMP Appendix F.3	51	63	52	57	66	67	59	61	62	70

Notes:

LEGEND * estimated by calculations and/or reference to other similar plant type data. The client is advised not to commit to fans which have not been tested in an approved laboratory. Testing plant is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested materials, estimates or opinions. The advice provided here is in respect of acoustics only.

GENERAL

- Sound power level of plant assumed based on sound power level of similar plant type, incorporating attenuation (acoustic attenuator/ muffler/ duct lining as required)
- The specified performances must be achieved by the product selected.
- Check the necessity for HOLD POINTS with the acoustic consultant to ensure that all building details have been correctly interpreted and constructed.
- The information provided in this table is subject to modification and review without notice.
- The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

Table C6: Managing Residual Impacts during 'out of standard hours' work

St Peters Interchange Tunnel Support Works

ID	Noise Mitigation/ Management Measure
1	At some receiver locations noise levels may exceed the NMLs and there are no physical mitigation measures that can be applied to achieve the NMLs Therefore, after all reasonable and feasible noise mitigation measures have been applied, the way forward is to seek a negotiated agreement with the affected receiver
2	The Construction Noise and Vibration Management Plan (CNVMP) identifies the management measures that can be applied to deal with residual impacts, including noise monitoring, letter box drops, phone calls, individual briefings, respite offers and alternative accommodation. Further mitigation measures may include changing operational procedures at night in order to reduce noise impacts, e.g. reduce the number of trucks on site during the night period (10 pm to 7am). The appropriate management measure would be determined by the degree of exceedance of the NML.
3	Where, after the application of all reasonable and feasible mitigation measures, noise levels still exceed the NML, then at property treatments may need to be considered. The following provides guidance on the level of treatment required in relation to the exceedance above the external NML.

Treatment 1	Mechanical ventilation only
<5dB(A) reduction	Where external noise levels are less than 5dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 15dB(A) from outside to inside when windows are closed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.
Treatment 2	Mechanical ventilation and sealing of wall vents
5-10 dB(A) reduction	Where external noise levels are less than 10dB(A) above the external assessment criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside (ENMM p20) when windows are closed and wall vents are sealed. If the internal noise goals can only be achieved with windows closed, then mechanical ventilation should be considered to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia. It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.
Treatment 3	Upgraded seals for windows and doors
10-12dB(A) reduction	Where external noise levels are only slightly greater than 10dB(A) above the external assessment criteria, then in addition to installing mechanical ventilation (Treatment 1) and sealing of wall vents (Treatment 2), special acoustic grade seals should be installed on windows and perimeter doors exposed to road traffic noise to enable the internal noise criteria to be achieved with windows and doors shut.
Treatment 4	Upgraded windows, glazing and doors
>12 dB(A) reduction	Where the predicted external noise level exceeds the external assessment criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors would be required on the facades exposed to the works, in addition to the mechanical ventilation, sealing of wall vents and acoustic seals for windows and doors described in Treatments 1, 2 and 3, respectively. Note that these upgrades are only suitable for masonry type buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.

4 All reasonable and feasible mitigation has been explored for the site. Exceedance of the sleep disturbance NML is predicted to occur at up to 15 receivers in NCA 15 in the area opposite the driveway exit from the site. The following at-property treatment may be required to reduce noise impact from the site:

Treatment Type	No. Residences	No. Apartment Blgs
Treatment 1	19	-
Treatment 2	-	1
Treatment 3	-	-
Treatment 4	-	-

5 At property treatment requirements will be reviewed once site access is gained and prior to the commencement of 24 hour operations. The review will include on site testing of trucks driving on site and entering/existing the site to verify noise levels predicted by the noise model. Once the noise model is verified, properties likely to exceed the OOHW (Night) NML and the sleep disturbance NML will be identified for consideration of at-property treatment.

APPENDIX H **Monitoring Specifications**

H.1 **Specification for Determining the Sound Power of Construction Plant and Equipment**

H.1.1 **Scope**

This document specifies methods for determination of sound power levels for construction plant including earthmoving equipment and other ancillary plant and equipment used during construction.

H.1.2 **Referenced Standards**

- AS IEC 61672.1 Electroacoustic - Sound Level Meters – Specifications;
- AS 2012.1 Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - Stationary test condition - Determination of compliance with limits for exterior noise
- ISO 3744 Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering methods for an essentially free field over a reflecting plane
- ISO 3746 Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane
- ISO 6393 Earth-moving machinery - Determination of sound power level - Stationary test conditions
- ISO 6395 Earth-moving machinery - Determination of sound power level - Dynamic test conditions

H.1.3 **Testing Procedures – Earthmoving Machinery**

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

Each significant plant item shall be tested in terms of both the 'stationary' and the 'dynamic' testing procedures detailed below.

All sound level meters used must be Type 1 instruments as described in AS IEC 61672.1 2004 "Electroacoustic - Sound Level Meters" and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the meters shall be checked in the field before and after the noise measurement period.

H.1.4 Stationary Testing

Stationary measurements shall be performed on all earthmoving plant according to the method of AS 2012.1 and/or ISO 6393.

In addition to measuring overall A-weighted noise levels, octave band frequency LAeq,T noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in Table 1 of AS2012.1.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band LAeq,T noise levels shall also be processed as described in Section 8 of that Standard to establish octave-band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the LAeq,T and LA10,T noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

All measured noise level data and determined sound power levels shall be included in the test reports.

H.1.5 Dynamic Testing

Details of equipment operation during testing will vary depending on the equipment type. Dynamic measurements shall be performed on all earthmoving plant according to the method in International Standard ISO 6395.

In addition to measuring overall A-weighted noise levels, octave band frequency LAeq,T noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in International Standard ISO 6395.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed to establish octave-band sound power levels.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $LA_{10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

All measured noise level data and determined sound power levels shall be included in the test reports.

H.1.6 Testing Procedures – Other Construction Plant

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All sound level meters used must be Type 1 instruments as described in AS IEC 61672.1 'Electroacoustic - Sound Level Meters'. The calibration of the meters shall be checked in the field before and after the noise measurement period.

Noise measurements shall be performed on all non-earthmoving construction plant according to the methods of either ISO 3744 or ISO 3746, whichever is applicable to the items of plant being tested.

Machinery shall be operated at high idle speed. In the case of drilling, boring and rock-breaking machines, the testing location shall allow for these machines to be operated in rock of characteristics that are typical for the project site.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in Table 1 of AS2012.1.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish octave-band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $LA_{10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures. All measured noise level data and determined sound power levels shall be included in the test reports.

H.2 Specification for Construction Noise Monitoring

H.2.1 Scope

This document specifies methods for undertaking noise monitoring during the construction phase of the project.

H.2.2 Referenced Standards & Guidelines

- AS IEC 61672.1 Electroacoustic - Sound Level Meters – Specifications;
- AS 1055 Acoustics - Description and Measurement of Environmental Noise;
- DECCW NSW Interim Construction Noise Guideline 2009; and
- EPA NSW Industrial Noise Policy 2000.

H.2.3 Testing Procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All noise monitoring equipment used must be at least Type 2 instruments as described in AS IEC 61672.1 2004 'Electroacoustic - Sound Level Meters - Specifications' and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of long-term noise monitoring, calibration levels shall be checked at minimum weekly intervals.

Long-term noise monitoring equipment or Noise Loggers, consist of sound level meters and computers housed in weather resistant enclosures. The operator may either retrieve the data at the conclusion of each monitoring period either in person or via a telephone modem if the logger is fitted with a mobile phone option.

All environmental noise measurements shall be taken with the following meter settings:

- Time Constant - FAST (i.e. 125 milliseconds)
- Frequency Weightings - A-weighting
- Sample Period - 15 minutes

All outdoor noise measurements shall be undertaken with a windscreen over the microphone. Windscreens reduce wind noise at the microphones.

Measurements of noise should be disregarded when it is raining and/or the wind speed is greater than 5 m/s (18 km/HR).

H.2.4 Long-term (unattended) Monitoring

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

Noise monitoring equipment shall be placed at positions which have unobstructed views of general site activities, whilst shielded as much as possible from non-construction site noise (e.g.. road traffic, rail noise and other surrounding noise).

Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory for later retrieval is the following A-weighted noise levels: L_{min} , L_{90} , L_{eq} , L_{10} , L_1 and L_{max} .

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Meteorological conditions such as wind velocity, wind direction and rainfall shall also be either monitored on site or recorded from the nearest weather station to the project site, over the entire noise monitoring period.

H.2.5 Short-term (attended) Monitoring

All attended short-term noise monitoring shall be recorded over 15 minute sample intervals. Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory and reported are the following A-weighted noise levels: L_{min} , L_{90} , L_{eq} , L_{10} , L_1 and L_{max} .

In addition to measuring and reporting overall A-weighted noise levels, statistical L_{90} , L_{eq} , L_{10} noise levels shall also be measured and reported in third-octave band frequencies from 31.5Hz to 8kHz.

Outdoor noise monitoring is to be undertaken at least 3.5m from any reflecting structure other than the ground. The preferred measurement height is 1.2-1.5m above the ground. Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures.

Measurements inside buildings should be at least 1m from the walls or other major reflecting surfaces, 1.2 m to 1.5m above the floor, and about 1.5m from windows.

Conditions such as wind velocity, wind direction, temperature, relative humidity and cloud cover shall also be recorded during short-term noise monitoring.

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

The following information shall be recorded:

- Date and time of measurements
- Type and model number of instrumentation
- Results of field calibration checks before and after measurements
- Description of the time aspects of each measurement (i.e. sample times, measurement time intervals and time of day)
- Sketch map of area
- Measurement location details and number of measurements at each location
- Weather conditions during measurements
- Operation and load conditions of the noise sources under investigation
- Any adjustment made for presence or absence of nearby reflecting surfaces
- Noise due to other sources (e.g. traffic, aircraft, trains, dogs barking, insects etc.)

H.3 Specification for construction vibration monitoring

H.3.1 Scope

This document specifies methods for undertaking vibration monitoring during the construction phase of the project.

H.3.2 Referenced Standards and Guidelines

- AS 2775 Mechanical Mounting of Accelerometers
- AS 2670.2 Part 2: Evaluation of human exposure to whole body vibration
- DECC NSW Assessing Vibration: A Technical Guideline
- DIN 4150.3 Structural Vibration in Buildings – Effects on Structures
- BS 7385:1 Evaluation and Measurement for Vibration in Buildings – Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings

- BS 7385:2 Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Groundborne Vibration
- ISO 4866 Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings

H.3.3 Testing Procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be calibrated at least once every two years to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The monitoring system should also have a measurement frequency range down to 1Hz.

H.3.4 Short-Term (Attended) Monitoring

Vibration monitoring shall be undertaken at the following locations:

- at the commencement of operation for each plant or activity on site, which has the potential to generate significant vibration levels, so to refine the indicative minimum working distances and provide a site-specific table of minimum working distances
- vibration sensitive locations determined to fall within the 'buffer distances' established for each item of plant. Areas likely to require vibration monitoring are identified in this report; and
- where vibration complaints or requests from relevant authorities, at the requested location and at any other relevant vibration receiver location with closest proximity to the construction activities.

Vibration monitoring shall be undertaken over the following period(s):

- for plant operating within the 'buffer distances', during the commencement of use of each plant on site until site-specific minimum working distances are established; and
- for complaints or requests from relevant authorities, during the of use of requested plant until site-specific minimum working distances are established.

All attended short-term vibration monitoring shall be recorded over 15 minute sample intervals. The magnitude of vibration is to be recorded at a minimum rate of 10 samples per second. The following minimum range of vibration metrics should be stored in memory and reported:

- Vibration Dose Values (VDVs)
- root-mean-square (rms) – maximums and statistical levels

- peak-particle velocity (ppv) – maximums and statistical levels.

In addition to measuring and reporting overall vibration, statistical vibration shall also be measured and reported in third-octave band frequencies from 1Hz to 250Hz.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;
- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using either bees wax or a magnetic mounting plate onto a steel washer, plate or bracket which shall be either fastened or glued to the surface of interest; and
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Description of the time aspects of each measurement (i.e. sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Operation and load conditions of the vibrating plant under investigation; and
- Possible vibration influences from other sources (e.g. domestic vibrations, other mechanical plant, traffic, etc.).

H.3.5 Long-Term (Unattended) Monitoring

Vibration monitoring shall be undertaken at vibration sensitive locations determined to fall within the 'minimum working distances' established for each item of plant during the commencement of use of each plant on site.

Vibration monitoring shall be undertaken over the following period(s):

- continuously whilst the vibrating plant is operational within the pre-determined 'minimum working distance' from the potentially affected building.

Vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.

Vibration is to be recorded at a minimum rate of 10 samples per second. The data is to be processed statistically and stored in memory. The minimum range of vibration metrics to be stored in memory for later retrieval is the following:

- Vibration Dose Values (VDVs)
- vector-sum root-mean-square (rms) – maximums and statistical metrics; and
- vector-sum peak-particle velocity (ppv) – maximums and statistical metrics.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;
- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using bees wax or a magnetic mounting plate onto a steel plate or bracket either fastened or glued to the surface of interest;
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that; and
- a flashing light alarm should be attached in a visible position from the construction work area. When vibration exceeds the set threshold, the light will flash notifying the operator that works in that area should cease immediately.

APPENDIX I **Blast Management Strategy**

Report to

CDS

**Blast Management Strategy -
Stage 2 M5
(Kingsgrove to St.Peters)**

Prepared By:

Heilig & Partners Pty. Ltd.

December, 2016

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COMPLIANCE TABLE

The blasting Conditions of Approval have been addressed in the Blast Management Plan. The following Table highlights the areas where each Condition is addressed:

<i>Condition</i>	<i>Description</i>	<i>Reference in Blast Management Strategy</i>
D28	Prepare a Blast Management Strategy demonstrating that all blasting will not generate unacceptable vibration impacts	This document
D29	The vibration levels for the blasting activities shall meet the requirements of D34 and D35	Section 1.3 - Performance Limits on Page 6
D30	Blasts shall be limited to an average of one single detonation per day per single receiver and maximum of six per week, unless otherwise agreed by the EPA	Section 1.1 - Blasting Times on Page 8
D31	A series of initial trials at reduced scale shall be completed prior to production blasting to determine site specific blast response characteristics	Section 5.1 - Trial Blasting on Page 23
D32	Blasting associated with the project will only be undertaken during specified times	Section 1.1 - Blasting Times on Page 8
D33	Where vibration levels exceed acceptable values, feasible and reasonable mitigation measures shall be implemented	Section 6 – Contingencies On Page 25
D34	Specified airblast criteria	Section 1.3 - Performance Limits on Page 6
D35	Ground vibration generated by blasting shall be limited to human comfort criteria	Section 1.3 - Performance Limits on Page 6
D36	The blasting criteria specified in conditions D34 and D35 do not apply where there is a written agreement with the relevant landowners. The blasting limit agreed to any under any agreement can at no time exceed 25mm/s or 125dBL	

1. BACKGROUND

Stage 2 of WestConnex – The New M5 – will run from the existing M5 East corridor at Kingsgrove via tunnel to St Peters, providing improved access to the airport, south Sydney and Port Botany precincts.

