Temporary Noise Barrier Strategy – Arncliffe

Project Name: WestConnex New M5

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Document Approval

Rev.	Date	Prepared by	Reviewed by	Recommended by	Approved by	Remarks
00	30/08/16	CDS-JV				
01	19/09/16	CDS-JV				
02	7/11/16	CDS-JV				
03	27/06/17	CDS-JV				
04	19/07/17	CDS-JV				
Signature:						

Details of Revision Amendments

Document Control

The Project Director is responsible for ensuring that this Strategy is reviewed and approved. The Engineering and Design Director is responsible for updating this Strategy 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	Update for consistency with approved TNBS and update to Appendix A
02	Update to address design changes and address DP&E comments
03	Update to include additional noise barrier on Marsh Street
04	Update to include WCX M5 AT and RMS comments. For DP&E approval.

Contents

1. Introduction

1.1. Project Description

WestConnex is one of the NSW Government's key infrastructure projects which aims to ease congestion, create jobs and connect communities. It is the largest integrated transport and urban revitalisation project in Australia.

The 33 kilometre project was a key recommendation of the State Infrastructure Strategy released in October 2012. It brings together a number of important road projects which together form a vital link in Sydney's Orbital Network. They include a widening of the M4 east of Parramatta, a duplication of the M5 East and new sections of motorway to provide a connection between the two key corridors.

Figure 1: WestConnex Project Map

WestConnex will support Sydney's long term growth and boost the city's economic productivity. It will:

- Provide quicker, more reliable trips between Western Sydney and the Port Botany/Sydney Airport precinct to support Sydney's urban freight task
- Help distribute traffic across the wider road network, removing bottlenecks and relieving congestion for local trips
- Provide better connections along the M4 and M5 corridors to cater for the forecast growth in employment and population along these routes
- Allow urban revitalisation and increase opportunities for active and public transport along and across Parramatta Road.

The WestConnex project includes a number of stages:

- Stage 1a – M4 Widening
- Stage 1b – M4 East

- Stage 2 – New M5
- Stage 3 – M4-M5 Link

In November 2015, the Sydney Motorway Corporation (SMC) awarded the CPB Contractors Dragados Samsung Joint Venture (CDS-JV) the contract for the design and construction of Stage 2 – New M5. The New M5 will run from the existing M5 East corridor at Beverly Hills via a 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 which are higher, wider and flatter. These 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.

Stage 2 of WestConnex is being accelerated following an historic funding agreement signed by the Australian and New South Wales Governments in May 2014.

This has allowed work to start on the M5 - King Georges Road Interchange upgrade.

The duplication of the M5 East corridor will improve travel times and reliability for the 100,000 motorists which use this key route every day.

It will allow for improved movement of freight to and from the Port Botany area and provide an express route between Western Sydney and Sydney Airport once WestConnex is completed.

1.2. Purpose of this Plan

The CDS-JV has prepared this Temporary Noise Barrier Strategy – Arncliffe (TNBS) in accordance with the Conditions of Approval (CoA), in particular condition D20.

The TNBS for Arncliffe takes into account works which influence possible noise barriers incorporating the Arncliffe construction compound (C7). The TNBS details the strategy that CDS-JV will employ to mitigate and manage construction and traffic noise.

1.3. Scope of this Document and Compliance with D20

This document provides the structure and details of the TNBS required for the project as prescribed in CoA D20. This strategy focuses on the Arncliffe C7 construction compound. This TNBS-ARN forms part of the project-wide TNBS as detailed in the New M5 Staging Report.

Table 1 shows where compliance with CoA D20 is addressed within this document.

Table 1: Compliance with D20

D20 Requirements	Compliance
The Proponent must develop and implement a **Temporary Noise Barrier Strategy** which includes:	
a) identification and confirmation of all temporary noise barriers including -	**Appendix A** - Construction Noise and Vibration Temporary Noise Barrier Acoustic Report (Arncliffe compound), identifies all temporary noise barriers required for the Arncliffe C7 construction compound
(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),	**Section 1.3** - See Temporary Noise Barrier Strategy – Kingsgrove M5N-CN-PLN-WSW-001, CoA D20 (a) (i) is not addressed within this TNBS
(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),	**Section 1.3** - See Temporary Noise Barrier Strategy – Kingsgrove M5N-CN-PLN-WSW-001, CoA D20 (a) (ii) is not addressed within this TNBS
(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),	**Section 1.3** - See Temporary Noise Barrier Strategy – Campbell Street and Road M5N-ES-PLN-LRW-0006 and the D20 Local Roads Report - Euston Road and C12 M5N-ES-PLN-LRW-0009. CoA D20 (a) (iii) is not addressed within this TNBS
(iv) temporary noise barriers around construction compounds;	**Section 2** - This TNBS defines noise barriers for construction compound C7. Separate TNBS have been developed for other construction compounds.
b) the consultation and decision-making process for all temporary noise barriers; and	**Section 3** - Details of the consultation process including how highly affected residents and stakeholders were consulted. The decision making process, which includes key stakeholder feedback prior to adopting the final design, is included in Section 3.4
c) an acoustic report detailing the final barrier heights, material analysis and predicted benefits.	**Appendix A** - Construction Noise and Vibration: Temporary Noise Barrier Acoustic Report (Arncliffe compound), identifies barrier heights, required construction material and predicted acoustic rating of construction.
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.	**Section 3** - Details key stakeholder feedback received through one on one briefings and how feedback trends have been incorporated into final designs. **Appendix B** – Lists the Community Consultation Records

D20 Requirements	Compliance
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.	Revision 2 of this TNBS was approved by the Secretary on 20 January 2017. Revision 4 addresses an additional noise barrier to be installed along Marsh Street, for mitigation of noise generated during construction of the permanent shaft. Noise impacts associated with excavation of the permanent shaft were not assessed as part of the EIS and mitigation for these impacts was therefore not considered in Revision 2 of this TNBS. Additional construction stages (V06-V08, refer Section 2.4) are therefore addressed in this update.

2. Temporary Noise Barrier Strategy

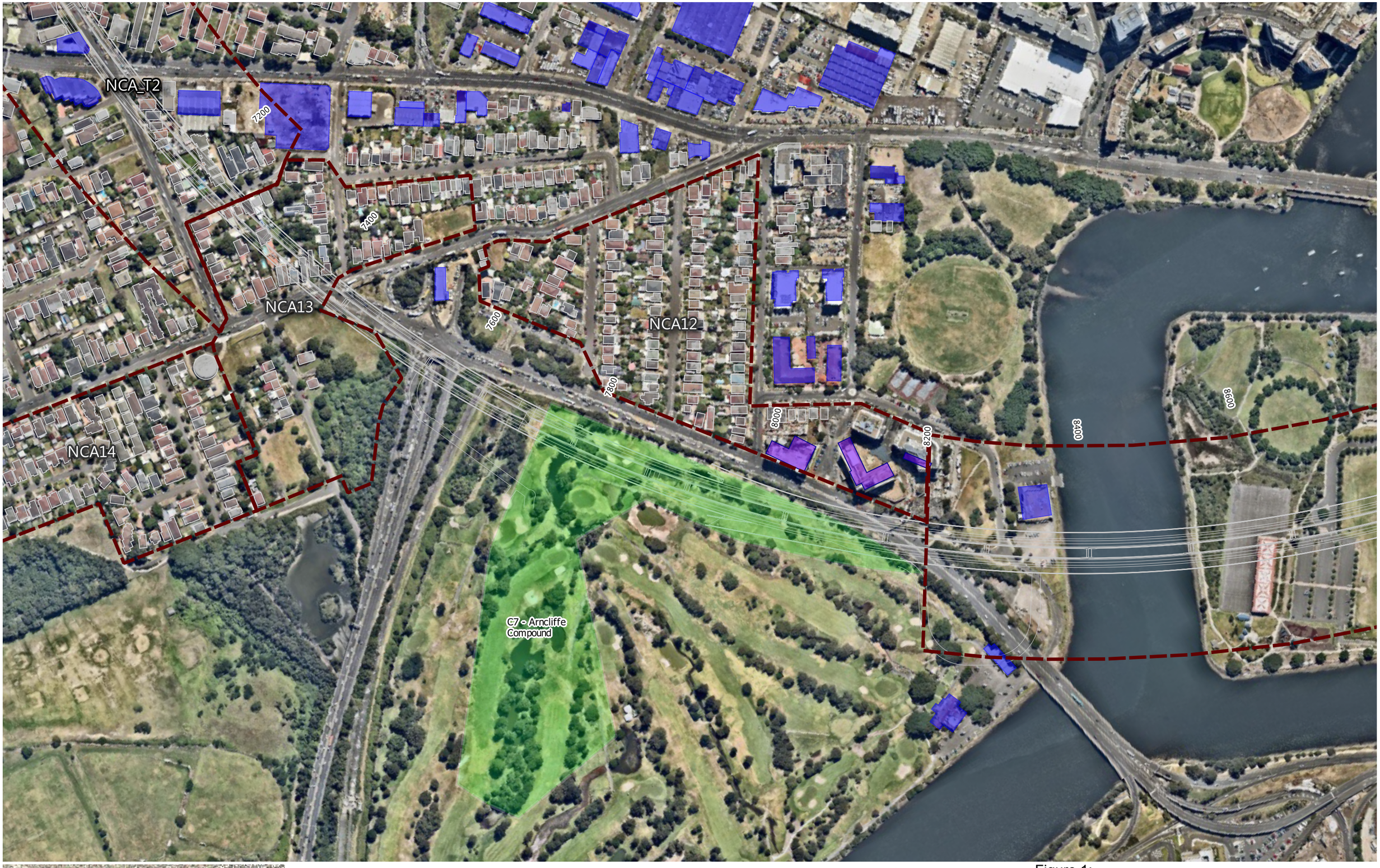
2.1. Temporary Barrier Overview

The overall approach of the TNBS is to ensure that reasonable and feasible temporary noise barrier solutions are developed and implemented in accordance with the CoA whilst specifically consulting with stakeholders and highly affected residents to address their concerns. An overarching approach during construction will target the installation of temporary noise barriers identified in Appendix A, prior to construction, where feasible and reasonable.