Key features of the New M5 include:

- new twin tunnels that are higher, wider and flatter, which will more than double capacity along the M5 East corridor and provide motorway access to north of Sydney Airport
- a new interchange at an industrial site at St Peters, which reduces the impact on nearby residential areas
- connections from the interchange to key roads in the area, including Campbell Road/Street, Euston Road and across the canal to Bourke Road
- widening of Campbell Road/Street and Euston Road through existing road widening reservations
- western tunnel entry and exit points at Kingsgrove.

This Blast Management Strategy report is prepared to provide a framework for the procedures to maintain best practice controls to manage potential environmental impacts during the blasting activities linked with developing the mainline tunnel and ramps, although will also apply to other areas where drilling and blasting may be required as method of excavation.

The objective of this document is therefore to:

- Describe how CDS propose to manage blasting activities and the related potential environmental impacts such as vibration. It sets out the performance requirements and procedures to ensure that potential environmental impacts associated with blasting activities are adequately identified and controlled for the project.
- This document is applicable to all the drilling and blasting activities during the construction phases of the project and will be equally applicable should other areas along the project alignment necessitate drilling and blasting activities. This document has been prepared to address the requirements of the project Environmental Management Plan (EMP).

In addition to this Blast Management Strategy Document, CDS will ensure that any engaged sub-contractor for the blasting activities will have developed their own comprehensive site blasting management regime. The contractor will have a comprehensive suite of procedures covering both workplace health and safety and safe blasting practices. Copies of these documents will be provided by the drill and blast contractor and reviewed by CDS prior to commencement of any blasting activities.

1.1. Baseline Conditions of Approval

In the Conditions of Approval, D28 indicates that should blasting be required, a Blast Management Strategy must be developed and in consultation with the Environmental Protection Agency (EPA) and this Blasting Management Strategy should be incorporated into the Construction Noise and Vibration Management Plan (CNVMP). The Strategy should be prepared with an aim to demonstrate that all blasting and associated activities will be undertaken in a manner that will not generate unacceptable noise and vibration impacts or pose a significant risk impact to residences and sensitive receptors. The Strategy also addresses the principles outlined in *Hazardous Industry Planning Advisory Paper No 6: Hazard Analysis* (Department of Planning January 2011) and *Assessment Guideline: Multi-Level Risk Assessment* (Department of Planning and Infrastructure May 2011) for the handling and storage of hazardous materials. Issues considered in the Strategy include, but not necessarily be limited to:

- a) Details of blasting to be performed, including location, method and justification of the need to blast;

- b) Identification of any potentially affected noise and vibration sensitive sites including heritage buildings and utilities;
- c) Establishment of appropriate criteria for blast overpressure and ground vibration levels at each category of noise sensitive site;
- d) Details of any storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction site;
- e) Identification of hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives;
- f) Determination of potential noise and vibration and risk impacts from blasting and appropriate best management practices; and
- g) Community consultation procedures.

Other relevant conditions in the Conditions of Approval include:

- D29 – The vibration levels for blasting activities, including both above ground and underground work, shall meet the requirements of D34 and D35.
- D30 – Blasts must be limited to an average of one single detonation in any one day per sensitive receiver, and a maximum of six per week, unless otherwise agreed by the EPA through consultation on the Blast management Strategy.

For the purposes of this condition a single detonation may involve a number of individual blasts fired in quick succession in a discrete area

- D31 – For any section of tunnel construction where blasting is proposed, a series of trials at reduced scale shall be conducted prior to production blasting to determine site-specific blast response characteristics and to define allowable blast sizes to meet the Airblast overpressure and ground vibration limits in conditions D34 and D35.
- D32 – Blasting associated with the project shall; only be undertaken during the following hours:
 - a) 9:00am to 5:00pm, Monday to Friday inclusive;
 - b) 9:00am to 1:00pm Saturday; and
 - c) At no time on Sunday or on a public holiday.

This condition does not apply in the event of a direction from police or other relevant authority for safety or emergency reasons to avoid loss of life, property loss and/or prevent environmental harm.

- D33 – Where vibration levels exceed the acceptable vibration does values, feasible and reasonable mitigation measures shall be considered and implemented.
- D34 – Airblast overpressure generated by blasting associated with the project shall not exceed the criteria specified in Table 1 when measured at the most affected residence or other sensitive receiver.
- D35 – Ground vibration generated by blasting associated with the project shall not exceed the criteria specified in Table 2 when measured at the most affected residence or other sensitive receiver.
- D36 – The blasting criteria identified in conditions D34 and D35 do not apply where the proponent has a written agreement with the relevant landowner to exceed the criteria and the Secretary has approved the terms of the written agreement. In obtaining the Secretary's approval for any such agreement, the Proponent shall submit to the Secretary;
 - a) Details of the proposed blasting program and justification for the proposed increase to blasting criteria including alternatives considered (where relevant);

- b) An assessment of the environmental impacts of the increased blast limits on the surrounding environment and most affected residences or other sensitive receivers including, but not limited to noise, vibration and air quality and any risk to surrounding utilities, services or other structures;
- c) Details of the blast management, mitigation and monitoring procedures to be implemented; and
- d) Details of consultation undertaken and agreement reached with the relevant landowners (including a copy of the agreement in relation to the increased blasting limits).

The following exclusions apply to the application of this condition:

- i. Any agreements reached may be terminated by the landowner at any time should concerns about the increased blasting limits be unresolved;
- ii. The blasting limit agreed to under any agreement can at no time exceed a maximum Particle Velocity vibration level of 25mm/s or Maximum Airblast Overpressure level of 125dB_L;
- iii. The provisions under this condition (to increase applicable blast criteria in agreement with the relevant landowners) do not apply where the property is a heritage property

1.2. Environmental Objectives

The environmental objectives for blasting are to:

- Minimise the impact of vibration from the blasting activities and to a lesser extent airblast overpressure to acceptable levels;
- Protect the amenity of residents and other building occupiers;
- Ensure the integrity of all infrastructure, including those buildings listed on the State or local heritage registers, is protected and not affected by the blasting activities;
- Prevent damage to adjacent public utilities, structures and buildings resulting from vibration and air overpressure;
- Comply with the project Environmental Management Plan.

In addition to the above mentioned environmental objectives and performance criteria, all blasting activities will meet the following objectives:

- Safety of all personnel;
- Secure environment;
- Control of flyrock;
- Fragmentation and diggability commensurate with excavating equipment.

1.3. Performance Limits

The Conditions of Approval are given for activities generating continuous, intermittent and impulsive type vibrations. The types of vibration require different methods of assessment and different applicable performance criterion. The performance limits are drawn from the “*DEC: Assessing Vibration: A technical guideline*”¹ or the Australian Standard AS2187.2: 2006. “*Explosives Storage and Use: Use of Explosives*”

Construction works that generate continuous or impulsive vibration values should comply with values specified in the DEC document. The DEC document provides information for continuous and impulsive vibration for different periods of the day/evening as well as different building uses (i.e. critical, residential, offices/workshops etc.). Whilst the limits are said to apply for impulsive events, blasting is excluded from this table.

¹ Department of Environment and Conservation NSW 92006), Environmental Noise Management, “Assessing Vibration: a technical guideline”

In terms of blasting related effects, the DEC refers to the ANZEC document that specifies vibration should be controlled to a limit of 5mm/s for 95% of occasions at any noise sensitive place. The level of overpressure should be controlled to 115dB(L) on 95% of measurement occasions. Importantly, the conditions do not differentiate between different building occupancies but rather group these together as a “noise sensitive site”. No distinction or other values are given for commercial, industrial or other building occupancies where higher limits are often tolerated.

Conditions can also specify vibration criteria for blasting which are aligned with the recommendations of the Australian Standard. Importantly these are different from those indicated in the ANZEC document, being slightly less restrictive from blasting where the number of blasts is less than 20 as well as proposing limits that consider different building types. It is proposed that blasting will adopt performance limits which are consistent with the Australian Standard AS2187.2. The AS2187.2 limits are more commonly applied to construction projects with the ANZEC levels applied to blasting activities associated with longer term projects like quarries and mines.

The proposed levels are taken from Table J4.5(A) of the Australian Standard AS2187.2 and are based on human comfort criteria. The standard recognises human comfort and proposes acceptable levels of vibration based upon the duration of the blasting operations. A summary of these criteria are given in Table J4.5(A) and reproduced as the following Table 1.

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site	Operations lasting longer than 12 months or more than 20 blasts	5mm/s for 95% blasts per year 10mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site	Operations lasting less than 12 months or less than 20 blasts	10mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites such as factories and commercial premises	All blasting	25mm/s maximum value unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer’s specification or levels that can be shown to adversely affect the equipment operation

Table 1 – Ground vibration limits for human comfort (reproduced from AS187.2 2006)

The limits presented in Table 1 indicate a permissible level of vibration of 5mm/s, increasing to 10mm/s where the total number of blasts is fewer than 20, or the duration is less than 12 months. Whilst the total number of blasts and duration for the project will exceed these values, any affected property owner, resident, or building occupier is unlikely to be exposed to repeat blasting that would necessitate the lower 5mm/s criterion.

It is proposed that the 10mm/s for residential properties is adopted, possibly increasing to 25mm/s for commercial properties where there are no other impacts, such as sensitive equipment, that necessitate imposing a lower limit.

The proposed permissible vibration values do not apply where there is a written agreement with the relevant land owner to exceed the criteria and the EPA/Secretary has approved the terms of the written agreement.

In addition, Table J4.4.2.1 of the Australian Standard suggests levels for the prevention of minor or cosmetic damage occurring to structures from ground vibration generated by blasting. The standard defines *cosmetic* damage as the formation of hairline cracks on drywall surfaces, the growth of

existing cracks in plaster or drywall surfaces or the formation of hairline cracks in the mortar joints of brick/concrete constructions. *Minor* damage is defined as the formation of cracks or loosening and falling of plaster or drywall surfaces, or cracks through brick/concrete blocks. The table is reproduced as follows:

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4Hz to 15Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	
Un-reinforced or light framed structure. Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

Table 2 – Transient vibration guide values for cosmetic damage (reproduced from AS2187.2-2006)

Alternatively, construction vibration goals to eliminate structural damage may also be required to comply the levels set out in the German Standard DIN4150-3 “*Structural Vibration – Effects of Vibration on Structures*” rather than the equivalent table within the Australian Standard. It is considered appropriate to apply the levels in Table 2 for those blasting applications where blasting occurs adjacent to an unoccupied buildings where protection of the structure is important, although personal amenity is irrelevant.

The Australian Standard AS2187.2 makes no distinction for heritage structures or any suggestion that they should be addressed with a lower permissible vibration limit. It is therefore proposed that “*heritage*” listed properties will not be distinguished from these other commercial or residential properties by imposing a lower vibration limit, but rather the potential sensitivity of these structures will be addressed by undertaking an increased scale of monitoring, in particular:

- Detailed condition surveys, including both high resolution digital images;
- Dedicated vibration monitoring instrumentation on selected “*heritage*” properties;
- Where required, glass slides placed over a selection of open cracks or discontinuities and photographed weekly to confirm that there are no adverse effects of the blasting activities;
- As an additional precautionary measure for particularly sensitive sites, use of electronic strain gauges.

Table 3 indicates the Airblast overpressure criteria applicable for the above ground and underground blasting.

Airblast overpressure (dBL)	Allowable Exceedance
115	5% of total number of blasts over a 12 month period
120	0%

Table 3 – Airblast overpressure criteria

Overpressure levels for the underground tunnel blasting when measured at the nearest sensitive receivers will be negligible and indistinguishable from background values.

As per best practice, for any section of construction where blasting is proposed, a series of initial trials at a reduced scale shall be conducted prior to production blasting to determine site specific blast response characteristics and to define allowable blast sizes to meet airblast overpressure and ground vibration limits in the approval.

1.1. Blasting Times

Blasting will only be undertaken during standard construction hours and between the hours of 9:00am to 5:00pm Monday to Friday and 9:00am to 1:00pm on Saturday. No blasting will occur on Sunday or public holidays. Blasting outside these hours will only be undertaken in unforeseen

circumstances (e.g. safety issue with explosives) or the event of an emergency. Blasting will typically be undertaken at times which are determined as having the minimum impact on other aspects of the project and occupants of residential/commercial premises.

Discussions with local residents will occur several days prior to blasting to minimise disturbance.

Blasting will be limited to one blast single detonation in any one day per receiver group, unless there is an agreement with the EPA through consultation on the Construction Noise and Vibration Management Plan. Vibration modelling will be undertaken to determine impacts and the extent of a receiver group.

2. TUNNEL, RAMP AND CROSS PASSAGE BLAST AREAS

The possible blasting areas for the project are modelled to extend over the full length of the tunnel, Arncliffe cavern and the Westbound On and Eastbound Off ramps. The location of the blasts within the tunnel and/or ramps will however be determined by considering what sections can be excavated using mechanical methods. The size and depth of the blast in each case will vary to ultimately achieve a platform level consistent with the grade of the planned tunnels and ramps. The blast areas covered by the modelling within this Management Plan are shown in the following Figure 1. All areas where blasting will be undertaken will be remodelled prior to the commencement of blasting.

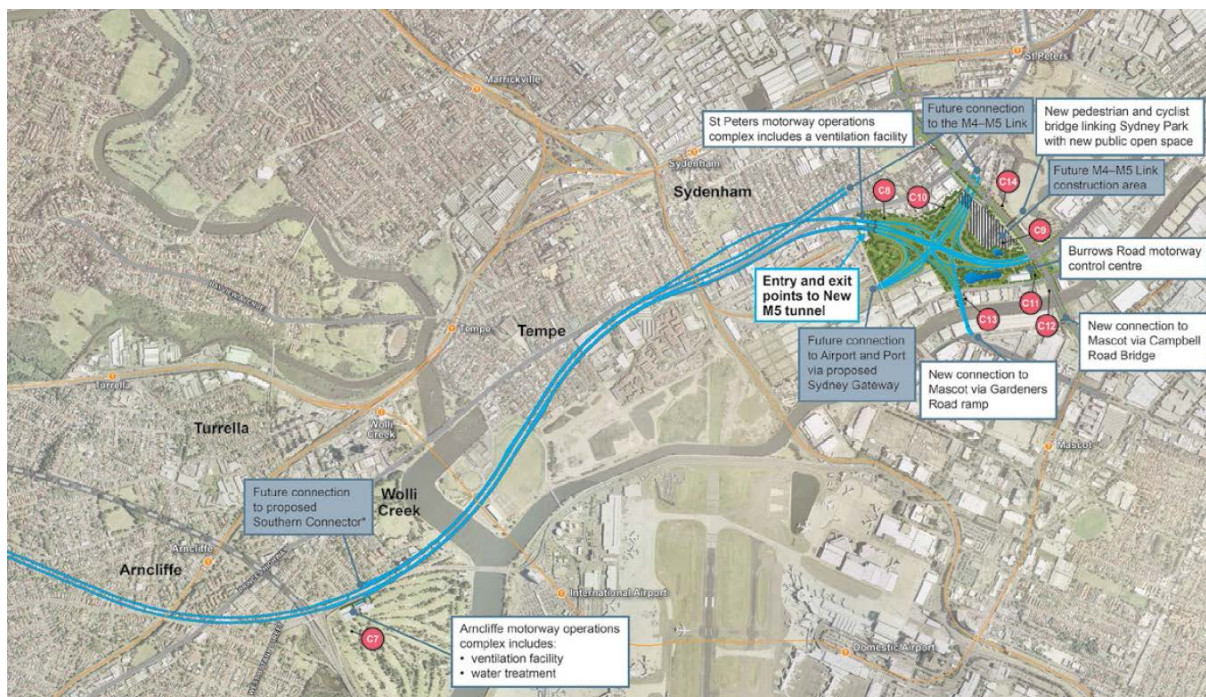


Figure 1 – Tunnel and ramp locations

Other blast areas may be required throughout the project although the details have not been identified at this stage of the project.

3. ADJACENT INFRASTRUCTURE

Potentially sensitive infrastructure is noted to exist around the tunnel alignment, including residential, commercial and industrial development together with some heritage infrastructure.

The Eastbound and Westbound Tunnels will be constructed beneath significant residential development. The initial 500 metres of the western portal is near to commercial buildings on both the north and southern sides of the M5 East Freeway.

3.1. Residential properties

The residential dwellings are of considerable age although a preliminary review of the external appearance suggests they are reasonably well constructed with some properties showing signs of disrepair. These will be reviewed as part of the condition survey assessment.

The dwellings are predominantly single storey and appear to be constructed from bricks or stone laid on a concrete course. While the dwellings are expected to be competent with respect to vibration effects and an ability to withstand elevated levels of vibration without damage, the type of construction is anticipated to offer minimal attenuation of vibration. For those properties with a large expanse of concrete or tiled areas (or generally any hard surfaces) there would be minimal further attenuation of the vibration compared with that expected from an elevated double storey dwelling constructed from timber or less dense materials.

Other multistorey residential complexes are located above the tunnels. These properties would also offer minimal attenuation between the ground vibration measured outside and those levels measured inside the property. Where the buildings have basement car parks, the level of vibration is expected to be elevated, although most likely of minor consequence with respect to personal amenity.

A detailed investigation of the types of residential properties and their susceptibility to vibration will be identified through the condition survey reports.

3.2. Commercial properties

Commercial properties are noted along the north and southern sides of the M5 east Freeway, and the southern side of the Princes Highway including the sections where the tunnel crosses approximately. A detailed investigation will be completed prior to construction to identify whether any additional vibration restrictions will be required as a consequence of potentially sensitive equipment that may be housed within the buildings. Impulsive vibration produced by any blasting within the tunnelling is not expected to jeopardise the building use, nor impact on the building integrity. Should there be any impact on these businesses, it is expected to be associated with quality of life issues or possible interactions with sensitive equipment.

A detailed investigation of the types of commercial properties and their susceptibility to vibration will be identified through the condition survey reports.

3.3. Heritage properties

There are a number of heritage properties listed on the State Heritage Register of NSW as well as multiple other properties listed in the Local Environment Plans (LEP) for the Rockdale, Marrickville and Sydney Councils. A preliminary assessment of the potential impact of the construction activities has been completed and those properties potentially affected by vibration have been identified. The analysed properties include those listed in Tables 4, 5 and 6.

Heritage, aboriginal or other sensitive infrastructure has been provided and grouped according to:

- Aboriginal heritage infrastructure
- Potential aboriginal heritage infrastructure
- *Non-aboriginal heritage infrastructure*

Table 4 shows the “*Aboriginal heritage infrastructure*”, including the AHIMS reference, site name, site type and potential impact.

Site Name	AHIMS reference	Site type	Potential impact
Undercliffe Road	45-6-0615	Rockshelter	No direct or indirect impact due to distance from project.
Shea's Creek	45-6-0751	Artefact scatter	Artefact-bearing deposits may be present in areas adjacent to Alexandra Canal.
		Edge-ground axes	Direct impact on subsurface deposits – Construction of two bridges across Alexandra Canal.
		Dugong bones	
View Street	45-6-2198	Midden	No direct or indirect impact due to distance from project.
4 Wollli_Creek 1.6	45-6-2414	Rockshelter	No direct or indirect impact due to distance from project.
Wollli_Creek 1.4	45-6-2415	Rockshelter	Closest valid site to the project surface works (250 metres). No direct or indirect impact due to distance from project.
Wollli_Creek 1.3	45-6-2416`	Rockshelter	No direct or indirect impact due to distance from project.
Wollli_Creek 1.2;	45-6-2417	Rockshelter	No direct or indirect impact due to distance from project.
Wollli_Creek 1.1;	45-6-2418	Rockshelter	No direct or indirect impact due to distance from project.
Nanny Goat Hill 1;NGH 1;	45-6-2547	Open artefact site	No direct or indirect impact due to distance from project.
Wollli Creek 2.5	45-6-2564	Rockshelter	No direct or indirect impact due to distance from project.
Wollli Creek 2.4	45-6-2565	Rockshelter	No direct or indirect impact due to distance for project.
Wollli Creek 2.1	45-6-2566	Rockshelter	No direct or indirect impact due to distance from project.
Wollli Creek	45-6-2567	Rockshelter	No direct or indirect impact due to distance from project.
Wollli Creek	45-6-2568	Rockshelter	No direct or indirect impact de to distance from project.
Fraser Park PAD	45-6-2654	PAD	No direct or indirect impact due to distance from project.
Wollli Creek 3	45-6-2671	Open artefact site	No direct or indirect impact due to distance from project.
Tempe House 1	45-6-2737	Open artefact site	No direct or indirect impact due to distance from project. Comprises subsurface deposit. No surface artefacts observed.

Table 4 - Aboriginal heritage infrastructure

A plate showing the location of the Aboriginal heritage infrastructure is given in Plate 1.

Table 5 shows the “Potential aboriginal heritage infrastructure”, including the site name, site type and potential impact. The AHIMS number is “pending” given the potential status.

Site Name	AHIMS reference	Site type	Potential impact
SR-OVRH-1	Pending	Sandstone overhang – South facing sandstone overhang measuring 4.8 metres long by 1.4 metres high by 3.1 metres deep. Located on an upper slope overlooking an unnamed tributary of Wollie Creek in Stotts Reserve.	No direct impact. Indirect – settlement vibration and impacts from blasting (within 50m of main tunnel alignment).
WC-OVRH-1	Pending	Sandstone overhang – South facing sandstone overhang measuring 5.8 metres long by 1.2 metres high by 2.7 metres deep. Located on a lower slope 20 metres from Wollie Creek. Site condition poor due to rubbish and collapsed ceiling.	No direct or indirect impact due to distance from project
WC-OVRH-2	Pending	Sandstone overhang – East facing sandstone overhang measuring 3.6 metres long by 1.9 metres high by 2.7 metres deep. Located on a middle slope. Site condition good.	No direct or indirect impact due to distance from project.
WC-OVRH-3	Pending	Sandstone overhang – South facing sandstone overhang measuring 12 metres long by one metre high by 3.2 metres deep. Located on a middle slope 100 metres from Wollie Creek. Site condition good.	No direct or indirect impact due to distance from project.
WC-OVRH-3	Pending	Sandstone overhang – Southwest facing sandstone overhang measuring 4.8 metres long by 1.4 metres high by 3.1 metres deep. Located on a middle slope 60 metres from Wollie Creek. PAD area size of overhang. Condition poor due to graffiti and presence of bed, mirror, chair and weights indicating it is regally occupied.	No direct or indirect impact due to distance from project.

Table 5 - Potential aboriginal heritage infrastructure

A plate showing the location of the Potential Aboriginal heritage infrastructure is given in Plate 2.

Table 6 shows the “Non-aboriginal heritage infrastructure”, including the Item name, number, register, location and potential impact.

Number	Item Name	Register	Location	Potential Impact
124	Roslyn Hospital	Rockdale LEP	30 Forest Road, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
123	St Francis Xavier Catholic Presbytery	Rockdale LEP	26 Forest Road, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
122	St Francis Xavier Church Group	Rockdale LEP	26 Forest Road, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
118	Street Plantings	Rockdale LEP	Firth Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
135	House	Rockdale LEP	31 Kyle Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
122	St Francis Xavier Church Group	Rockdale LEP	2-4 and 6 Forest Road, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.

Number	Item Name	Register	Location	Potential Impact
01647	Western Outfall Main Sewer (Rockdale to Homebush) (part of SWSOOS)	SHR	Corner Marsh Street and M5 East Freeway, Tempe	Secondary direct – possible vibration from tunnelling and construction of the ventilation station and water treatment plant.
4572728		S170 (Sydney Water)		Indirect – visual impact from GGBF bridge structure.
I303	Moreton Bay Fig Tree	Marrickville LEP	43 South Street, Tempe	Secondary direct – possible vibration and settlement from tunnelling.
01412 I249	Timber Slab Cottage	SHR Marrickville LEP	44 Barden Street, Tempe	Secondary direct – Possible vibration and settlement from tunnelling
I284	Brick kerb and sandstone kerb guttering	Marrickville LEP	George Street, Henry Street Park Road, Park Lane, Railway Lane, Rowe Lane, Reilly Lane and Stewart Lane, Sydenham	Secondary direct possible vibration and settlement from tunnelling.
I288	Victorian filigree style sandstone faced residence, including interiors	Marrickville LEP	3-47 Railway Road, Sydenham	Secondary direct – possible vibration and settlement from tunnelling and the construction of the ramps.
I312	Service Garage	Marrickville LEP	Corner Canal Street and Princess Highway, St Peters	Primary direct – acquisition.
				Secondary direct – possible vibration and settlement from construction of the ramps (surface works) and tunnelling.
				Indirect – visual.
I12	Terrace Group	Sydney LEP	2-34 Campbell Road, Alexandria	Secondary indirect – possible vibration from construction of the ramps.
				Secondary indirect – potential for at property acoustic treatment (subject to detailed design).
				Indirect – visual.
I1405	Warehouse 'Rudders Bond Store'	Sydney LEP	53-57 Campbell Road, Alexandria	Primary direct impact – demolition is required for the construction of the

Number	Item Name	Register	Location	Potential Impact
				ramps and St Peters interchange.
01621	Alexandra Canal including M5EE-02	SHR	General Holmes Drive (west of Engine Pond, within the boundary of Sydney (Kingsford Smith) Airport, Mascot	Primary direct – modification to the historical fabric and embankment, to enable new surface water discharge points and scour protection. Possible direct impact to the area of the archaeological remains of the old wharf.
I1		Botany LEP		Secondary direct – potential changes to navigability of canal.
I3		Sydney LEP		Secondary direct – possible vibration and settlement from tunnelling and surface works in close proximity to the canal embankments.
4571712		RNE		Indirect – visual impact due to introduction of three new bridges, including two road bridges and one dedicated pedestrian/cyclist bridge.
M5EE-02		S170 Register (Sydney Water) City Plan Heritage (2011)		
I18	Water Board Pump House (including interior and substructure)	Sydney LEP	48 Huntley Street, Alexandria	Secondary direct – possible vibration from surface works.
4571730		Sydney Water s170		Indirect – visual.
C2	Cooper Estate Conservation Area	Sydney LEP	Between Mitchell, Euston and Sydney Park Roads, Alexandria	Primary direct – change in heritage conservation area values.
				Secondary indirect – possible vibration from surface works.
I20	Industrial building 'Frank G Spurway'	Sydney LEP	20-30 Maddox Street, Alexandria	Secondary direct – possible vibration from surface works.
				Indirect – visual
I281	Town and Country Hotel, including interiors	Marrickville LEP	2 Unwins Bridge Road, St Peters	Secondary indirect – possible vibration from surface works.
				Indirect – visual
I282	Group of Victorian Filigree and Victorian Italianate terrace house – 'Narara'	Marrickville LEP	4-18 Unwins Bridge Road, St Peters	Secondary direct – possible vibration from surface works.
				Indirect – visual

Number	Item Name	Register	Location	Potential Impact
	<i>including interiors</i>			
1280	Waugh and Josephson industrial buildings former, showroom, officer and workshop, including interiors	Marrickville LEP	1-7 Unwins Bridge Road, St Peters	Secondary indirect – possible vibration from surface works. Indirect – visual
C16	Goodsell Estate Conservation Area	Marrickville LEP	Between Bedwin Road, May Street, Caroline and May Lanes and the rail line, St Peters	Primary direct – acquisition Primary direct – change in heritage conservation area values. Secondary direct – possible vibration and settlement from tunnelling and surface works.
1289	St Mary/St Mina Coptic Orthodox Church, including interiors	Marrickville LEP	24A Railway Road, Sydenham	Secondary direct – possible vibration and settlement from tunnelling.
00032 1275 1716	St Peters Anglican Church	SHR Marrickville LEP RNE	187-209 Princess Highway, St Peters	Secondary direct – possible vibration from surface works
1271	St Peters Public School, including interiors	Marrickville LEP	St Peters	Secondary direct – possible vibration from surface works. Secondary direct – potential for at property acoustic treatment (subject to detailed design)
16240	St Peters Brickpit Geological Site	RNE	Between Canal, Burrows and Campbell Road and the Princess Highway, St Peters	Primary direct – modification through construction of St Peters Interchange and shared path along northern boundary of interchange. Secondary direct – possible vibration from surface works. Indirect – visual
4801898	Bexley North Railway Station Group	S170 Register (Railcorp)	Bexley Road, Bexley North	Secondary direct – possible vibration and settlement from tunnelling and surface works. Indirect – visual
4805728 11	Arncliffe (Forest Road)	S170 Register (Railcorp)	Forest Road, Arncliffe	Secondary – possible vibration

Number	Item Name	Register	Location	Potential Impact
	Overbridge	Rockdale LEP		and settlement from tunnelling.
4305629	House	S170 Register (Roads and Maritime)	28-44 Campbell Street, St Peters	Primary direct – demolition to enable widening of Campbell Street.
4305643	House	S170 Register (Roads and Maritime)	82 Campbell Street, St Peters	Primary direct – demolition to enable widening of Campbell Street.
151	Victorian semi-detached dwelling	Rockdale LEP	26 Stanley Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
150	Victorian house	Rockdale LEP	22 Stanley Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
149	Victorian house	Rockdale LEP	20 Stanley Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
148	Victorian house	Rockdale LEP	16 Stanley Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
102085	Welfare Avenue Urban Conservation Area	RNE	Beverly Hills	Primary direct – change in heritage conservation area values.
				Secondary direct – possible vibration from surface works.
				Indirect – visual
#01076 11 #4801150	Arncliffe Railway Station Group	SHR Rockdale LEP Sydney Trains Section 170 register	Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
113	Bard of Avon, 39 Eden Street, Rockdale	Rockdale LEP	Rockdale	Secondary direct – possible vibration and settlement from tunnelling.
115	Californian bungalow house, 7 Fairview Street	Rockdale LEP	Fairview Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
116	Californian bungalow house, 21 Fairview Street	Rockdale LEP	Fairview Street, Arncliffe	Secondary direct – possible vibration and settlement from tunnelling.
19170 119	Arncliffe Post Office	RNE Rockdale LEP	Rockdale	Secondary direct – possible vibration and settlement from tunnelling.
121	Victorian shop and dwelling – 45 Firth Street, Rockdale	Rockdale LEP	Rockdale	Secondary direct – possible vibration and settlement from tunnelling.
156	House, 73	Rockdale LEP	Rockdale	Secondary direct –

Number	Item Name	Register	Location	Potential Impact
	West Botany Street, Rockdale			possible vibration and settlement from tunnelling.
161	House, 148 Wollongong Road, Rockdale	Rockdale LEP	Rockdale	Secondary direct – possible vibration and settlement from tunnelling.
1165	Stotts Reserve	Rockdale LEP	Rockdale	Secondary direct – possible vibration and settlement from tunnelling.
181	Stone Federation House – 15 East Street, Rockdale	Rockdale LEP	Rockdale	Secondary direct – possible vibration and settlement from tunnelling.
102071	Clemton Park Urban Conservation Area, Homer Street	RNE	Clemton Park	Primary direct – change in heritage conservation area values.
				Secondary direct – possible vibration from surface works.
				Indirect – visual
102106	Bardwell Park Urban Conservation Area	RNE	Bardwell Park	Secondary direct – possible vibration and settlement from tunnelling.
1273	Terrace housing including interiors -119 May Street, Marrickville	Marrickville LEP	Marrickville	Secondary direct – possible vibration from surface works.
				Indirect – visual
1277	Southern Cross Hotel	Marrickville LEP	Marrickville	Secondary direct – possible vibration and settlement from tunnelling and surface works.
				Indirect – visual

Table 6 - Non-aboriginal heritage infrastructure

A plate showing the location of the Non-aboriginal heritage infrastructure is given in Plate 3.