Revision 4 of this TNBS takes into account additional noise impacts identified to occur during excavation of the permanent shafts in the C7 construction compound. These impacts were not addressed in the EIS and mitigation for these impacts was therefore not considered in the previous revisions of this Strategy. The additional excavation works are identified in Section 2.4 below.

2.2. Identify Sensitive Receivers

A key component of the TNBS is to identify sensitive receivers based on the proposed construction footprint. Sensitive receivers are detailed in the Construction Noise and Vibration: Temporary Noise Barrier Report (Arncliffe compound). Refer to Appendix B of the Construction Noise and Vibration Management Plan for mapping of sensitive receivers across the project. Sensitive receivers are reviewed considering CoA D20 and specifically identified for consultation, especially residents directly adjacent to proposed temporary noise barriers. Refer to Appendix B for the identified sensitive receivers to the Arncliffe Tunnel Support works. Sensitive receivers are identified in Figure 1.



Building Type

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

50 0 50 100 m

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.

Figure 1:
Noise catchment areas & Sensitive Receivers

RENZO TONIN & ASSOCIATES
inspired to achieve
1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Created by: THW
Figure No: TH014-05 6 0 1 005 (r2)
Date: 04.08.2016
Scale: 1:4,000@ A3

2.3. Noise Objectives

Construction noise management levels have been developed using NSW Interim Construction Noise Guideline (ICNG), in accordance with CoA D16(a). Objectives have been set in the form of Construction Noise Management Levels and Road Traffic Noise Objectives.

Residential receivers are considered noise affected where construction noise levels are greater than the noise management levels (NMLs) as determined above. NMLs are detailed in Appendix B of Appendix A. Noise affected levels represent the point above which there may be some community reaction to noise. Where it is predicted and/or measured that construction noise levels will exceed / are exceeding NMLs, all feasible and reasonable work practices will be applied to meet the relevant NMLs.

During standard construction hours a highly affected noise objective of LAeq(15min) 75 dB(A) applies at all receivers.

2.4. Construction Noise Assessment

Modelling and assessment of airborne noise impacts from activities associated with the construction works have been determined by modelling the noise sources, receiver locations, topographical features, and possible noise mitigation measures using a Cadna-A computer noise model specifically developed for this project. The model calculates the contribution of each noise source at identified sensitive receivers and allows for the prediction of the total noise from a site for the various stages of construction.

For the purpose of this assessment the model has taken into account:

- Location of noise sources and sensitive receiver locations;
- Height of sources and receivers referenced to one metre digital ground contours for the site area and surrounding area;
- Sound Power Levels (Lw) of plant and equipment likely to be used during the various construction activities are included in Table C2 in Appendix C - Construction Timetable/ Activities/ Equipment. Table C2 also identifies the plant and equipment that will be operating during standard construction hours and outside of standard construction hours.
- Separation distances between sources and receivers;
- Ground type between sources and receivers; and
- Attenuation from barriers (natural and purpose built).

The model is used to determine the impact of construction noise for the below listed activities at the Arncliffe C7 construction compound:

Modelled construction stage	Key Activities
V01	Installation of environmental controls Demolition of existing structures Vegetation clearing
V02	Establishment of construction facilities

Modelled construction stage	Key Activities
V03	Road and intersection modifications and installation of traffic controls
V04	Piling of shaft and decline Excavation and construction of shaft and decline
V05	Tunnel support works
V06	Permanent shaft works – surface excavation
V07	Permanent shaft works – in shaft excavation
V08	Permanent shaft works – concrete pour.

Construction methods will be incorporated to reduce noise levels, specifically jack hammering and rock breaking, which have been identified as high noise impact activities. The Elliot method of pile breaking (or similarly effective methods) will be utilised, which will reduce jackhammering by up to 90%. Terrain levellers have been considered, but are inappropriate for the small quantity of rock to be excavated. To mitigate the impact of high impact activities, in accordance with CoA D14, high impact activities will be subject to respite periods and maximum durations.

Impacts to sensitive receivers have been determined and will be continually assessed during design development and construction. A noise management schedule has been prepared for the site identifying the noise mitigation strategies that are to be incorporated into the site design to minimise noise impacts where they may occur, including noise barriers (refer to Appendix A). Predicted airborne noise impacts have been determined taking into account the removal of spoil from the Arncliffe construction compound.

Where noise barriers alone are not sufficient to manage noise levels at sensitive receivers, additional mitigation measures are proposed, including at-property treatments, identified in Appendix A. Mitigation measures will be continually developed as design and construction methods are finalised. Mitigation measures are also detailed in construction work packs and the Construction Noise and Vibration Impact Statements for the Arncliffe construction compound.

2.5. Noise Barrier Design

The strategy focuses on modelling impacts based on proposed construction methodologies, determining the noise impacts of such methodologies, identifying sensitive receivers, consultation with sensitive receivers to help develop and finalise temporary noise barrier options based on Sections 2.4 and 2.5 above. Barrier options have been developed considering a variety of acoustic ratings and noise wall performance levels, options have been subsequently matched to required Rw ratings determined from the modelling process. Noise barrier design specifications have been classified using the below performance criteria:

- Low – Rw 10 to 15
- Medium – Rw 15 to 20
- Medium to High – Rw 20 to 25
- High – Rw 25 to 30
- Very High – Rw > 30.

Noise barriers are summarised in Table 2 (sourced from Appendix A). Barriers are specified by location and required Rw rating as determined by noise modelling. A variety of barrier options have been considered and the selected barriers are based on ensuring actual barrier acoustic ratings are greater than specified Rw ratings. Where specified, traditional plywood hoardings meet the required Rw ratings.

Noise barriers (Table 2) have been designed and positioned to achieve noise reduction required to achieve the ICNG goal levels for surrounding sensitive receivers. Refer to Appendix A for a detailed description of noise barriers required for the site. Noise barrier design at the C7 construction compound has also taken into account potential impacts on the adjacent Green and Golden Bell Frog (GGBF) habitat. Perspex has been incorporated into the design of the noise wall adjacent to the primary GGBF habitat (NB04, Table 2) in accordance with the approved GGBF Plan of Management. Impacts from the additional shipping container wall (SCW, Table 2), such as overshadow, have been assessed and advice from the Project Herpetologist has confirmed this additional mitigation will have minimal impact on the GGBF population in this area.

Table 2 – Noise barrier distance to nearest resident

Noise Barrier	Location	Barrier Height	Distance to Nearest Resident	Anticipated completion date	Required performance (RW)	Proposed construction	Acoustic rating of construction
NB01	Northern perimeter Marsh St from Innesdale Rd to northern boundary	4 m	Approximately 30 m	Completed	Rw 15-20 Medium	• 17mm Plywood hoarding	• Rw 24
NB02	Northern perimeter Marsh St from entry gate to Innesdale Rd	5 m	Approximately 30 m	Completed	Rw 25 High	• Sandwich construction of 17mm plywood (45mm air gap); or • Speedwall panel; or • 150 mm Hebel	• Rw 28 • Rw 41 • Rw 40
NB03	Adjacent to internal truck haul routes. From entry gate to temporary shaft spoil shed.	3 m	Approximately 160 m (total)	Partially complete, remaining sections August 2017	Rw 20 Medium	• 17mm Plywood hoarding	• Rw 24
NB04	Southern & western perimeter From Marsh St boundary western corner of the shaft spoil shed 'Frog' noise wall - requirement for top 3m of NB04 to be transparent plastic extends 28 m south east from Marsh St boundary	5 m	Approximately 40 m	Completed	Rw 25 High	• Sandwich construction of 17mm plywood (45mm air gap); or • Speedwall panel; or • 150 mm Hebel; and For 'frog' noise wall component: • Perspex 8 mm; or • LEXAN MARGARD Soundglaze SC Sheet 8 mm; or • PALGLAS 15 mm	• Rw 28 • Rw 41 • Rw 40 • Rw 29 • Rw 31 • Rw 32

Noise Barrier	Location	Barrier Height	Distance to Nearest Resident	Anticipated completion date	Required performance (RW)	Proposed construction	Acoustic rating of construction
NB05	Southern perimeter From southern corner of the shaft to past air compressors	5 m	Approximately 80 m	Completed	Rw 25 High	• Sandwich construction of 17mm plywood (45mm air gap); or • Speedwall panel; or • 150 mm Hebel	• Rw 28 • Rw 41 • Rw 40
SCW	Shipping Container Wall Permanent shaft site, north western boundary	13 m	Approximately 40 m	August 2017	Rw 15-20 Medium	• Steel shipping containers stacked 5 high	• Rw40+

Additional noise mitigation will also be provided in the form of shipping containers (SCW in Table 2), stacked 5 high adjacent to the existing noise barrier NB04 along part of the northern perimeter of site as shown in Figure 2. The shipping container wall will be located behind the existing NB04 noise barrier. However, the container wall will be visible to residents that were previously consulted during development of this strategy and have therefore been consulted again in regards to the container wall.