No detailed investigation of these heritage structures, their condition or susceptibility to vibration is available at this stage. The proposed vibration criteria discussed in Section 1 are considered appropriate for heritage structures in all but the most distressed condition. CDS will confirm if there are heritage structures that would need special attention.

A detailed investigation of the types of heritage infrastructure and their susceptibility to vibration will be identified through the condition survey reports.

Buildings or other above ground structures that may be in poor condition would be adequately protected by the vibration criteria applicable for heritage infrastructure.

3.4. Sensitive building contents

Buildings adjacent to the tunnelling works area may house vibration-sensitive equipment. This type of equipment may require vibration protection beyond that calculated by personal amenity and standard vibration criteria. Such equipment may include medical imaging equipment, telecommunications networks or scientific apparatus. Buildings and businesses that could potentially contain sensitive

equipment will be identified. The details of the sensitive equipment will be identified through correspondence with the relevant building owners prior to construction activities in the area. On review of the equipment, an acceptable vibration criteria will be defined. The impact of the blasting activities will be determined on a case-by-case basis, although in general, only the most sensitive of electronic equipment is affected by vibration and in these cases, the equipment is commonly vibration-isolated through false floors or purpose-designed spring balance systems.

The effect of vibration is most often observed by rattling of small objects or trinkets on hard surfaces which occurs at vibration levels around 1mm/s. At similar levels of vibration, loosely secured objects, such as pictures, plates and blinds, can be disturbed and these items would also be identified in a condition survey, with measures such as their temporary removal required in some unusual circumstances.

3.5. Services

Telecommunications (fibre and copper), gas, electricity, water, drainage and sewer services may exist along the alignment. Correspondence with asset owners will confirm a permissible vibration value, commonly of 50mm/s, for the services. This is consistent with value imposed on the same services for the other blasting, construction or tunnelling projects. The 50mm/s level is higher than the vibration limits for residential and commercial properties. The scale of any blasting activity is therefore controlled by the properties rather than the services.

In some instances, an assessment of the condition of services within the project boundary may be required by the asset owner prior to the commencement of works. If the condition of the infrastructure is poor, the proposed level of vibration will be reviewed and, where necessary, the effects of the activities remodelled. In some cases, the review may necessitate a CCTV scan to ascertain the condition of the service and justify and appropriate vibration criterion.

4. TUNNEL BLAST DESIGN

In general, the scale of blasting within the tunnel will be controlled by the requirement to comply with vibration criteria at the adjacent infrastructure around the tunnel. The blast design is therefore based upon:

- A small blasthole diameter, most likely less than 64mm, drilled using mechanical equipment;
- A nominal blasthole length of up to 3 metres although shorter blastholes will be required depending upon excavation geometry, particularly adjacent to the walls of the excavation. It may be appropriate to leave a pillar of rock adjacent to edges of the excavation that will be excavated mechanically;
- A nominal blasthole pattern with a burden and spacing of less than 1 metre to 1.5 metres depending upon rock strengths, blasthole diameter and allowable explosive quantity;
- A single explosive charge per blasthole, independently sequenced to restrict the maximum explosive quantity per delay to achieve vibration compliance;
- The excavation sequence is expected to involve blasting the tunnel in two separate left and right sides to permit access ahead of the blast area for the road header to excavate the upper sections of the tunnel heading.

Blast patterns for the tunnelling works will be based on two criteria:

- The powder factor which provides an indication of the expected level of fragmentation and is expressed in terms of the kilograms of explosive per cubic metre of rock. A value of 0.6 kg/m³ in the Hawkesbury Sandstone for blasting in a benching configuration is expected to yield fragmentation amenable to excavation without extensive use of a hydraulic hammer. As a comparison, a value of 0.2 kg/m³ can be used to precondition the rock and improve hammer efficiency.
- The maximum explosive weight per delay (MIC) determines the level of vibration generated at the adjacent sensitive receivers. As the quantity of explosive increases, so too does the level

of vibration. For a given vibration criteria, like the 5mm/s or 10mm/s, as the distance to a sensitive receiver decreases, the explosive quantity per blasthole must also decrease to ensure compliance with the vibration criteria.

As the explosive weight per delay reduces, the distance between the blastholes (referred to as the burden and spacing) must also decrease to maintain a constant powder factor. Where the blasting is further from a sensitive receiver (i.e. residential property) as a result of the depth of the tunnel or a greater horizontal separation distance, and larger explosive weights per delay can be used, the distance between blastholes can increase.

The use of small explosive weights less than 0.5 kilograms does not generally permit cost effective blasting at a powder factor of 0.6kg/m³. At these lower explosive weights it is most appropriate to precondition the rock mass only. It is expected that blasting in the Hawkesbury Sandstone material will require a powder factor in the region of 0.6kg/m³. A powder factor less than 0.6kg/m³ may be possible although the fragmentation and diggability of the blasted rock will be challenged. The following Table 7 shows the range of explosive weights as a function of the blast results that could be used. Where the explosive weight per delay is less than 0.5kg, the use of other non-explosive methods should be considered.

Description	Powder Factor	Acceptable range of explosive weights per delay
Fragmentation in the Hawkesbury sandstone material sufficient to allow cost effective removal	0.6 kg/m ³	>1.5 kg
Fragmentation and diggability of the blasted rock will require use of rock hammers or rippers to remove	0.2 kg/m ³	0.5 kg to 1.5 kg

Table 7 - Summary of limiting explosive weight criteria

Based on the allowable explosive quantity produced from the modelling results (determined by the vibration criteria and the proximity to sensitive receivers), the burden and spacing can be calculated to the given powder factor.

A typical blast plan for tunnel blasting showing explosive quantities, bench height, burden and spacing is provided in Figure 2 although will necessarily vary according to the tunnel profile, vibration compliance conditions.

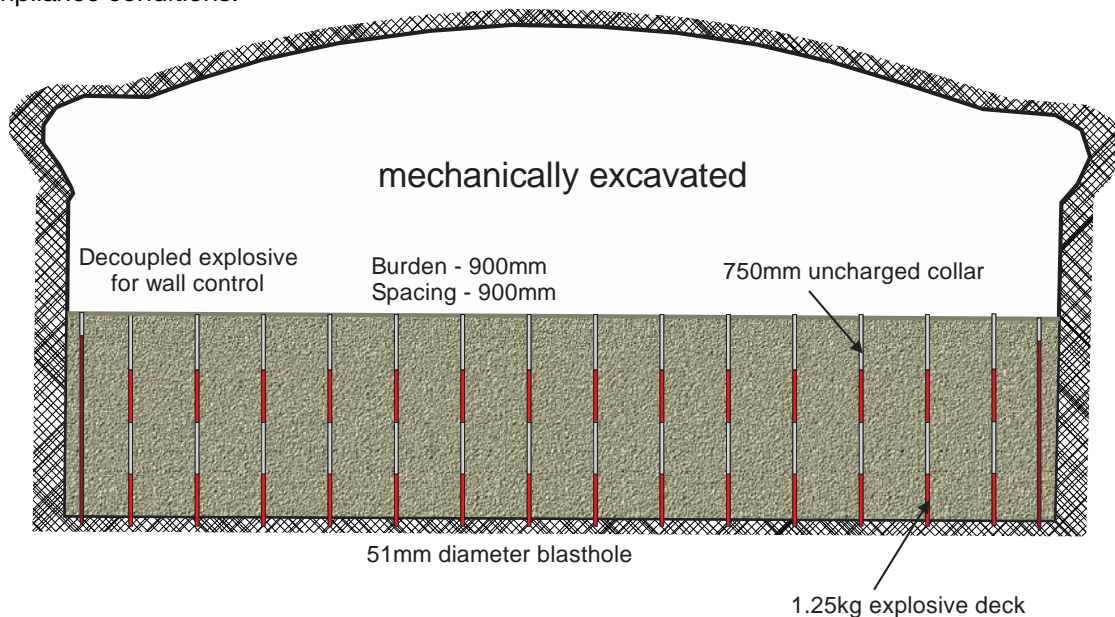


Figure 2 – Typical blast plan for tunnel blasting - Explosive quantities, bench height, burden and spacing will vary according to vibration compliance conditions

Blasthole diameter will be small to accommodate reasonable explosive columns with the low explosive weights. A blasthole diameter greater than 64mm is not expected. Where explosive weights are around 2 kilograms and it is desirable to excavate material in slices that are greater than 2.5 metres, it is feasible to “deck” blastholes. This involves placing two columns of explosive into the blasthole: a lower deck of explosive into the bottom of the blasthole and an upper deck separated by a column of inert stemming material.

5. CROSS PASSAGE BLAST DESIGN

Blasting of the cross passages may utilise small scale horizontal or slightly inclined blasting specifically undertaken to provide access between the tunnels. The blast design and effects with respect to vibration do not significantly differ from those for the tunnel/bench blasting, although the potential effects are likely to be less as a result of the lesser explosive quantities.

The key aspects of the cross passage blasting include:

- *Blasthole diameter:* Cross passage blasting utilises a small blasthole diameter commonly in the range of 45mm to 51mm;
- *Blasthole length:* The maximum blasthole length for a cross passage blast is around 3 metres compared with longer lengths up to 5 metres for the bench blasting;
- *Blast yield:* The yield from a cross passage blast is typically less than 250 tonnes compared with the greater tonnages for the bench blasting;
- *Blast duration:* Cross passage blasts are initiated over a 10 second window compared with bench blasts which are complete within several seconds;
- *Explosive quantity:* Cross passage blasts typically use up 150 kilograms of explosive in total with each blasthole containing up to 4 kilograms of explosive. Production blasts may contain several hundred kilograms of explosive in total with each hole containing up to 40 kilograms.

With respect to the vibration generated by the different types of blasting, cross passage blasting commonly produces lower levels of vibration than that produced by bench blasting by virtue of the lesser explosive quantity (smaller diameter blasthole and the smaller length of blasthole). The lower level vibration however persists longer than that produced from a bench blast due to the different initiation systems.

Three cross passage blasting scenarios are considered as shown in Table 1.

Scenario	Description	Explosive Quantity per Blasthole
A	45mm diameter blasthole drilled to length of 1.5 metres with a 500 mm uncharged collar and pneumatically loaded with ANFO (0.95g/cm ³) or 38mm cartridge emulsion	1.5 kilograms
B	45mm diameter blasthole drilled to length of 2 metres with a 500 mm uncharged collar and pneumatically loaded with ANFO (0.95g/cm ³) or 38mm cartridge emulsion	2.5 kilograms
C	45mm diameter blasthole drilled to length of 3 meters with a 500 mm uncharged collar and pneumatically loaded with ANFO (0.95g/cm ³) or 38mm cartridge emulsion	4 kilograms

Table 8 – Summary of development blasting scenarios

The level of vibration from the cross passage activities will be controlled by adjusting the scale of blasting. This will be achieved through monitoring and where necessary, changing the blasthole diameter, the length of the blasthole or the type of explosive.

6. SHAFT BLAST DESIGN

The WestConnex project may also consider the development of the access shafts using conventional drilling and blasting methods. Shaft blasting is similar to the cross passage blasting in terms of both blasthole diameter, explosive quantities and blast durations, with the exception that blastholes are drilled vertically rather than horizontally.

A number of blasting options for the shafts have been considered, including:

- 1) A conventional parallel hole full face burn cut design;
- 2) A wedge-cut design where the burn cut is replaced with a series of angled blastholes to create an initial void for the remaining firing blasthole
- 3) A full face design where the burn cut has been replaced by a larger relief drilled from surface. The relief hole extends the full depth of the shaft, backfilled with sand and blown clear for the depth of each blast;
- 4) A benching design where the blast alternates from side to side to eliminate the requirement for a burn cut void.

A typical shaft blast design based upon a conventional parallel hole full face design is shown in Figure 3.

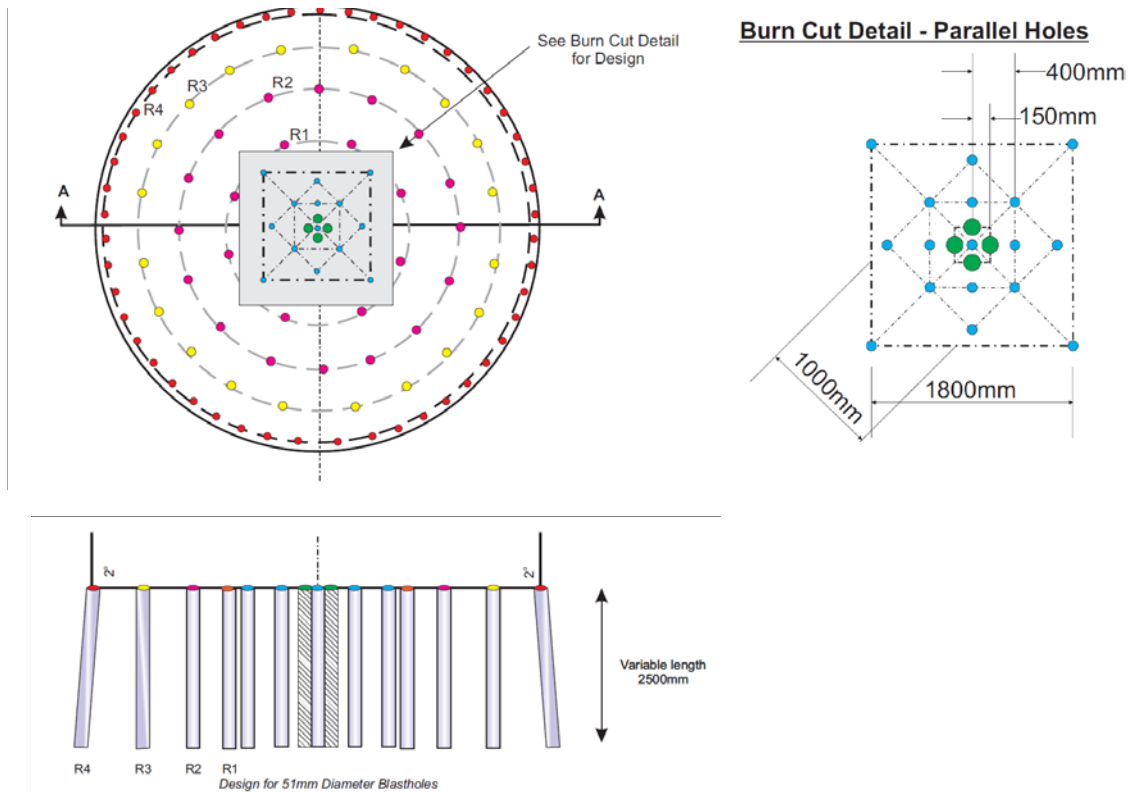


Figure 3 – Shaft blast design based upon a conventional parallel hole burn cut

The advance per blast is typically around 2.5 metres in vibration sensitive environments. Large advances may be possible dependent upon vibration compliance restrictions. The options of increasing the length of advance or reducing the number of blastholes will be reviewed once the blasting commences and an assessment of the vibration levels undertaken.

The initiation sequence for the blast designs could be based around the use of conventional non-electric delay elements however given the requirement for vibration control and the relatively shallow rates of advance, the use of the electronic elements is likely to be used.

Bulk explosive could be used however is unlikely based upon the small scale of blasting, a small bulk emulsion systems like that considered used for the bench blasting would be feasible.

The control of vibration as a consequence of adjacent sensitive receivers will be achieved through adjustments to the blasthole length. Where the explosive weight cannot be reduced to sufficiently low vibration levels, a reduction in the blasthole diameter is feasible.

7. BLAST VIBRATION ANALYSES

The primary factors known to influence the level of ground vibration from blasting include:

- a) The weight of explosive per delay;
- b) The distance between the blastholes and the point of measurement;
- c) The local geological conditions and the influence of geology and topography on vibration attenuation.

Consistent with the recommendations of the Australian Standard AS2187.2 – Use of Explosives², the most common form of the vibration equation to predict the amplitude of ground vibration from blasting at any distance from the blasthole and is given as:

$$PPV = K \left(\frac{d}{\sqrt{w}} \right)^{-\beta}$$

where d is the distance between the blastholes and the point of measurement;
w is the maximum instantaneous charge weight per delay;
K and β are site specific constants.

Based on the above equation, the expected level of ground vibration can be determined for a given distance and maximum charge weight.

A relationship between the level of vibration, the quantity of explosive and the distance from the blast has been estimated from other vibration measurements from blasting activities in rock types consistent with the sandstone rock masses. An equation consistent with the format described above has been developed. In accordance with Condition D31, a series of initial trials at a reduced scale will be undertaken to confirm the site-specific blast vibration equations.

The following Figure 4 identifies vibration level as a function of distance from the blasthole for varying quantities of explosive.

² AS2187.2-2006, “Explosives – Storage, transport and use Part 2: Use of explosives”

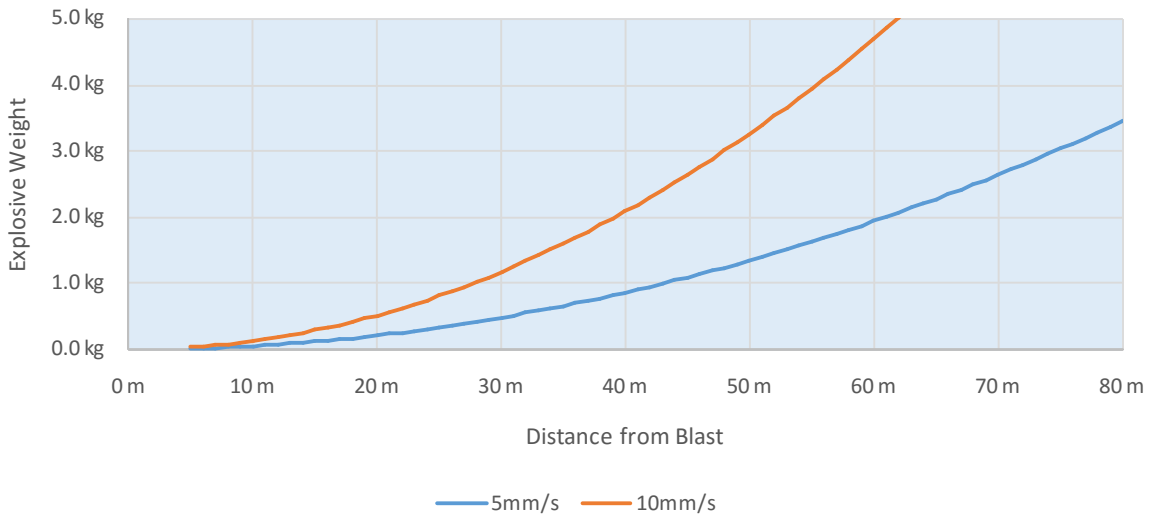


Figure 4: Estimated vibration level as a function of distance from varying explosive quantities per delay

Because of the proximity of blast area to possibly sensitive infrastructure, explosive quantities per blasthole will be small. The following shows explosive quantities per blasthole ranging up to 5 kilograms as a function of distance from the blast for two different permissible vibration criterion, 5mm/s and 10mm/s. The data relate to the measurements in the Sydney sandstone rock mass and will be confirmed during the initial stages of blasting.

To account for the variability in explosive performance and ground characteristics, it is accepted industry practice to design blast patterns using an equation that predicts the 95 percentile level (i.e. a level which will exceed 95% of all measured values) and continually update and review practices according to the measured levels. If measured levels routinely exceed, or fall below, the predicted value, the equation is adjusted to reflect the different site conditions. This conforms to the recommendations of the Australian Standard AS2187.

7.1. Trial Blasting

Consistent with the Condition D31, a series of trial blasts will be undertaken at a reduced scale to confirm the site specific blast response characteristics. These data will be analysed to determine a relationship between vibration level, distance and explosive quantity. This site specific relationship will be compared to the proposed relationship identified in Section 5 (Figure 3).

The site trials will be small scale to ensure compliance with the permissible vibration criteria. The trial blast will involve a number (~5) single-hole explosive charges with the resulting vibration levels measured at multiple locations (~5 around the blast area). Between each trial, the measured vibration levels will be checked to confirm compliance and the explosive weights adjusted for subsequent trials.

Should the measured data differ significantly from the expected values, the blast areas will be remodelled on the basis of the site specific relationship.

7.2. Modelling Approach

The scale of blasting will be modelled for the tunnel and ramp alignment data based upon compliance with a 5mm/s and 10mm/s vibration limit. For the Eastbound and Westbound mainline tunnels, and each of the access and egress ramps, the analyses will identify the quantity of explosive that will achieve compliance with the permissible level of vibration. The modelling is based upon a relationship between explosive quantity, vibration level and distance consistent with blasting in a sandstone rock mass that has been determined from data collected from other Sydney projects. The

vibration contours that identify the overall impacts of the blasting activities are also based upon this same relationship.

The modelling is three dimensional and uses the reduced level (RL) of the residential, commercial and heritage properties together with the surface topography identified from a digital terrain model (DTM). The tunnel and ramp alignments and their coordinates will be used to determine distances between the blasting and the nearest sensitive receivers.

The modelling considers each 1 metre square section of the tunnel or ramp blast area and identifies the nearest and most sensitive property to this area. Based upon the separation distance, the permissible vibration criterion and the relationship between these parameters and explosive quantity, an allowable explosive quantity is calculated. The explosive weights are coloured according to their values, allowing the modelled results to display which sections of the works may be impacted by having to reduce explosive quantities, and therefore the length of advance or depth of blasting to achieve vibration compliance. The model is three dimensional and considers the depth of the vertical separation between the tunnel and the properties as well as the horizontal separation.

The modelling results show both the expected explosive quantities and the expected level of vibration that would be measured on the surface. The results are shown as a series of vibration contours. For those locations further from the tunnel alignment than identified by the vibration contour, the level of vibration is modelled to have reduced to below this value. In simple terms, for locations closer to the tunnel than say where the 5mm/s contour is shown, the maximum level of vibration that would be measured over the entire project is expected to exceed 5mm/s. For locations further than the 5mm/s contour, the level of vibration is modelled to be less than 5mm/s.

The vibration contours will show the maximum extent of vibration. When blasting in the western end of the tunnel, the level of vibration towards the east will be less than that shown by the contours. As blasting advances towards the east, the vibration levels for the eastern properties will increase and approach the levels identified by the contours values.

In determining the scale of blasting, the analyses will consider the use of a small diameter blasthole. The modelling will however be based upon explosive weights. Different configurations of blasthole diameter, explosive density and length of the blasthole should produce similar vibration results provided the explosive quantity loaded into hole is equal.

7.3. Blast Modelling of Explosive Quantities

The analyses will given as a set of drawings. The drawings will show the expected maximum explosive quantities for blasting in based upon compliance with either a 5mm/s or 10mm/s at the nearest residential properties. The scale of blasting and corresponding bench heights can be related to the predicted quantities in these drawings. The modelling results are shown for any extent of blasting within the tunnels and ramps blast area.

The drawings will also show the expected location of vibration contours for blasting with the modelled explosive quantities, which is the maximum quantity of explosive that is predicted to comply at the nearest sensitive receivers. The contours are shown for 2.5mm/s, 5mm/s, 7.5mm/s and 10mm/s vibration levels.

The modelling will indicate that the scale of blasting can be controlled to achieve compliance at the adjacent properties. In particular, the properties immediately above the tunnel or ramp alignment will affect the quantity of explosive that can be initiated. The quantity of explosive will be low and less than a few kilograms.

Blast patterns will be designed according to the modelled explosive quantities. The measured vibration results after each blast will be analysed and adjustments to subsequent designs will be determined according to the recorded values.

7.4. Results for Eastbound and Westbound Tunnels

The following comments relate to blasting for the mainline Eastbound and Westbound tunnels:

- Blasting for the initial western section near the portal for approximately 300 metres of the Eastbound tunnel and 500 metres of the Westbound tunnel will require low explosive quantities that are less than 1 kilogram. Should blasting occur in these sections, the shallow depth of the tunnel necessitates that small explosive quantities are used;
- The 1500 metre sections of the tunnel between approximately 500 metres from the western portal through to around 2000m metres from the portal can be blasted with explosive quantities between 1 and 2 kilograms. There are some small isolated sections where the tunnel passes beneath the rail line and green open space along Shaw Street where greater explosive quantities are expected to be possible;
- For the approximate 1000 metre sections of the tunnel east Kingsland Road where the tunnels pass beneath the treed hill area and the Bardwell Valley Golf course, the expected explosive quantities range between 4 to 5 kilograms with a few smaller sections requiring 2 to 3 kilograms;
- For the section of the tunnel east of the Bardwell Valley Golf Course, explosive quantities of around 5 kilograms can predominantly be used. The depth of cover between the tunnel alignment and the properties allow of the greater explosive quantities;
- For the sections of the tunnels that pass beneath the Kogarah Golf Course, Cahill Park, Alexandria Canal and the Tempe Recreation Reserve, similar explosive weights of around 5 kilograms are expected as a result of both the depth of cover and the fewer properties above the alignment;
- For the 1800 metre section of the tunnels between the Tempe Recreation Reserve and Mary Street the properties along the Princess Highway restrict the explosive quantity.

The explosive quantities and vibration impacts will be confirmed once the initial data have been collected and analysed as per the standard trial blast procedures.

7.5. Results for Arncliffe Cavern

Blasting activities associated with the Arncliffe cavern are modelled as not being impacted by the vibration criteria and the associated properties. The depth of the tunnel and the Kogarah Golf course is expected to allow explosive 5 kilograms.

7.6. Results for the Westbound On Ramps and Eastbound Off Ramp

The following comments relate to blasting for the ramps. The proximity of the properties and the shallow depth of the ramps restrict the quantity of explosive that can be used. From the eastern most section of the ramp:

- Blasting for the initial 170 metre section will require the use of less than 1 kilogram;
- Blasting for the following 180 metre section allows the use of marginally elevated weights between 1 and 2 kilograms;
- Blasting for the next 240 metre section is modelled to allow explosive quantities up to 3 kilograms;
- Blasting for the remaining 350 metre section where it joins to the mainline tunnels allow explosive quantities varying from 3 kilograms up to the 5 kilograms.

8. CONTINGENCIES

The modelled results have assessed the levels of vibration from the blasting that will comply with the proposed 10mm/s criteria. In the event that the trial blast programme indicates that the modelling has underestimated the level of vibration, several mitigation procedures are available and could include:

- limiting the quantity of explosive by further reducing the length of the blasthole or the length of the explosive column;

- introducing additional explosive columns within the blasthole (ie decking);
- reducing the blasthole diameter;
- alternative explosive types, including both low density products and cartridge explosives.

9. CONDITION SURVEYS

Based on experience from other projects that supportable claims for damage from vibration induced by the construction activities are uncommon, unless the activity is very near to a property and the corresponding vibration is of a level that is intolerable to persons within the property, the onset of complaints about vibration damage is generally better aligned with the degree of perception. Table 9 shows the human perception as a function of vibration levels, as given in the International literature.

Vibration Range		Effect
Lower	Upper	
0 mm/s	0.5 mm/s	<i>Imperceptible</i>
0.5 mm/s	1.0 mm/s	<i>Barely Noticeable</i>
1.0 mm/s	5.0 mm/s	<i>Easily Noticeable</i>
5.0 mm/s	10.0 mm/s	<i>Distinctly Noticeable</i>
>10mm/s		<i>Strongly Noticeable</i>

Table 9 - Effect of vibration from blasting activities

It is therefore proposed to undertake condition surveys for properties where the expected effect ranges above “easily noticeable”, or approximately 2.5mm/s as the midpoint of “easily perceptible” range. The 2.5mm/s contour of vibration will be shown on each of the modelled drawings.