Figure 2: Noise barriers

3. Stakeholder Consultation

3.1. Consultation

CDS-JV has adopted a well-coordinated, targeted and personalised approach to consult with highly affected residents and other key stakeholders regarding the TNBS following the principles and processes outlined in the Community Communication Strategy. Consultation has been carried out with residents along Marsh Street and the Kogarah Golf Club. Consultation will continue as required subject to design development.

3.2. Aim

Consultation has been completed and will be ongoing as required subject to project works design development with an aim to:

- Provide an overview of project works in the area, including construction compound layout, construction activities and program.
- Explain the purpose of the barriers and options for consideration.
- Present proposed options for the design of the barriers, including location, height, material and colour.
- Provide an opportunity for residents and stakeholders to provide feedback on the proposed options.
- Outline the construction methodology and timing.
- Communicate the final barrier design following consultation.

3.3. Affected stakeholders

During temporary noise barrier design development and optioneering phases, landowners adjacent to proposed noise barrier locations have been identified via a desktop analysis and verified by site assessments. Identified landowners were consulted as above and where possible feedback has been included in designs of the temporary noise barrier construction. Further information will be provided just prior to the commencement of temporary noise barrier construction. Properties consulted with and a report on the consultation for the Arncliffe C7 construction compound is attached as Appendix B.

Consultation was undertaken with eight residential properties located along Marsh Street (as shown in Figure 3) and the Kogarah Golf Course.

Figure 3: Residences consulted in regards to temporary noise barriers at Arncliffe

3.4. Communication and Consultation Activities

During the initial preparation of this TNBS, CDS-JV used a suite of specific TNBS targeted communication and engagement activities to achieve the aims of this strategy. These are outlined in this section below.

Subsequent to the approval of Revision 2 of this TNBS, however, additional noise mitigation has been identified as required at the site, as described in Section 2.1. An additional notification has therefore been provided to affected stakeholders to inform them of the installation of the shipping container wall (SCW) adjacent to noise barrier NB04. The top of this wall will be visible to some of the residences north of Marsh Street and is in addition to the noise barrier design originally communicated during consultation. Feedback received during this consultation is provided in Appendix B.

Consultation undertaken during the initial preparation of this TNBS included the following:

- One-on-one briefings

  Briefings were conducted with residents along Marsh Street and Kogarah Golf Course. The purpose of these briefings was to consult with impacted stakeholders prior to the adoption of the final design.

  These briefings were undertaken by a door knock and undertaken by the Place Manager and Construction Manager for the area.

  The following tools were used during these briefings to facilitate stakeholder's understanding of the proposed barriers options:

  - Maps and plans to illustrate the barrier location, compound layout and project design.
  - Barrier material and colour samples
  - Arncliffe fact sheet, community update and other relevant project communications

- Council Interface Meetings

  Regular interface meetings are held with Rockdale City Council and provide a forum to inform and consult with the council regarding a range of project matters, including the temporary noise barriers options.
  Temporary noise barrier options have been presented at council interface meetings, providing council representatives with an opportunity to provide feedback. The final barrier design will be tabled at a subsequent meeting.

- Notification

  Notifications were sent to affected stakeholders to inform them of final temporary noise barrier designs. CDS-JV recognises the importance of closing out the consultation process regarding temporary noise barrier options to ensure that further consultation and feedback is forthcoming. Ongoing notifications and project updates will be provided as works progress.

3.5. Decision Making Process

During consultation, it was clear there were several key design elements which residents desired and there were no significant issues raised regarding proposed options. Key trends are evident in the feedback received as detailed in Appendix B and are summarised below;

- No objection to proposed height of 5.0 m along Marsh St between Valda Ave and Innesdale Rd and 4.0 m from Innesdale Rd to Rockwell Ave
- No strong preference towards noise barrier type or colour by residents
- Koragah Golf Club preferred Pale Eucalypt

The above key trends have been considered and will be accounted for in the final design as below;

- Pale Eucalypt tone will be incorporated
- Proposed heights will be incorporated into final design.

The above demonstrates that residents adjacent to proposed temporary noise barriers have been consulted and feedback received has been incorporated in the development of final barrier designs.

The additional shipping container wall has been selected as an additional noise mitigation measure to ensure noise impacts associated with permanent shaft construction comply with the relevant criteria and for constructability reasons. The issues raised by affected stakeholders during consultation on the additional wall related to noise impacts from site and did not raise any specific concerns with the additional barrier.

3.6. Monitoring and reporting

All stakeholder interactions regarding the implementation of the TNBS with landowners and community representatives will be recorded in the project's community contact database and included in the monthly and quarterly progress reports. Appendix B outlines the report for consultation associated with this TNBS for the Arncliffe area.

4. Ongoing Monitoring

The strategy sets the overall approach to how construction and traffic noise will be mitigated during construction. The effectiveness of the strategy will rely on multiple iterations of implementation of the strategy principles as design and construction methodologies are refined and implemented. The TNBS will be assessed for effectiveness and site based compliance. The TNBS will be updated as required to account for key learnings as they are identified and in accordance with the reviews detailed above.

5. Conclusion

The CDS-JV has prepared this TNBS in accordance with the Conditions of Approval (CoA), in particular condition D20.

The strategy sets the overall approach to how construction and traffic noise will be mitigated during construction. The strategy focuses on modelling impacts based on proposed construction methodologies, determining the noise impacts of such methodologies, identifying sensitive receivers, consultation with sensitive receivers to help develop and finalise temporary noise barrier options and ongoing monitoring of the overall effectiveness of the strategy. This strategy demonstrates that optimum barrier solutions have been developed utilising sound analytical modelling which demonstrates the benefit of proposed solutions and at the same time is a desired solution for highly affected residents as the consultation process demonstrates.

A key component of the implementation of the overall strategy is the Construction Noise and Vibration: Temporary Noise Barrier Acoustic Report (Arncliffe compound), provided in Appendix A. The mitigation measures outlined in Appendix A, as well as those outlined in the CNVMP, will be implemented to minimise noise impacts from the Arncliffe site.

Appendix A: Construction Noise and Vibration: Temporary Noise Barrier Acoustic Report (Arncliffe compound)

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Acoustics
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WESTCONNEX NEW M5

Construction Noise and Vibration: Temporary Noise Barrier Acoustic Report (Arncliffe compound)

20 July 2017

CPB Dragados Samsung Joint Venture

TH014-05 01F14.2 WXC_M5N Temp Barrier Nse Rep_ARN (r4)

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Document control

Date	Revision history	Non-issued revision	Issued revision	Prepared	Instructed	Authorised
14.09.2016	Final report	0	1	[redacted]	[redacted]	[redacted]
7.11.2016	Minor amendments	-	2	[redacted]	[redacted]	[redacted]
23.06.2017	Addition of barriers at ARN	-	3	[redacted]	[redacted]	[redacted]
12.07.2017	Minor amendments	-	4	[redacted]	[redacted]	[redacted]

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1 Introduction

1.1 Relevant requirements and purpose of this report

This Construction Noise and Vibration Temporary Noise Barrier Acoustic Report (TNBAR) has been prepared to address the Conditions of Approval for the WestConnex New M5 Project (New M5 or Project), more specifically Condition D20.

D20 The Proponent must develop and implement a Temporary Noise Barrier Strategy which includes:

(a) identification and confirmation of all temporary noise barriers including -

(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),

(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. This identifies the temporary noise walls to be installed at the Kingsgrove Road site, at the Western end of the M5N.

This TNBAR forms part of the Temporary Noise Barrier Strategy and has been prepared to address the temporary noise barriers associated with the Project's Arncliffe compound (C7) to satisfy condition D20(a)(iv).

Separate acoustic reports have been prepared to address the temporary noise barriers at other compounds associated with the Project, including:

- Kingsgrove Road compounds C1, C2 and C3 and western surface works
- Bexley Road compounds C4, C5 and C6
- St Peters Interchange compounds C8, C9 and C10
- Local Roads compounds C11, C12, C13 and C14.

This report will be submitted to the Department of Environment and Planning (DEP) as part of the Temporary Noise Barrier Strategy required by Condition D20.

1.2 Structure of this report

This report is structured as follows:

- **Section 2** Description of work area and noise sensitive receivers surrounding the site;
- **Section 3** Noise objectives; and
- **Section 4** Construction Noise Assessment.

1.3 Quality assurance

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

2 Work area and sensitive receivers

2.1 Description of work area

This TNBAR provides information on the temporary noise barriers associated with the Arncliffe compound of the M5N Project, more specifically in relation to:

- Temporary noise barriers to mitigate construction noise associated with the Arncliffe construction compound C7 located south east of the M5 Motorway and Marsh Street at Arncliffe.

Figure B1 and B2 in Appendix B shows the Arncliffe construction work areas addressed in this report.

2.2 Sensitive receivers

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 have been based on those established in the EIS, with some modifications to allow for site specific characteristics identified during the detailed assessment and delivery phase. The NCAs are identified in more detail in the Construction Noise and Vibration Management Plan (CNVMP) prepared for the Project.

An indicative list of the nearest and potentially worst affected noise and vibration sensitive receivers and their respective NCAs are summarised in Table 2.1 below.

Table 2.1 Nearest Residential Noise and Vibration Sensitive Receivers

NCA	Receiver Type	Nearest construction work area	Distance from receiver to works
NCA12	Residential	Arncliffe construction compound (C7)	20-350 m
NCA13	Residential	Arncliffe construction compound (C7)	250-450 m
NCA14	Residential	Arncliffe construction compound (C7)	300-650 m

All relevant residential sensitive receivers in the vicinity of the worksites are identified on aerial photographs located in APPENDIX B.

3 Noise Objectives

3.1 Construction Noise Management Levels

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

Figure B1 and Table B1 in APPENDIX B identify the adopted construction noise management levels (NMLs) for the nearest noise sensitive receivers to the worksite. The NMLs for residential receivers are based on long-term noise monitoring conducted by AECOM on behalf of SMC to quantify ambient noise levels for the Environmental Impact Statement (EIS) as noted in the CNVMP. The NMLs are derived from the lowest measured RBLs within each NCA and are generally considered to be conservative.

The NMLs for 'other' sensitive receivers are from the ICNG, as reported in Section 3.1.1 of the CNVMP.

Residential receivers are considered 'noise affected' where construction noise levels are greater than the NMLs identified in APPENDIX B. The noise affected level represents the point above which there may be some community reaction to noise. Where predicted and/or measured construction noise levels exceed NMLs, all feasible and reasonable work practices will be applied to meet the NMLs.

During standard construction hours a highly affected noise objective of $L_{Aeq(15min)}$ 75 dB(A) applies at all receivers.

Any construction related activities that could exceed the NMLs shall be identified and managed in accordance with the CNVMP.

4 Construction Noise Assessment

4.1 Noise prediction methodology

Modelling and assessment of airborne noise impacts from activities associated with the construction works were determined by modelling the noise sources, receiver locations, topographical features, and possible noise mitigation measures using a Cadna-A computer noise model developed for this Project. The model calculates the contribution of each noise source at identified sensitive receiver locations and allows for the prediction of the total noise from a site for the various stages of the construction works.

The noise prediction models consider:

- Location of noise sources and sensitive receiver locations;
- Height of sources and receivers referenced to one metre digital ground contours for the site area and surrounding area;
- Sound Power Levels (L_w) of plant and equipment likely to be used during the various construction activities are included in Table C2 in Appendix C - Construction Timetable/ Activities/ Equipment. Table C2 also identifies the plant and equipment that will be operating during standard construction hours and outside of standard construction hours.
- Separation distances between sources and receivers;
- Ground type between sources and receivers; and
- Attenuation from barriers (natural and purpose built).

Key details regarding the construction site layout, the likely plant and equipment (including truck movements), and hours of operation were informed by the Design and Construction Teams. This information is presented in APPENDIX C and formed the basis for all modelling assumptions used in this assessment.

4.2 Preliminary detailed design outcomes

During the development of the site design, Renzo Tonin & Associates are playing a key role in assisting CDS JV to determine the physical noise mitigation measures required to reduce noise impact from the operation of the site. The following sections describe briefly the noise design methodology and outcomes, including the location of acoustic sheds and the length, height and location of noise walls required around the site. To ensure the timely and efficient provision of inputs to the design process, these mitigation measures were documented in the Noise Design Report.

A noise management schedule has been prepared for the site identifying the noise mitigation strategies that are to be incorporated into the site design to minimise noise impact where it may occur. The schedule is presented in Table C2 in APPENDIX C. Further to this, Table C3 sets out the noise wall schedule in relation to temporary noise barriers for the construction phase of the Project.

Figure B1 in APPENDIX B identify noise wall/ hoarding locations around each site.

4.3 Predicted noise levels

The stages/operations of the Arncliffe compound (C7) are summarised in the table below, including:

- Arncliffe to Bexley tunnelling support shaft
- Arncliffe to SPI tunnelling support decline considered in the noise model.

For more detail on specific works being undertaken for each modelling scenario see the activity and timing Table C.1 in APPENDIX C.

Table 4.1 Noise modelling assumptions - Arncliffe tunnelling support sites

Aspect	Includes OOHW?	Approx. timing	Modelled construction stage							
			V01	V02	V03	V04	V05	V06	V07	V08
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	Yes	07-09 2016								
Road and intersection modifications and installation of traffic controls	No	07-09 2016								
Piling of shaft and decline	No	09-12 2016								
Excavation and construction of shaft and decline	No	09-12 2016								
Tunnel support works	Yes	2016-2018								
Permanent shaft works - surface excavation	Yes	2017-2018								
Permanent shaft works - in shaft excavation	Yes	2017-2018								
Permanent shaft works - concrete pour	Yes	2017-2018								

Sections 4.3.1 and 4.3.2 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.

APPENDIX D provides a summary, for comparative purposes of the predicted noise levels from the:

- EIS Technical working paper: Noise and vibration;
- detailed design without noise mitigation; and
- detailed design incorporating the design noise mitigation.

4.3.1 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 4.2 Summary of construction noise impacts (standard hours) - level of compliance with NML

NCA	V01	V02	V03	V04	V05	V06	V07	V08
NCA12	⬟	⬟	⬟	⬟	⬟	⬟	⬟	⬟
NCA13	⬟	⬟	⬟	⬟	⬟	⬟	⬟	⬟
NCA14	⬟	⬟	⬟	⬟	⬟	⬟	⬟	⬟

Notes All works to be undertaken during Standard construction hours (7am to 6pm Monday to Friday; 8am to 1pm Saturday)

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 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 C 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.
- During the permanent shaft works, which are concurrent with tunnel support works, there is only likely to be non-compliance with the NML during the surface excavation works. Receivers may be noise affected in NCA12 – construction noise is highly likely to be audible at the nearest affected receivers. The bulk of permanent shaft works (once shaft excavation is underway) is predicted to comply with the NMLs during standard construction hours.

Measures for managing the noise impacts are outlined in Section 4.4.

4.3.2 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 4.3 Summary of construction noise impacts (OOHW) - level of compliance with NML

NCA	V01	V02	V03	V04	V05	V06	V07	V08
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)

Predicted noise levels include existing permanent noise walls and earth mounds as these will not have been removed at the time of the works.

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 1 receiver 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. Consequently, there are up to 32 residences in NCA12 that may be exposed to noise levels up to 10 dB(A) above the NML at night. 22 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.
- During permanent shaft OOHW the there are predicted to be up to 11 residential receivers affected by noise greater than 2dB(A) above the NML in NCA12 at night. All feasible and reasonable mitigation measures have been applied to reduce the noise impacts at night. At-property treatments to resolve these residual exceedances have been recommended and are outlined in APPENDIX C of this TNBAR and in the CNVIS addressing these works (TH014-06 01F33.1 WCX_NM5 CNVIS Arncliffe PS).

Measures for managing the noise impacts outlined in Section 4.4.

4.4 Noise Mitigation and Management

4.4.1 High noise impact activities

To limit the potential impact from high noise impact activities such as piling, jack hammering and rock hammering, the works will be carried out with respite periods as set out in condition of approval D14, such that:

- High noise impact activities (including jackhammering and rock breaking) are only carried out between:
  - 8 am and 6pm Monday to Friday; and
  - 8 am and 1 pm Saturday;
- High noise impact activities are carried out in continuous blocks of up to 3 hours. Respite from high noise impact activities will be provided between each block for at least 1 hour. No high noise impact activities will be carried out during this 1 hour respite period.