10. ENVIRONMENTAL MITIGATION MEASURES

Environmental mitigation measures will be incorporated into each blast to minimise the impact of the following effects of vibration and include:

- Ensuring the planned blast area has been properly analysed to determine scale of blasting required;
- Ensuring only exact quantity of explosives is used for each hole;
- Condition surveys for adjacent structures whose risk assessment has highlighted that vibration from blasting may cause complaints, or where the owner has expressed concern in relation to the possibility of damage, will be undertaken;
- Placing vibration monitors at strategic locations to record and confirm that vibrations being imposed are at or below design limits.

11. BLASTING CONTROL MEASURES

The following instructions will be undertaken prior to the commencement of blasting. Whilst the blasting contractor will have procedures documenting the blasting steps, the following blast control measures are identified as key measures in completing blasting in an environmentally sensitive area.

11.1. Pre-Blast Activities

Prior to undertaking drilling and blasting, the following actions will be completed:

- Provide reasonable notice of intended blasting and the anticipated impacts on the nearby properties, occupants of these premises, authorities, affected public utilities owners and any service agencies that could be impacted by road control measures at the time of blasting;
- Blasting notification to the NSW WorkCover covering the jurisdiction of the proposed blasting activities for the intended period of blasting;
- A condition survey report of adjacent infrastructure, including an assessment of any increased susceptibility of the infrastructure to vibration related effects;
- Preliminary review assessing the expected maximum explosive quantities for control of vibration.

11.2. Blasting Notification

A blast notification form will be completed prior to undertaking blasting activities and submitted to the New South Wales WorkCover.

11.3. Community Consultation

Community Consultation will be undertaken as described in the Community Communication Strategy (Appendix B).

11.4. Preparation of Drilling Area

The area where blasting will be undertaken will be prepared to a condition to enable accurate drilling. Areas for drilling, particularly the drilling defining the perimeter of the tunnel will be surveyed in advance of the works.

11.5. Design and Layout of Blastholes

Drilling of blastholes will be completed using well maintained, hydraulic drill equipment supplied and operated by the drill and blast contractor. Key issues include:

- The drilling crew will establish a drilling pattern, including blasthole depths, and record the information on a blast pattern design worksheet;
- The quantity of explosive which will be loaded into each blasthole will be identified and clearly marked on the plan;
- The total quantity of explosive for each blast will be calculated and reconciled against the designed quantity;
- The blasthole burden and spacing will be measured as accurately as possible;
- The location of the perimeter blastholes will be determined by survey control.

The nearest distance to the closest property, or other sensitive receiver or infrastructure, will be used to calculate the expected level of vibration. An initial assessment of these data will be provided as part of the Blast Management Strategy Plan and will be attached in Appendix A.

11.6. Tunnel Wall Control

Protection of the walls of the tunnels may be improved through pre-splitting the perimeter of the excavation or the use of closely spaced blastholes with adjusted explosive loading. Closely spaced, possibly slightly angled small diameter holes with a centre to centre spacing of around 500mm to 1000mm will be drilled along the wall of the tunnel before the main production blast is initiated. The drill holes will be accurately set up in terms of their alignment to minimise drilling error over depth. Variation between the intended and actual location at the toe of the hole is expected to be less than several hundred mm.

The blastholes will be loaded with small diameter cartridge explosive or low density bulk emulsions and initiated prior to any production blasting.

11.7. Blasthole Drilling

Blasthole drilling will only be completed once the area has been cleared to establish a reasonable platform to ensure that blastholes can be accurately drilled, both in terms of their inclination as well as the depth. Careful placement of drill holes to ensure the tunnel profile is achieved is critical to the design.

On the completion of each blasthole, or group of blastholes, the driller will measure and confirm the depth of the hole and, if it is within tolerance, plug the collar of the hole. Variation in the depth, re-drilled holes or other amendments will be marked on the drilling loading sheet.

11.8. Transport and Storage of Explosives

Transport and storage requirements for blasting activities will be defined by the drill and blast contractor and in accordance with the NSW Explosives Act 2003 and the NSW Explosives Regulation 2013.

Explosives will be stored off site under the appropriate authority license and delivered to site as required. No explosive will be stored on site. The quantity of explosive and detonators will be transported on the day of the blast from the magazines in approved vehicles. Any unused explosive will be returned to the magazine at the completion of loading.

11.9. Priming and Loading of the Blasthole

The following key issues will be included as part of the blasthole priming and loading methods:

- Prior to priming a blasthole, the shotfirer will confirm the depth of the blasthole is consistent with the depth indicated on the blasting plan depth. The measured depth will be recorded on the blasthole loading plan;
- If a short hole is encountered, the shotfirer will ensure the depth is adequate to eliminate the possibility of flyrock that could damage services within the tunnel, or otherwise the blasthole will not be loaded;
- If any blastholes are loaded with loose poured ANFO, the quantity of explosive will be carefully measured and not estimated by pouring from a bag;
- Where blastholes are loaded with cartridge product, the diameter, length and number of cartridges will be recorded;
- Where the blastholes are loaded with bulk emulsion, the quantity of explosive will be carefully controlled and monitored to be consistent with the modelled quantities;
- Any overloaded blastholes will be not be blasted, but will have the explosive removed or in the case of ANFO, flushed with water;
- The quantity of explosive loaded into each blasthole, or deck, will be reported on the blast loading plan;
- The total quantity of explosive loaded into the blast will be reconciled against the quantity indicated on the submitted blast plan. Where the quantities differ, a comment for the variation will be included on the blast loading plan and confirmed as acceptable prior to initiating the blast.

11.10. Stemming of Blastholes

The stemming of blastholes will be undertaken with care. The bridging of stemming in a blasthole will result in stemming material ejecting, producing overpressure, flyrock and poor fragmentation. In addition:

- The stemming material will be imported to site and consist of a graded crushed aggregate with a diameter of around 10mm;
- The stemming length, and if required the length between individual decks of explosive, will be measured and written onto the blast loading sheet;
- All blastholes will be stemmed before the surface tie up commences.

11.11. Initiation

Blasting, including the loading, stemming and sequencing of blastholes will be completed in accordance with all appropriate NSW legislation. Key issues include:

- The shotfirer will determine the tie up;

- The blast pattern will indicate the proposed tie up sequence, clearly identifying the different delay elements that will be used. This will be used to confirm the explosive quantity will comply with accepted vibration level at the nearest potentially sensitive receiver;
- A timing sequence will be shown and calculate the maximum instantaneous explosive quantity. This quantity of explosive (MIC) will be clearly identified on the loading plan;
- When the total shot has been tied in, all connections will be checked.

11.12. Additional Protection

Blasting near potentially sensitive equipment within the tunnel, or at the tunnel portal or shafts where there maybe possible flyrock, and to ensure that blasted material is not projected beyond the project boundaries or safe working areas, additional safety measures may be incorporated into the design. These will include one or more the following options:

- Placement of fill material (sand or similar), referred to as false overburden, on top of the blast area;
- Use of rubber matting placed to ensure no material can be ejected from the blast area;
- An increased uncharged stemming length (beyond the recommendations of the Australian Standard AS2187.2) will be incorporated into the design.

11.13. Firing

Firing of the blast will be under the control of the shotfirer. The following key issues will be confirmed:

- The community team have informed the potentially affected persons of the intent to blast;
- The area will be inspected to ensure all personnel are a safe distance from the blasting activities;
- CDS will place all control points to block access to the tunnel, including internal access other than ramps, at a safe distance from the blast area. The safe distance will be determined through standard risk assessment procedures;
- Prior to the blast, a siren of sufficient loudness will be sounded to alert all adjacent personnel of the immediate intention to blast.

11.14. Misfires

Should there be a cut-off (severing of the leads to the detonators, either surface or in-hole) during the blast, compliance with the NSW Explosives Act (2003) will be followed. The following checks for cut-offs will be implemented:

- After the blast is fired and the tunnel area has been adequately ventilated, the shotfirer will visually inspect entire shot for evidence of misfires.
- If found, the shotfirer will notify the CDS immediately along with the blast guards;
- The shotfirer will decide if it is safe to re-fire shot;
- The same method of initiation will be used.

If a misfire (unexploded explosive) is detected during excavation:

- Stay well clear;
- Warn all personnel in the area;
- The project area supervisor will notify the shotfirer immediately;
- A detailed and safe excavation plan will be formulated and implemented.

11.15. Reconciliations and Reporting

Prior to firing each blast, CDS will have in their possession the following documents:

- A pre-blast sheet confirming that the expected level of vibration at each of the nearest sensitive receivers complies with the vibration limits;
- A completed drilling sheet prepared by the shotfirer showing the measured depth of each blasthole. The sheet will identify and clearly mark any “*anomalous*” blastholes;
- A blast loading plan showing the depth of each blasthole, quantity of explosive in each blasthole and the uncharged stemming length. The initiation sequence will also be shown. Reconciled explosive quantities used versus the designed quantity will also be shown and any variations accounted for;
- A signed blast summary sheet showing that each of these forms been received and no variations between the intended and implemented design exist.

These requests are in accordance with the specifications listed in the Australian Standards AS2187.2 document.

12. TUNNEL CLEARANCE PROCEDURES

Safety of personnel within the tunnel and any adjacent work areas will be ensured through documented clearance procedures. Procedures will be completed for both the main production blasting and any secondary or smaller scale blasting that may be required.

12.1. Production Blasting Evacuation Procedure

All tunnel personnel will be evacuated to a safe working area prior to blasting within the tunnel. Safe working areas will be determined by the shotfirer and will comply with CDS risk management procedures. The safe areas for the main production blasting will be located outside of the tunnel portal at a distance determined by the shotfirer. It may be possible that at a safe work area for the smaller secondary blast to fragment oversize rock maybe within the tunnel, although at a safe distance from the blast. These areas will contain a permanent source of fresh air and maintain positive means of egress in the event of an emergency. These locations are to be risk assessed individually and comply with WorkCover NSW Work Health and Safety requirements.

Personnel evacuation and tunnel clearance will be controlled by CDS under the direction of the shotfirer. A tag on-tag off board will be the primary means of personnel accountability. All CDS personnel, sub-contractors and visitors will use of a tag board as part of the site specific tunnel induction for personnel entering the tunnel area of works.

Blast sentries will be positioned at entrances to the tunnel portal. These guards, under the supervision of the shot firer, will conduct a final tunnel clearance prior to initiation. Upon confirmation to the shotfirer and senior tunnel supervisors that all personnel are evacuated from the tunnel the direction to commence firing procedures will be given. Initiation of the blast will be conducted by the shot firer only when they are satisfied that it is safe to commence firing. The shot firer will have full discretion to terminate the blast sequence at any time if it is determined unsafe to proceed.

Following the blast, tunnel ventilation will allow blast fumes to clear. This complies with the NSW “*Tunnels Under Construction Code of Practice 2006*” air quality and ventilation systems guidelines. When it is determined safe, the shot firer will inspect the blast location and determine correct detonation. Upon confirmation that the tunnel is safe to enter the all clear will be given by the shot firer and personnel allowed to re-enter the tunnel.

If it is deemed unsafe to enter the tunnel the shot firer will make the area safe and determine actions required to neutralise and make safe the blast area before allowing personnel entry to the tunnel environment.

13. MONITORING OF BLASTING ACTIVITIES

The vibration monitoring system will consist of a series of individual monitors which will be positioned at key locations around the blast. Each vibration monitor will have a minimum of three recording channels. An external geophone (transducer) will monitor ground vibration in three directions

(transverse, vertical and longitudinal particle velocities) and report the level in mm/s. For any blasting at the tunnel portals, an external microphone will also measure the level of overpressure, reporting the data in units of dBL. The monitors will be configured with a vibration threshold trigger to record blast events which exceed a minimum value, typically around 0.3mm/s. The recording duration will be set to exceed the duration of the blast.

Monitoring locations for blasting will be identified prior to each blast. The proposed blast monitoring sites will include:

- Nearest four residential properties, generally a property towards the north, south, east and west of the blast zone;
- Any heritage property that is within 150 hundred metres of the blast area;
- Commercial property that contains potentially sensitive equipment, such as electronic or scientific apparatus or other equipment with tight tolerances for vibration impacts.

In the event that additional monitoring sites are required, these will be confirmed by the community relations team.

Blast monitoring will be undertaken in accordance with Australian Standard AS2187.2 recommendations.

Blast data will be made available after each blast for analysis, comment and close out. Blast monitoring results will be summarised in a monthly reports. The monthly report will contain details of blast monitoring including the following information:

- Locations of the monitoring positions;
- The type, serial numbers and calibration details of the monitoring equipment used;
- Blast monitoring results;
- Date and time when testing was performed.

Principal: Heilig & Partners Pty Ltd
RPEQ 6304

14. APPENDIX A – EXPLOSIVE WEIGHT ANALYSES



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- Vibration Levels**
- Expected 10 mm/s Vibration Contour
 - Expected 7.5 mm/s Vibration Contour
 - Expected 5 mm/s Vibration Contour
 - Expected 2.5 mm/s Vibration Contour

- Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 1 of 8



Plate No. A

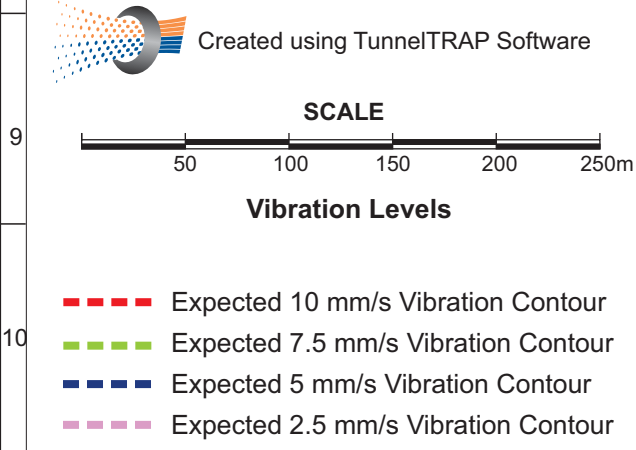
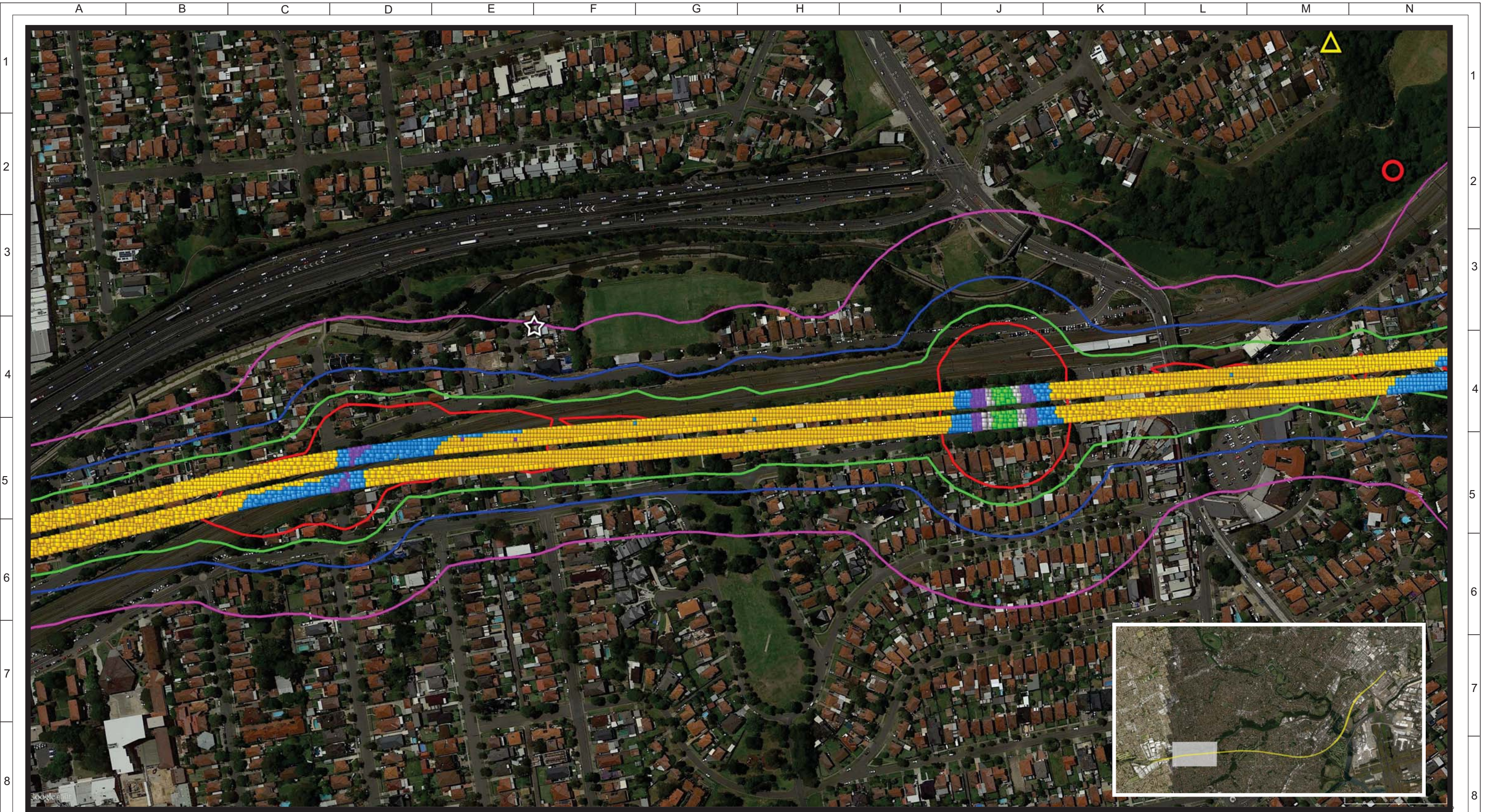
Revision History
V1: Original

Date Drawn: **19 February 2016**

Ref No: **M5 Stage 2 Main 5mms**

Job No: **HP1511-3**

In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.



- ☆ Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - △ Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 2 of 8



Plate No. B

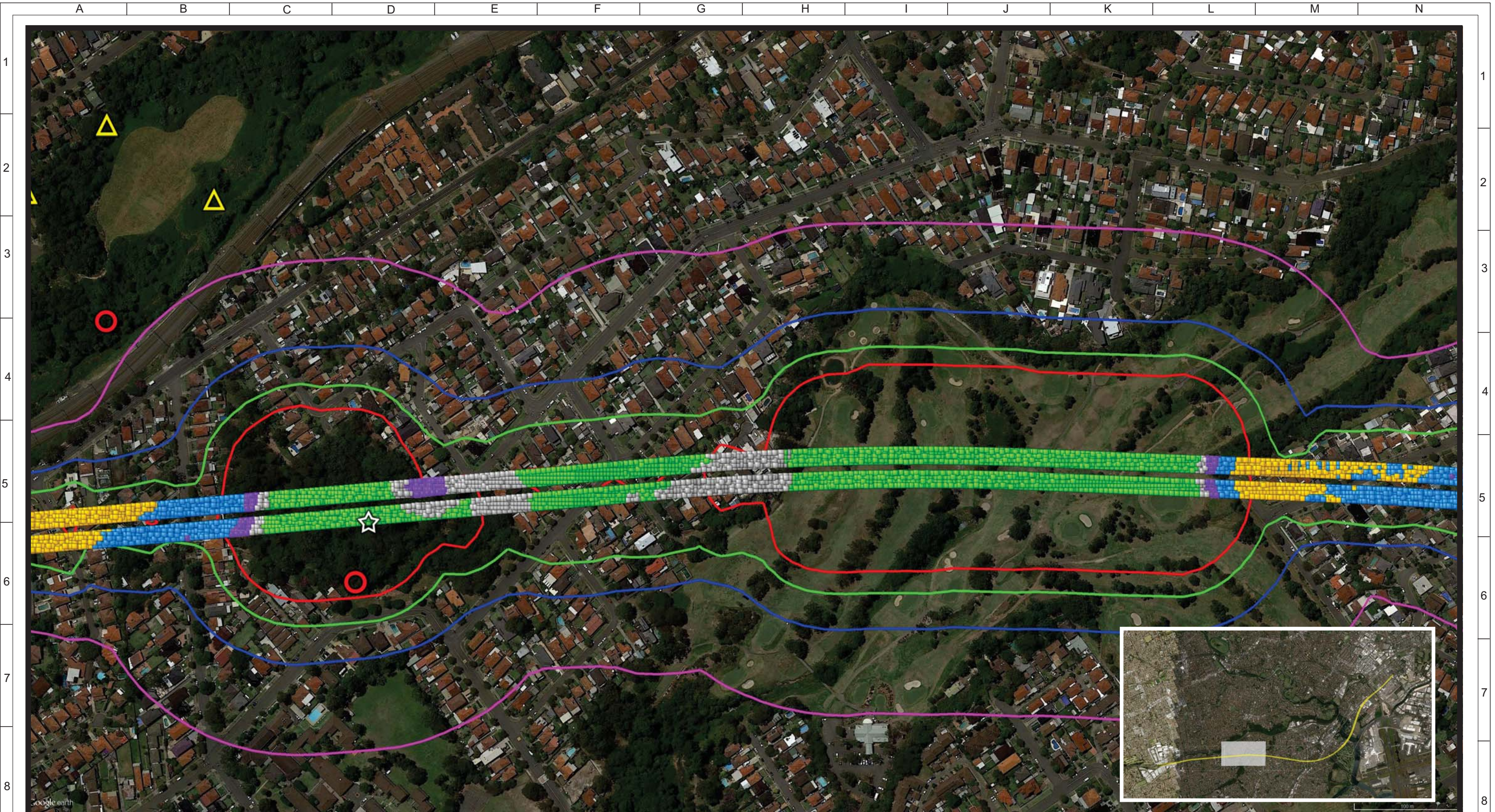
Revision History
V1: Original

Date Drawn: **19 February 2016**

Ref No: **M5 Stage 2 Main 5mms**

Job No: **HP1511-3**

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Created using TunnelTRAP Software

SCALE

50 100 150 200 250m

Vibration Levels

- Expected 10 mm/s Vibration Contour
- Expected 7.5 mm/s Vibration Contour
- Expected 5 mm/s Vibration Contour
- Expected 2.5 mm/s Vibration Contour

- ☆ Non-Aboriginal Heritage
- Potential Aboriginal Heritage
- △ Aboriginal Heritage

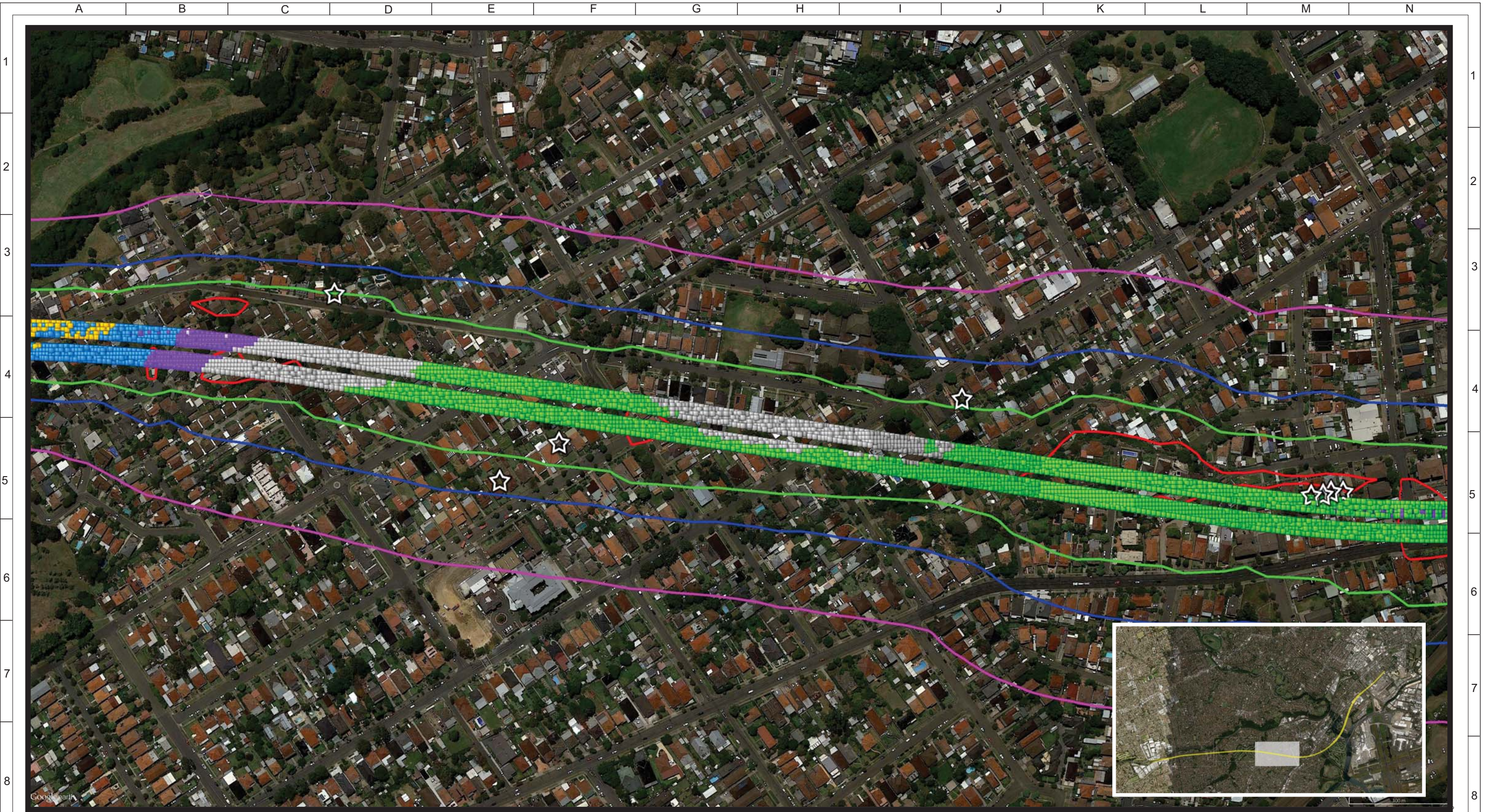
Explosive Quantities

- More than 5 kilograms
- Between 4 and 5 kilograms
- Between 3 and 4 kilograms
- Between 2 and 3 kilograms
- Between 1 and 2 kilograms
- Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 3 of 8

<p>HEILIG & PARTNERS Engineered Excellence</p>		Plate No. C	Date Drawn: 19 February 2016
		Revision History V1: Original	Ref No: M5 Stage 2 Main 5mms
		Job No: HP1511-3	

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Created using TunnelTRAP Software

SCALE

0 50 100 150 200 250m

Vibration Levels

- Expected 10 mm/s Vibration Contour
- Expected 7.5 mm/s Vibration Contour
- Expected 5 mm/s Vibration Contour
- Expected 2.5 mm/s Vibration Contour

- ☆ Non-Aboriginal Heritage
- ⊙ Potential Aboriginal Heritage
- ▲ Aboriginal Heritage

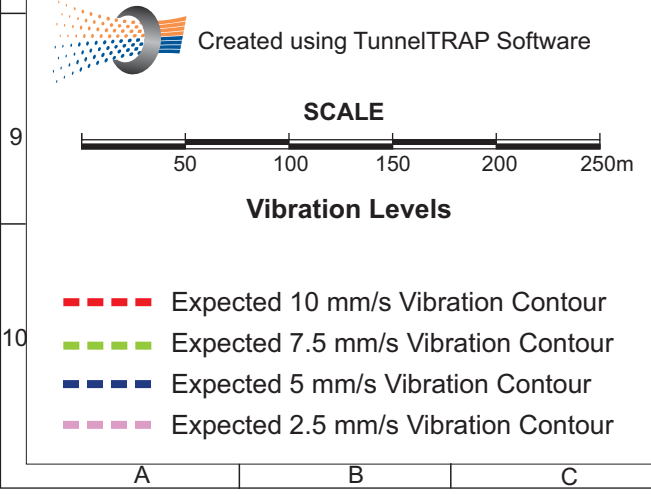
Explosive Quantities

- More than 5 kilograms
- Between 4 and 5 kilograms
- Between 3 and 4 kilograms
- Between 2 and 3 kilograms
- Between 1 and 2 kilograms
- Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 4 of 8

		Plate No. D	Date Drawn: 19 February 2016
		Revision History V1: Original	Ref No: M5 Stage 2 Main 5mms
		Job No: HP1511-3	

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- ☆ Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - ▲ Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 5 of 8