4.4.2 Other noise control measures

Other noise mitigation measures and noise monitoring requirements are addressed in the following documents:

- Construction Noise and Vibration Impact Statement: Site Establishment (Project Wide) [ref: TH014-05 01F02 WCX_NM5]
- Construction Noise and Vibration Impact Statement: Arncliffe Site Establishment OOHW [ref: TH014-05 01F11 WCX_NM5]

- Construction Noise and Vibration Impact Statement: Arncliffe Tunnel Support site [ref: TH014-06 01F23 WXC_NM5 CNVIS ARN TS]
- Construction Noise and Vibration Impact Statement: Arncliffe Permanent Shafts excavation [ref: TH014-06 01F33.1 WCX_NM5 CNVIS Arncliffe PS].

The required locations, heights and performance requirements of the site boundary noise walls and hoardings are presented **Table C3** in APPENDIX C and **Figure B1** in APPENDIX B. The Weighted Sound Reduction Index (Rw) for each noise wall is nominated. Based on the required acoustic rating, suitable noise wall constructions have been established through discussion with CDS.

There are two noise sheds to be constructed at the Arncliffe tunnel support site:

- Arncliffe to Bexley tunnelling support shaft Spoil Shed; and
- Arncliffe to SPI tunnelling support decline Spoil Shed.

An acoustic enclosure schedule has been developed and is presented as **Table C4** in APPENDIX C.

Plant and equipment used on site shall achieve the noise level requirements in **Table C1** of APPENDIX C. More specifically, tunnel ventilation fans and front end loaders used in the spoil shed shall be managed to achieve the performance requirements in **Table C5** of APPENDIX C.

5 Conclusion

This Construction Noise and Vibration Temporary Noise Barrier Acoustic Report has been prepared to identify and confirm:

- Temporary noise barriers to mitigate construction noise associated with the Arncliffe construction compound C7, located on the southern side of Marsh Street and east of the M5 Motorway.

Impacts predicted because of construction activity following the installation of temporary noise barriers have been quantified and reported in Section 4, in relation to construction noise impact.

Noise management schedules for the site have been developed identifying the noise mitigation strategies that are to be incorporated into the site design to minimise noise impact where it may occur. The schedules are:

- Table C2 in APPENDIX C setting out the Construction Noise Management schedule
- Table C3 in APPENDIX C setting out the Noise Wall / Hoarding Design specifications
- Table C4 in APPENDIX C setting out the Noise Shed/ Enclosure Design specifications
- Figure B1 in APPENDIX B identifying noise walls and hoarding locations around the site.

A comparison of the predicted noise levels in the EIS compared to those predicted from the detailed design is presented in APPENDIX D.

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. British Standard BS 7385 Part 2-1993, Evaluation and measurement for vibration in buildings
6. German Standard DIN 4150-3 : 1999-02, Structural vibration - Effects of vibration on structures, February 1999
7. ASHRAE Applications Handbook (SI) 2003, Chapter 47 Sound and Vibration Control, pp47.39-47.40
8. Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration, p16
9. Australian Standard AS/NZS 2107:2000 *Acoustics - Recommended design sound levels and reverberation times for building interiors*
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 – Technical Working Paper: Noise and Vibration Report Revision 8 – 20-Nov-2015
12. Renzo Tonin & Associates WestConnex Stage 2 M5 East Operational Noise Management Report (ONMR), 8 July 2015 [ref: TH014-01 01BF01 ONMR (r5)]
13. Transport for NSW Construction Noise Strategy (ref: 7TP-ST-157/2.0) April 2012
14. Minister for Planning Infrastructure approval SSI 6788 dated 20 April 2016

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]	The units of sound measurement. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear, defined as 20 micro Pascal 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	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.
dB(C)	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.
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.
DIN	German Standard
DnT,w	Weighted Standardised Field Level Difference 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. 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. The value is indicative of the level of speech privacy between spaces. The higher its value the better the insulation performance.
ECRTN	Environmental Criteria for Road Traffic Noise, NSW, 1999
EPA	Environment Protection Authority
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' 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. 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.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	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.
Frequency	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.
Ground-borne noise	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.

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
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq or Leq	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 LAeq.
LAeq(1hr)	The LAeq 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 Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
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	Weighted Standardised Field Impact Sound Pressure Level As for Ln,w but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The equivalent measurement in a laboratory is the Ln,w. A lower value indicates a better performing floor.
Laboratory Test	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.
Loudness	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.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially constant.
Noise	Unwanted sound
NRC	Noise Reduction Coefficient. 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. 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.
Passive recreation	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
Reflection	Sound wave reflected from a solid object obscuring its path.
Reverberation Time	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.
RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australa. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, NSW, March 2011
SEL	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.
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 Rw and the sound insulation between two rooms can be described by the DnT,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 mico Pascal.
Spoil	Soil or materials arising from excavation activities.
Standardised	A method of adjusting the measured noise indices in-situ so that they are independent of the measuring space. 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'.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by Rw.
Structure-borne Noise	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. 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). 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'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	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. 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 Rw or R'w or DnT,w.

APPENDIX B Nearest Sensitive Receivers and Noise Management Levels

B.1 Arncliffe Tunnel Support Site

Building Type

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

50 0 50 100 m

Client: WestConnex New M5

CPB CONTRACTORS | DRAGADOS | SAMSUNG C&T

Project: WestConnex Stage 2 M5

Description: Noise catchment areas & Sensitive Receivers

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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Table B1: Noise sensitive receivers and construction noise management levels **Arncliffe Permanent Shafts Excavation**

NCA	Receiver Type	Reference RBL	Rating Background Levels (RBLs)			Residential Noise Management Levels (NMLs) $L_{Aeq(15\ min)}$				Sleep Dist. L_{Amax}		Comments
			Day	Evening	Night	Day (S)	Day (O)	Evening	Night	Screening	Max	
NCA12	Residential	EISL20	55	55	45	65	60	60	50	60	65	Based on NCAs and NMLs presented in the EIS.
NCA13	Residential	EISL21	49	48	42	59	54	53	47	57	65	Based on NCAs and NMLs presented in the EIS.
NCA14	Residential	EISL22	47	47	39	57	52	52	44	54	65	Based on NCAs and NMLs presented in the EIS.
ID	**Other Sensitive Recievers**											
OSR	Hotel/ Motel	AS2107	-	-	-	60	60	60	60	-	-	NML of 60dB(A) is external equivalent of 40dB(A) internal goal for hotels on busy roads based on AS2107 assuming windows closed
OSR	Active recreation areas	ICNG	-	-	-	65	65	65	65	-	-	Ref: ICNG p13
OSR	Commercial Receivers/ Offices	ICNG	-	-	-	70	70	70	70	-	-	When premise is in use. External.
OSR	Industrial Receivers	ICNG	-	-	-	75	75	75	75	-	-	When premise is in use. External.

APPENDIX C Construction Timetable/ Activities/ Management

C.1 Arncliffe Tunnel support site

Figure C1: Site layout showing mitigation **Arncliffe Permanent Shafts Excavation**

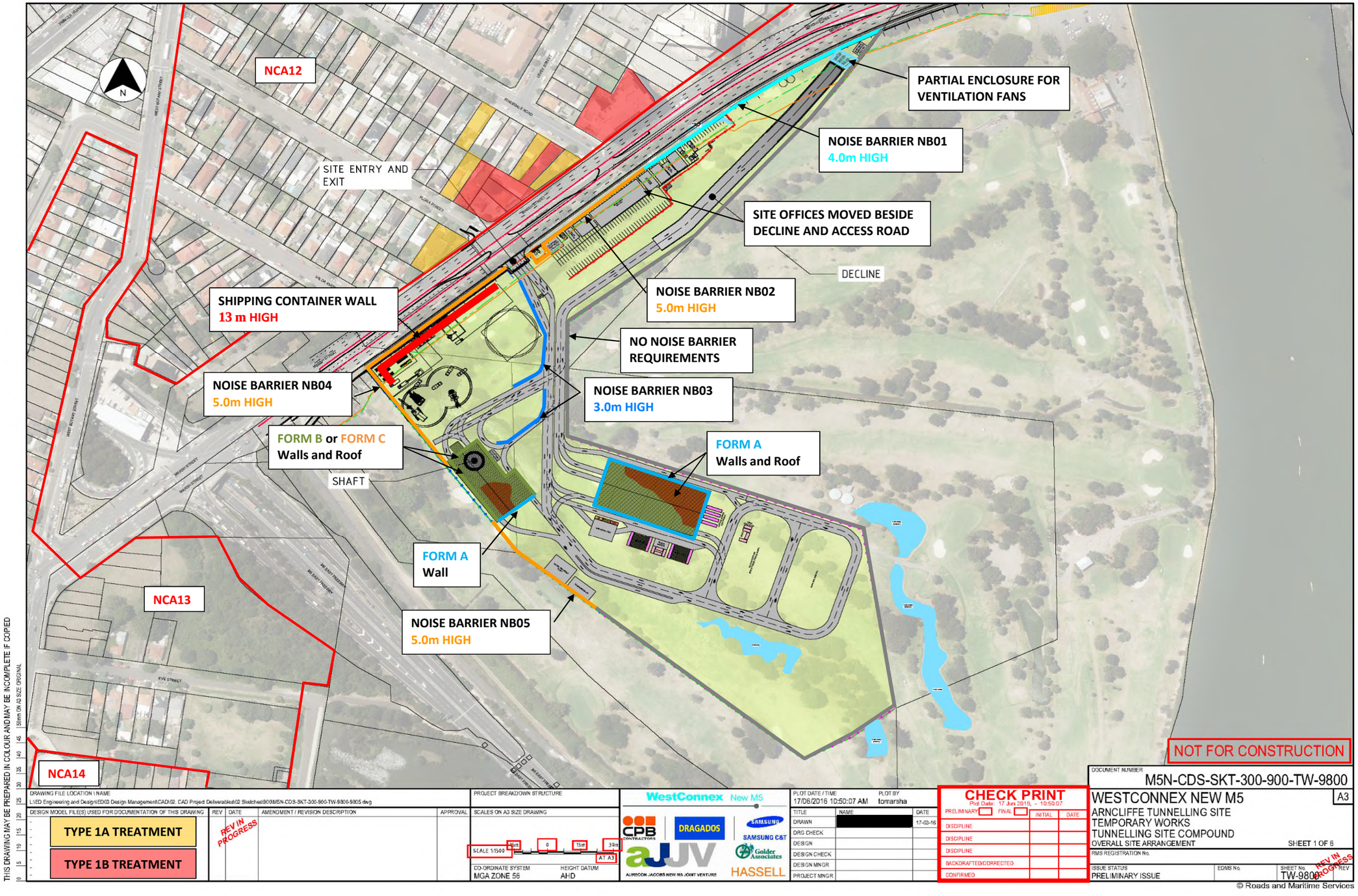

Table C1: Tunnel support construction timetable/ activities/ equipment **Arncliffe Tunnel Support**

Activity/ Work Area	Aspect	Plant/ Equipment	Net Power kW	Operating Weight kg	Day 7am - 6pm	Evening 6pm - 10pm	Night 10pm - 7am	Sound Power Level (Lw re: 1pW) in Noise L_{Aeq}	L_{A1}	Notes
TUNNELLING SUPPORT										
Construction Compound & Car Park	General worksite and Car parking	Water treatment plant pumps	10		2	2	2	97		Surface; Compound and car park will operate for the entire duration of construction works. Busy on shift changes only.
		Light vehicle	80		40 p.h.	16 p.h.	16 p.h.	89		
	Workshop; Deliveries; Maintenance; Storage	Road truck (deliveries to site)			4 p.h.	-	-	108		Surface
Site sheds, workshop, car parking & laydown areas		Compressor	110	2660	2	2	2	70		Surface
		Workshop Hand Tools			2	2	1	107		Surface
		Franna Crane	205	20 tonne	1	1	1	99	106	Surface
		Water cart		15kL	4 p.h.	4 p.h.	-	108		Surface
Decline Tunnelling Support Site ARN to SPI (4 Road header site)	Tunnelling & Support	Road Header 1,000V Electric	350		6	6	6	111		Underground
		Dust Scrubber			10	10	10	110 (no attenuator)		Underground; Attenuator to be confirmed
		Ventilation fan D5			2	2	2	110 (105)		Surface; Attenuator or enclosure to be confirmed
		Ventilation fan D6			2	2	2	112 (107)		Surface; Attenuator or enclosure to be confirmed
	Spoil Handling	Moxie (spoil out of tunnel)	95	38T	14 p.h	14 p.h	14 p.h	110		Surface
		Truck & Dog (spoil haulage)			13 p.h	13 p.h	13 p.h	108		Surface
		FE Loader in spoil loading area	130		2	2	2	110		Inside shed
	Tunnel Lining (concreting)	Concrete pump	130		2	-	-	N/A		Underground
		Compressor	90		2	2	2	N/A		Underground
		Concrete truck	120		8 p.h	8 p.h	8 p.h	108	117 (air brakes)	Surface; NIGHT trucks access site via Marsh St
Shaft Tunnelling Support Site ARN to BXR (2 Road header site)	Tunnelling & Support	Road Header 1,000V Electric	350		4	4	4	111		Underground
		Dust Scrubber			4	4	4	110 (no attenuator)		Underground; Attenuator to be confirmed
		Ventilation fan D4	600		2	2	2	104 (93)		Surface; Attenuator to be confirmed
	Spoil Handling	Moxie (spoil out of tunnel)	95	38T	8 p.h	8 p.h	8 p.h	110		Underground
		Truck & Dog (spoil haulage)			8 p.h	8 p.h	8 p.h	108		Surface
		Gantry crane (electric)			1	1	1	90		Inside shed
		Crane Alarm (broadband)			1	1	1	96		Inside shed
		FE Loader in spoil loading area	130		2	2	2	110		Inside shed
	Tunnel Lining (concreting)	Concrete pump	130		2	2	2	N/A		Underground
		Compressor	90		2	2	2	N/A		Underground
		Concrete truck	120		4 p.h.	4 p.h.	4 p.h.	108	117 (air brakes)	Surface; NIGHT trucks access site via Marsh St

Table C1: Tunnel support construction timetable/ activities/ equipment **Arncliffe Permanent Shafts Excavation**