Plate No. E

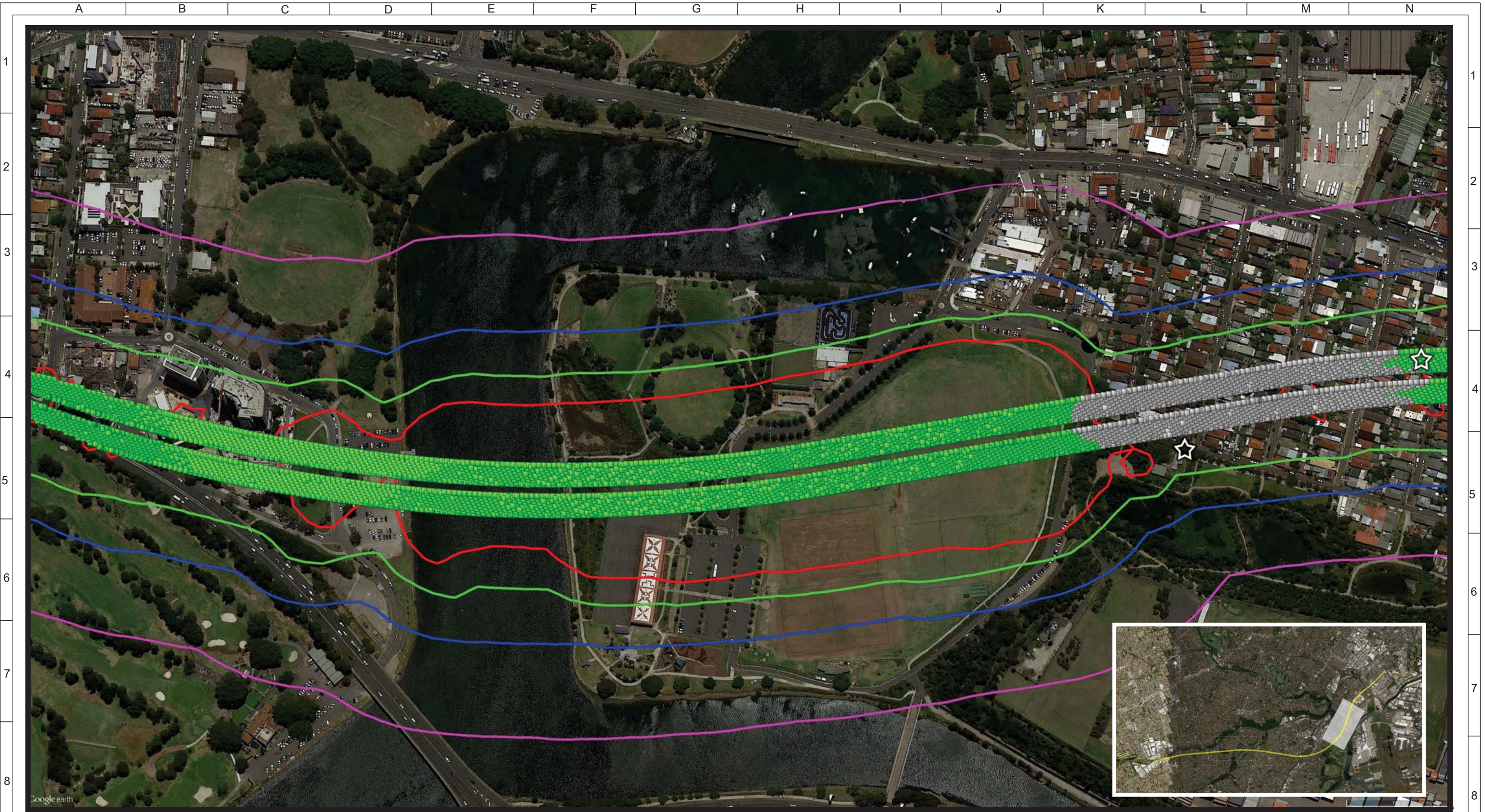
Revision History
V1: Original

Date Drawn: **19 February 2016**

Ref No: **M5 Stage 2 Main 5mms**

Job No: **HP1511-3**

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- Vibration Levels**
- Expected 10 mm/s Vibration Contour
 - Expected 7.5 mm/s Vibration Contour
 - Expected 5 mm/s Vibration Contour
 - Expected 2.5 mm/s Vibration Contour

- Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 6 of 8



Plate No. F

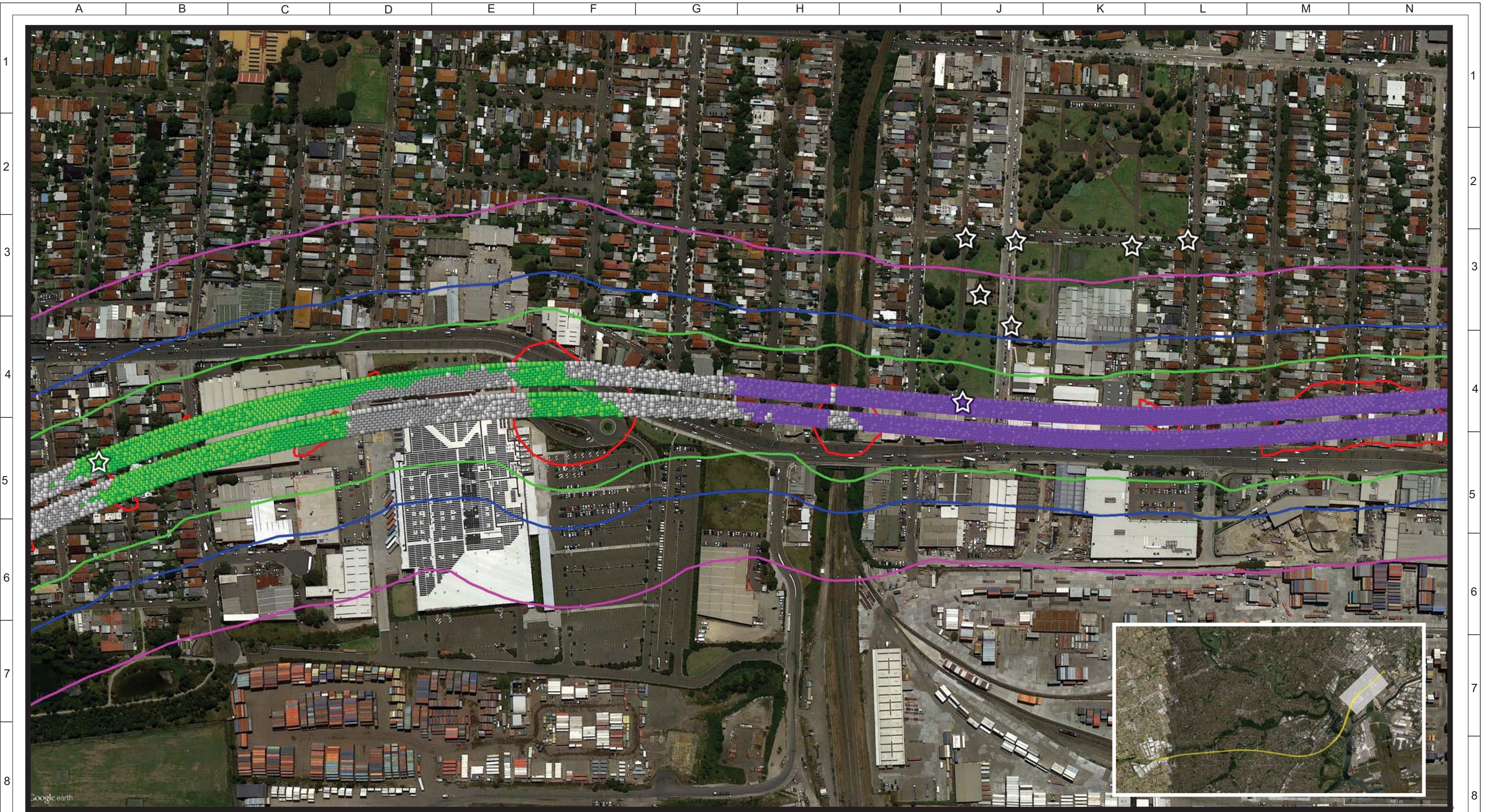
Revision History
V1: Original

Date Drawn: **19 February 2016**

Ref No: **M5 Stage 2 Main 5mms**

Job No: **HP1511-3**

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- ☆ Non-Aboriginal Heritage
- Potential Aboriginal Heritage
- ▲ Aboriginal Heritage



- Vibration Levels**
- Expected 10 mm/s Vibration Contour
 - Expected 7.5 mm/s Vibration Contour
 - Expected 5 mm/s Vibration Contour
 - Expected 2.5 mm/s Vibration Contour

- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 7 of 8



Plate No. G

Revision History
V1: Original

Date Drawn: **19 February 2016**

Ref No: **M5 Stage 2 Main 5mms**

Job No: **HP1511-3**

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- ☆ Non-Aboriginal Heritage
- Potential Aboriginal Heritage
- ▲ Aboriginal Heritage

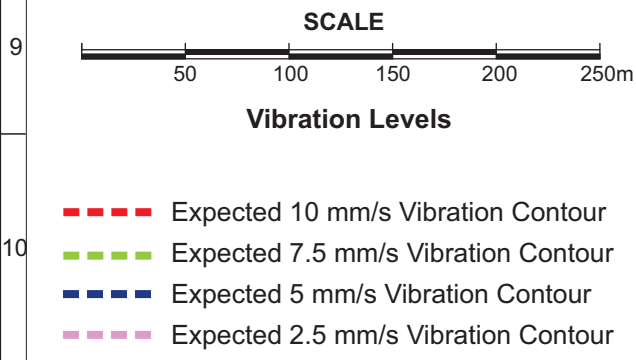
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

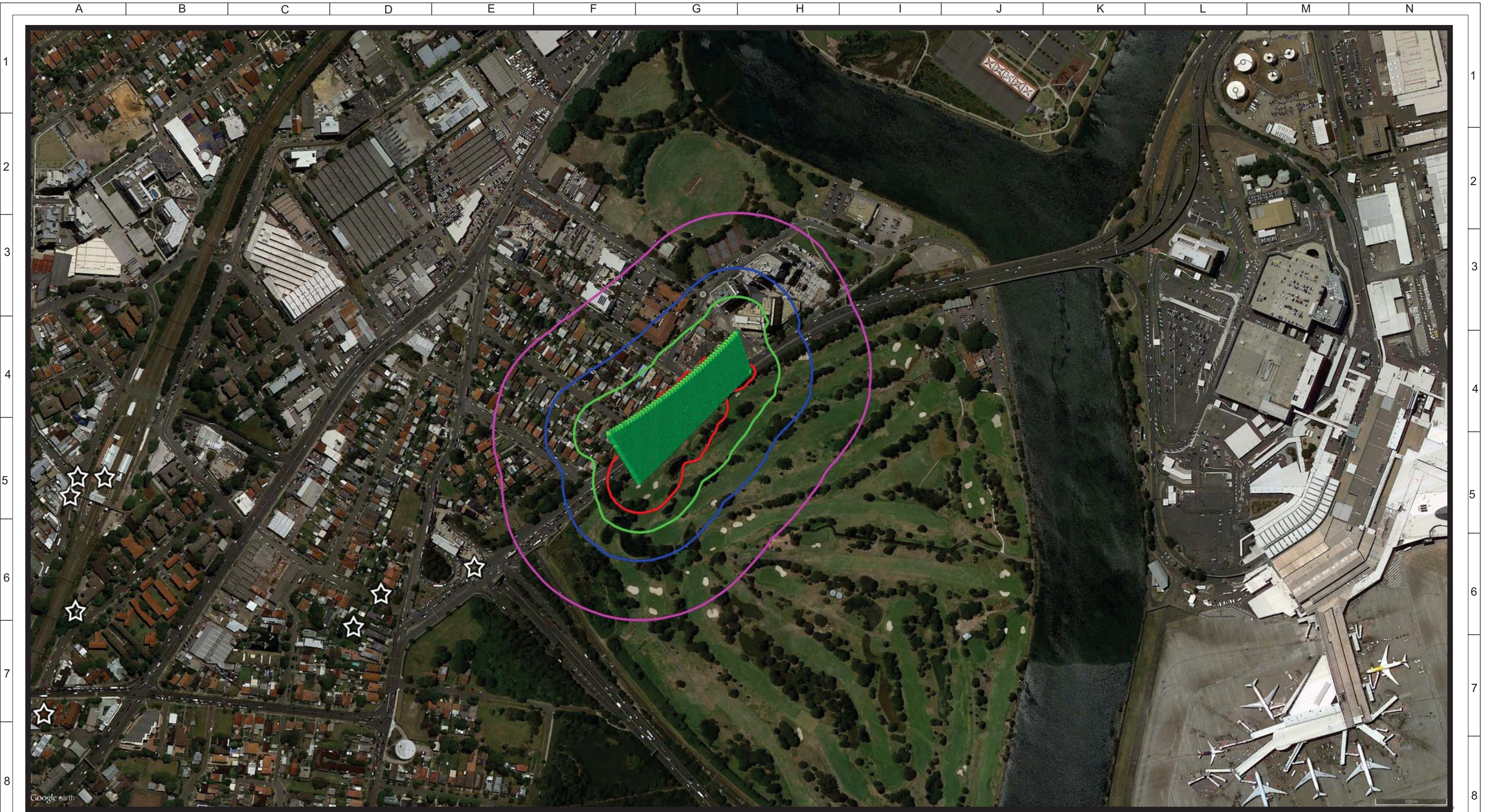
Project Description: WESTCONNEX STAGE 2 - TUNNELS - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties Sheet 8 of 8



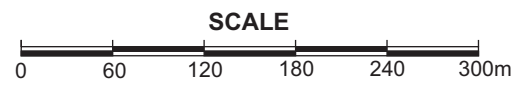
Plate No. H	Date Drawn: 19 February 2016
Revision History V1: Original	Ref No: M5 Stage 2 Main 5mms
	Job No: HP1511-3

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- Vibration Levels**
- Expected 10 mm/s Vibration Contour
 - Expected 7.5 mm/s Vibration Contour
 - Expected 5 mm/s Vibration Contour
 - Expected 2.5 mm/s Vibration Contour

- Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - BOX - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties

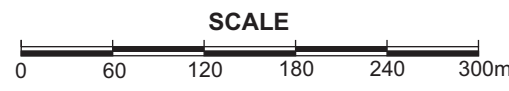


Plate No. 1	Date Drawn: 19 February 2016
Revision History V1: Original	Ref No: M5 Stage 2 Main 5mms
	Job No: HP1511-3

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- Vibration Levels**
- Expected 10 mm/s Vibration Contour
 - Expected 7.5 mm/s Vibration Contour
 - Expected 5 mm/s Vibration Contour
 - Expected 2.5 mm/s Vibration Contour

- Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - WESTBOUND OFFRAMP - Modelled maximum explosive weights and vibration contours based on compliance with 10mm/s vibration criterion at adjacent properties

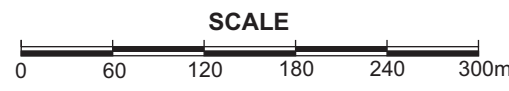


Plate No. J	Date Drawn: 19 February 2016
Revision History V1: Original	Ref No: M5 Stage 2 Main 5mms
	Job No: HP1511-3

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- Vibration Levels**
- Expected 10 mm/s Vibration Contour
 - Expected 7.5 mm/s Vibration Contour
 - Expected 5 mm/s Vibration Contour
 - Expected 2.5 mm/s Vibration Contour

- Non-Aboriginal Heritage
 - Potential Aboriginal Heritage
 - Aboriginal Heritage
- Explosive Quantities**
- More than 5 kilograms
 - Between 4 and 5 kilograms
 - Between 3 and 4 kilograms
 - Between 2 and 3 kilograms
 - Between 1 and 2 kilograms
 - Less than 1 kilogram

Project Description: WESTCONNEX STAGE 2 - EASTBOUND ONRAMP - Modelled maximum explosive weights and vibration contours base on compliance with 10mm/s vibration criterion at adjacent properties



Plate No. K	Date Drawn: 19 February 2016
Revision History V1: Original	Ref No: M5 Stage 2 Main 5mms
	Job No: HP1511-3

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