Activity/ Work Area	Aspect	Plant/ Equipment	Net Power kW	Operating Weight kg	Day 7am - 6pm	Evening 6pm - 10pm	Night 10pm - 7am	Sound Power Level (Lw re: 1pW) in Noise L_{Aeq}	L_{A1}	Notes
PERMANENT SHAFTS OUT-OF-HOURS EXCAVATION										
Construction Compound & Car Park	General worksite and Car parking	Water treatment plant pumps	10		2	2	2	97		Surface; Compound and car park will operate for the entire duration of construction works. Busy on shift changes only.
		Light vehicle	80		40 p.h.	16 p.h.	16 p.h.	89		
Site sheds, workshop, car parking & laydown areas	Workshop; Deliveries; Maintenance; Storage	Road truck (deliveries to site)			4 p.h.	-	-	108		Surface, also for TS operations
		Compressor	110	2660	2	2	2	70		Surface, also for TS operations
		Truck and dog			32 p.h.	21 p.h.	21 p.h.	106		Within limits for total tunnel support operations (cumulative)
		Moxies			24 p.h.	17 p.h.	17 p.h.	106		Within limits for total tunnel support operations (cumulative)
		Workshop Hand Tools			2	2	1	107		Surface, also for TS operations
		Franna Crane	205	20 tonne	1	1	1	99	106	Surface, also for TS operations
		Water cart		15kL	4 p.h.	4 p.h.	-	108		Surface, also for TS operations
		Front end loader (muffled)		25T	-	1	1	105		Stockpile area
Binocular shaft	Initial excavation	Longreach excavator with bucket		30T	4	4	2	109		Surface, 2 per half shaft, maximum 2 at night in entire work area
	(first 10-15m)	Dump Truck (CAT 730)		30T	2	2	2	110		1 per half shaft, taking spoil to stockpile
2 conjoined shafts	Mid excavation	Excavator with bucket		13T	4	4	4	103		In shaft, 2 per half shaft
	(from 10-15m to rock)	Excavator with bucket		20T	2	2	1	103		On surface loading spoil trucks, 1 at night in entire work area
		Crawler crane		100T	2	2	2	99		1 per half shaft, using kibble
		Crawler crane		250T	1	1	1	100		1, spread between exhaust and supply shafts
		Ventilation fan			2	2	2	95		On surface, 1 per half shaft
		Dump Truck (CAT 730)		30T	2	2	2	110		1 per shaft, taking spoil to stockpile
	Rock excavation	Excavator (hammer attachment)		30T	4	4	4	122+5		In shaft, 2 half per shaft, rock breaking
	(30m onwards)	Excavator with bucket		20T	2	2	1	103		On surface loading spoil trucks, 1 at night in entire work area
		Crawler crane		100T	2	2	2	99		1 per half shaft, using kibble
		Crawler crane		250T	1	1	1	99		1, spread between exhaust and supply shafts
		Ventilation fan			2	2	2	95		On surface, 1 per half shaft
		Dump Truck (CAT 730)		30T	2	2	2	110		1 per shaft, taking spoil to stockpile
	Ring beam installation	Crawler crane		100T	2	2	2	99		2 per half shaft, using kibble
		Handtools						-		
		Ventilation fan			2	2	2	95		On surface, 1 per half shaft
		Jackhammer			1	1	1	115		
	Ring beam concrete pour	Crawler crane		100T	2	2	2	99		1 per half shaft, using kibble
		Ventilation fan			2	2	2	95		On surface, 1 per half shaft
		Concrete agi			4 p.h.	4 p.h.	2 p.h.	108		Max 2 agis in PS work area after 10, avoid using when possible
	Rock bolting	Percussion drill			2	2	2	120+5		In shaft, 1 per half shaft
		Ventilation fan			2	2	2	95		On surface, 1 per half shaft
	Rock bolt concrete pour	Concrete agi			4 p.h.	4 p.h.	2 p.h.	108		Max 2 agis in PS work area after 10, avoid using when possible
		Ventilation fan			2	2	2	95		On surface, 1 per half shaft
		Shotcrete rig			2	2	2	102+99		In shaft, 1 per half shaft
Supply shaft	Diaphragm wall construction	Crawler crane		100T	2	2	2	99		2 per shaft, using cutter, grabber, moving rebar cages
		Concrete agi			4 p.h.	4 p.h.	2 p.h.	108		Max 2 agis in PS work area after 10, avoid using when possible
1 shaft, split in half		Excavator		5-20T	1	1	1	103		Used for concrete pour
		Excavator (hammer attachment)		5-20T	1	1	1	122+5		Capping beam activity, + manual hammers
	Initial excavation	Longreach excavator with bucket		30T	4	4	4	109		Surface, 2 per half shaft, maximum 2 at night in entire work area
	(first 10-15m)	Dump Truck (CAT 730)		30T	2	2	2	110		1 per shaft half half, taking spoil to stockpile
	Mid excavation	Excavator with bucket		13T	4	4	4	103		In shaft, 2 per shaft half half
	(from 10-15m to rock)	Excavator with bucket		20T	2	2	1	103		On surface loading spoil trucks, 1 at night in entire work area
		Crawler crane		100T	2	2	2	99		1 per shaft half half, using kibble
		Crawler crane		250T	1	1	1	9		1, spread between exhaust and supply shafts
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
		Dump Truck (CAT 730)		30T	2	2	2	110		1 per shaft half, taking spoil to stockpile
	Shallow rock excavation	Excavator (hammer attachment)		8T	4	4	4	118+5		In shaft, 2 per shaft half, rock breaking
	(40-45m)	Excavator with bucket		20T	2	2	1	103		On surface loading spoil trucks, 1 at night in entire work area
		Crawler crane		100T	2	2	2	99		1 per shaft half, using kibble
		Crawler crane		250T	1	1	1	9		1, spread between exhaust and supply shafts
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
		Dump Truck (CAT 730)		30T	2	2	2	110		1 per shaft half, taking spoil to stockpile
	Deep rock excavation	Excavator (hammer attachment)		30T	4	4	4	122+5		In shaft, 2 per shaft half, rock breaking
	(45m onwards)	Excavator with bucket		20T	2	2	1	103		On surface loading spoil trucks, 1 at night in entire work area
		Crawler crane		100T	2	2	2	99		1 per shaft half, using kibble
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
		Dump Truck (CAT 730)		30T	2	2	2	110		1 per shaft half, taking spoil to stockpile
	Vent floor build	Crawler crane		100T	4	4	4	99		2 per shaft half, using kibble
		Handtools						-		
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
		Jackhammer			1	1	1	115+5		
	Vent floor concrete pour	Crawler crane		100T	2	2	2	99		1 per shaft half, using kibble
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
		Concrete agi			4 p.h.	4 p.h.	2 p.h.	108		Max 2 agis in PS work area after 10, avoid using when possible
	Rock bolting	Percussion drill			2	2	2	120+5		In shaft, 1 per shaft
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
	Rock bolt concrete pour	Concrete agi			4 p.h.	4 p.h.	2 p.h.	108		Max 2 agis in PS work area after 10, avoid using when possible
		Ventilation fan			2	2	2	95		On surface, 1 per shaft half
		Shotcrete rig			2	2	2	102+99		In shaft, 1 per shaft half

Table C2: Construction noise management schedule

Arncliffe Tunnel Support

	Area to be Managed	Mitigation/ Management Measure	Typical Details	Comments
Tunnel RH Support, Spoil Handling and Tunnel Lining (decline)				
1	Noise barriers	NB01: 4m temporary noise barrier along Marsh St from Innesdale Rd to northern boundary	see Table C3 for details	
		NB02: 5m temporary noise barrier along Marsh St from entry gate to Innesdale Rd	see Table C3 for details	
		NB03: 2.4m temporary noise barrier along edge of decline to even with carpark entrance	see Table C3 for details	
		NB04: 5m temporary noise barrier around perimeter from Marsh St boundary to north of shaft spoil shed	see Table C3 for details	
		NB05: 5m temporary noise barrier along boundary from south of shaft spoil shed to past the air compressors	see Table C3 for details	
2	Work outside Standard Construction Hours	Restricted as outlined below		
3	Workshop	Partial acoustic enclosure: 3 walls + rigid roof		
		EVE/ NIGHT: 1 handtool only		
		NIGHT: Limit use of franna crane		
4	Spoil bin area	Acoustic shed	see Table C4 for details	
		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		
5	Water Treatment Plant Pumps	N/A	see Table C4 for performance requirements	
6	Compressors	N/A		
7	Ventilation Fan	Attenuator/ acoustic enclosure		To be revised when fan details are known
8	Concrete Truck restrictions for OOHW period	EVE: ≤ 8 trucks per hour		The following items are TBC during first 12 months on site:
		NIGHT: ≤ 8 trucks per hour		- truck noise levels on and off site (model verification)
9	Spoil Truck restrictions for OOHW period	EVE: ≤ 13 trucks per hour		- Lmax noise levels/ sleep disturbance (model verification)
		NIGHT: ≤ 13 trucks per hour		
10	Moxie Truck restrictions for OOHW period	EVE: ≤ 14 trucks per hour		Compression braking and air brake release will be managed on site
		NIGHT: ≤ 14 trucks per hour		throughh toolbox talks etc
11	Water Cart restrictions for OOHW period	EVE: ≤ 4 trucks per hour		
		NIGHT: 0 trucks per hour		
12	Treatment of noise affected houses	Treatment of houses affected by residual impacts	See Table C5 for details	
Tunnel RH Support, Spoil Handling and Tunnel Lining (shaft)				
1	Noise Barrier	As above		
2	Work outside Standard Construction Hours	Restricted as outlined below		
3	Workshop	As above		
4	Spoil bin area	Acoustic shed	see Table C4 for details	
		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		
5	Water Treatment Plant Pumps	As above		
6	Compressors	As above		
7	Ventilation Fan	Attenuator/ acoustic enclosure		To be revised when fan details are known
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: ≤ 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	Treatment of noise affected houses	Treatment of houses affected by residual impacts	See Table C5 for details	

Table C2: Construction noise management schedule

Arncliffe Permanent Shafts Excavation

Area to be Managed		Mitigation/ Management Measure	Typical Details
OOH Decline and Surface Excavation			
1	Noise barriers	NB01: 4m temporary noise barrier along Marsh St from Innesdale Rd to northern boundary	see Table C3 for details
		NB02: 5m temporary noise barrier along Marsh St from entry gate to Innesdale Rd	see Table C3 for details
		NB03: 3m temporary noise barrier along truck route from main gates to shaft spoil shed	see Table C3 for details
		NB04: 5m temporary noise barrier around perimeter from Marsh St boundary to north of shaft spoil shed	see Table C3 for details
		NB05: 5m temporary noise barrier along boundary from south of shaft spoil shed to past the air compressors	see Table C3 for details
2	Shipping container walls	Wall of stacked shipping containers 5 high, from main gate south along border of Marsh Street, turning south-east along corner of compound, continuing for as far as practicable	See Figure C1
3	Use of temporary screening	Temporary screening must be used between NB03 and the shipping container wall to block line of sight to main gate when works are taking place at supply shaft	
4	Spoil truck and moxie restrictions	OOH limit on number of moxies/ truck and dogs per hour from permanent shaft works and tunnel support works combined: Truck and Dogs: 21 per hour Moxies: 17 per hour	
5	Moxie noise reduction kits	Moxies must be fitted with noise control kits to reduce their sound power level to at most 106dB(A), unless validation monitoring shows that they are sufficiently quiet without noise control kits	See Table C4 for details
6	Fan sound power level	Permanent shaft ventilation fans must have a sound power level of ≤ 95dB(A)	Attenuator or partial enclosure, see Table C4 for details
		Tunnel support ventilation fans must have sound power levels equal to those recommended in Tunnel Support CNVIS	See Table C4 for details
7	Permanent shafts spoil handling	Only 1 excavator on the surface may be used for spoil handling during soft ground excavation at night Excavator must must load trucks behind spoil bund wall No night-time spoil handling during excavation using hammers	
8	Concrete pours	At night, only 2 concrete trucks may be located at permanent shaft area during a 15-minute period If additional trucks are necessary at night, reserve concrete trucks can queue in south-western corner of site behind spoil mound, or inside decline spoil shed Concrete pours must not take place simultaneously with any other activities, except for excavation using buckets in the shaft	
9	Surface excavation restrictions	During surface excavation of shafts, only 2 long-reach excavators located on the surface may operate between 10pm and 7am	
10	Diaphragm wall work restrictions	Only concrete pours may continue after 10pm, all other activities must not resume until 7am Capping beam activity using rock hammer must only take place during standard hours	
11	Crane usage restrictions	Cranes must not operate simultaneously with the plant at the bottom of their respective half-shafts Only 1 crane per half shaft may be used after 10pm, except during concrete pours where necessary	Informed that this is also an OH&S restriction
12	Treatment of noise affected houses	Treatment of houses affected by residual impacts	See Table C5 for details
13	Verification monitoring	Extensive verification monitoring must be conducted to validate predictions in the nominated positions In the event that verification monitoring shows that noise levels are greater than those predicted, further mitigation must be implemented	
14	Mitigation measures for Arncliffe tunnel support	Refer to WestConnex New M5 Construction Noise and Vibration Impact Statement: Arncliffe Tunnel Support Site (TH014-06 01F23 WXC_NM5 CNVIS ARN TS)	

Table C3: Noise barrier design specifications **Arncliffe Permanent Shafts Excavation**

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); OR Speedwall panel; OR 150mm Hebel	Rw 28 Rw 41 Rw 40
NB03	Adjacent to internal truck haul routes From entry gate to temporary shaft spoil shed	3m	**Rw 15-20** **Medium**	17 mm plywood hoarding	Rw 24
NB04	Southern & western perimeter From Marsh St boundary western corner of the shaft spoil shed	5m	**Rw 25** **High**	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); OR Speedwall panel; OR 150mm Hebel; OR	Rw 28 Rw 41 Rw 40
	'Frog' noise wall - requirement for top 3m of NB03 to be transparent plastic extends 28 m south east from Marsh St boundary			Perspex 8mm; OR LEXAN MARGARD® Soundglaze SC Sheet 8mm; OR PALGLAS 15mm	Rw 29 Rw 31 Rw 32
NB05	Southern perimeter From southern corner of the shaft spoil shed to the past the air compressors	5m	**Rw 25** **High**	Sandwich construction of 17mm plywood on either side of 45mm frame (45mm air gap between plywood sheets); OR Speedwall panel; OR 150mm Hebel; OR	Rw 28 Rw 41 Rw 40
SCW	Shipping Container Wall Permanent shaft site, north western boundary	13m	**Rw 15-20** **Medium**	Steel shipping containers stacked 5 high	Rw 40+

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 Tunnel Support

Area to be Mitigated	Construction component	Acoustic element type
1. Arncliffe to Bexley Shaft Spoil Shed (assumed shed height: 16m over shaft, 8m over rest)	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.
3. Workshop	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	1 side of shed open, oriented away from sensitive receivers

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: Managing residual impacts during 'out of standard hours' work **Arncliffe Permanent Shafts Excavation and Tunnel Support**

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 accomodation. 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 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. 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 1B	**Mechanical ventilation and sealing of wall vents**
5-10dB(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 2	**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 3	**Upgraded windows, glazing and doors**
>12dB(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	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.

Table C5b: Receivers requiring at-property treatment

NCA	Address	At-property treatment
NCA12	32 FLORA STREET ARNCLIFFE	Type 1A
NCA12	34 FLORA STREET ARNCLIFFE	Type 1B
NCA12	36 FLORA STREET ARNCLIFFE	Type 1B
NCA12	41 FLORA STREET ARNCLIFFE	Type 1A
NCA12	39 INNESDALE ROAD WOLLI CREEK	Type 1A
NCA12	41 INNESDALE ROAD WOLLI CREEK	Type 1B
NCA12	43 INNESDALE ROAD WOLLI CREEK	Type 1A
NCA12	24 MARSH STREET ARNCLIFFE	Type 1B
NCA12	24A MARSH STREET ARNCLIFFE	Type 1B

APPENDIX D Comparison of EIS predictions to detailed design

The noise modelling assumptions for Arncliffe tunnelling support sites (C7) are as follows:

- V01
  - Power Generator
  - Installation of enviro controls
  - Demolition of existing structures
  - Vegetation Clearing
- V02
  - Power Generator
  - Establishment of construction facilities (includes OOHW at Arncliffe)
- V03
  - Power Generator
  - Road and intersection modifications and installation of traffic controls
- V04
  - Piling of shaft/ decline (C4, C5 and C7)
  - Excavation & Construction of shaft/ decline (C4, C5 and C7)
- V05
  - Tunnel support works (of shaft/ decline - includes OOHW)
- V06-V08
  - Permanent shaft works (note EIS only assesses 'Construction of ventilation facilities', not specifically shaft excavation works)

The impacts presented in the following tables show a comparison between the predicted impacts presented in the EIS compared with the detailed design. Note that Renzo Tonin & Associates did not prepare the EIS for the New M5. The results presented for the EIS noise predictions are therefore based on our best interpretation of the results presented in the EIS Technical Working Paper; Noise and Vibration [11].

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

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.1 Summary of construction noise impacts (standard hours) - level of compliance with NML for construction stage

NCA	V01		V02		V03		V04		V05		V06		V07		V08	
	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD
NCA12		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]
Level above NML, dB(A)	18	7	0	8	0	3	7	15	0	0	0	2	6	0	6	0
NCA13		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]
Level above NML, dB(A)	8	0	00	7	0	0	0	7	0	0	0	0	3	0	3	0
NCA14		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]		[ ]
Level above NML, dB(A)	6	0	0	5	0	0	29	7	0	0	0	0	0	0	0	0

Notes

All works to be undertaken during Standard construction hours (7am to 6pm Monday to Friday; 8am to 1pm Saturday)

EIS refers to results presented in EIS noise and vibration assessment report

DD refers to detailed design noise assessment. Number in brackets refers to noise predictions without temporary noise barriers.

Table D.2 Summary of construction noise impacts (OOHW) - level of compliance with NML for construction stage

NCA	V01		V02		V03		V04		V05		V06		V07		V08	
	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD	EIS	DD
NCA12			**	[ ]						[ ]	**	[ ]	**	[ ]	**	[ ]
Level above NML, dB(A)				7					2	10		10		10		10
NCA13			**	[ ]						[ ]	**	[ ]	**	[ ]	**	[ ]
Level above NML, dB(A)									0	2		0		0		0
NCA14			**	[ ]						[ ]	**	[ ]	**	[ ]	**	[ ]
Level above NML, dB(A)									0	0		1		0		1

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)

EIS refers to results presented in EIS noise and vibration assessment report. ** Activity not modelled as OOHW in EIS

DD refers to detailed design noise assessment. Number in brackets refers to noise predictions without temporary noise barriers.

Appendix B: Consultation Records

9 June 2017

Additional temporary noise barrier - Arncliffe construction compound

Work is underway on WestConnex which involves widening and extending the M4 and M5 and joining them to create a free-flowing motorway network.

As part of the project, the New M5 will duplicate the existing M5 East corridor, doubling vehicle capacity and easing congestion between St Peters and Beverly Hills. It will include twin tunnels, an upgrade of King Georges Road Interchange and a new interchange at St Peters. For more information, visit westconnex.com.au/NewM5.

Excavation at the Arncliffe compound is required for the construction of the ventilation shafts. In order to mitigate construction noise, an additional temporary noise barrier, made up of shipping containers, will be assembled at the compound next to the Marsh Street boundary. Please see location overleaf. This additional noise barrier will reduce the noise impact from construction of the shafts to surrounding residents.

The noise barrier will consist of five (5) shipping containers in height and ten (10) containers in length. Three (3) rows of containers will be visible above the existing noise wall (about eight (8) metres above the wall). Each container measures 2.6m high, 2.5m wide and 10m long.

This noise barrier will remain in place for approximately eighteen (18) months.

This noise barrier amongst other noise mitigation measures will allow us to undertake excavation work out of hours. Once the noise barrier is installed, excavation work will commence.

Please provide us with any feedback you may have about this additional noise barrier by calling us on 1800 660 248 (ask to speak to a member of the New M5 team) or emailing us at info@newm5.com.au by 16 June 2017.

Alternatively, you can visit the New M5 Community Information Centre which is open 9am – 5pm (Monday to Friday) at 27 Burrows Road, St Peters.

Notification no: 228

ABOUT WESTCONNEX
WestConnex is part of a broader transport plan for Sydney which includes improved public transport, such as Sydney Metro and light rail, as well as better, more reliable motorway solutions. More than two-thirds of WestConnex will be built underground. Once complete, motorists will be able to avoid up to 52 sets of traffic lights and enjoy significant travel time savings.

Location of the additional temporary noise barrier on Marsh Street

We speak your language

ENGLISH
To learn more, simply visit westconnex.com.au/yourlanguage. Need an interpreter? Call the Translating and Interpreting Service on **131 450**.

ARABIC
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