

ACOUSTICS ADVISOR ENDORSEMENT SYDNEY METRO WEST (SSI 10038)

Review of:	Central Tunnelling Package: DNVIS for North Strathfield	Reviewed document reference:	21028-NV-RP-5-9
Prepared by:	████████████████████ Alternate Acoustics Advisor		Revision 9
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As approved alternate Acoustics Advisor (AA) for the Sydney Metro West project, I reviewed and provided comments on Revision 9 of the Sydney Metro West – CTP – Detailed Noise and Vibration Impact Statement (DNVIS) for North Strathfield Station. Revision 9 is a minor update for the replacement of a franna crane to operate in the station box, with a mobile crane to operate on the surface at the northern end of the station box.

I note AFJV's advice that:

- Noise mats will be installed on the chain mesh fence (gate to the surface area where the mobile crane will be located), set up with the correct orientation.
- As feasible as practicable the crane will be located and oriented to minimize noise to receivers
- The crane is planned for 4 nights with 2 nights contingency; alternate accommodation offers have been made where required.
- The appendices have been updated to reflect the new impact and will be transmitted with the final version.

I am satisfied that my comments have been adequately addressed and I endorse Revision 9 of the DNVIS Addendum for North Strathfield Station for implementation, as per Condition of Approval A36(e).

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Larry Clark, Metro West Alternate Acoustics Advisor

**Acciona Ferrovia Joint Venture
Sydney Metro West Central Tunnelling Package
North Strathfield**

**Detailed noise and vibration impact statement
July 2024**

Doc no. 21028-NV-RP-5-9





Detailed noise and vibration impact statement

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Project	Sydney Metro West Central Tunnelling Package
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Revision history

0	25 November 2021	Draft report to client
1	26 November 2021	Issued to client
2	21 January 2022	Updated following client comments
3	9 February 2022	Updated program dates, added mitigation definitions
4	30 March 2022	Minor Edits AA
5	29 August 2023	Updated to reflect changes in ripping and nozzle activities
6	4 October 2023	Updated with AA/ER comments
7	10 May 2024	Updated with TBM operations and site demobilisation activities
8	29 May 2024	Updated with revised Demobilisation activities and AA comments
9	25 July 2024	Updated equipment activity 4b and added new equipment location for activity 4bi

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Definition of acoustic terms and acronyms

AA	Acoustic Advisor
AMM	Additional mitigation measures – applicable where standard measures have been implemented and NML is still expected to be exceeded.
Assessment period	The period in a day over which assessments are made.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation.
CSSI	Critical
Decibel (dB)	A measure of sound equivalent to 20 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure, and 10 times the logarithm (to base 10) of the ratio of a given sound power to a reference power.
dB(A)	Unit used to measure ‘A-weighted’ sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.
dB(C)	Unit used to measure ‘C-weighted’ sound pressure levels, an adjustment made to sound level to approximate low frequency noise between 10 Hz and 200 Hz.
DPIE	NSW Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
Extraneous noise	Noise resulting from activities that are not typical of the area such as construction, and traffic generated by holiday periods or special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.
Highly affected receivers	Residential receivers are considered to be highly noise affected where construction activities are determined to have an LAeq, 15 minute noise level of 75 dB(A) or higher.
Highly noise intensive works	Construction activities which are defined as annoying under the ICNG. See Section 2.1.2.
ICNG	Interim Construction Noise Guideline (Department of Environment and Climate Change 2009)
Noise assessment criteria	A standard rule or test by which the acceptability of the nature and characteristics of noise may be judged or evaluated. Criteria are generally based on guidelines or standards developed by Government agencies (eg EPA) to protect the majority of people for the majority of the time from adverse impacts.
NCA	Noise Catchment Area

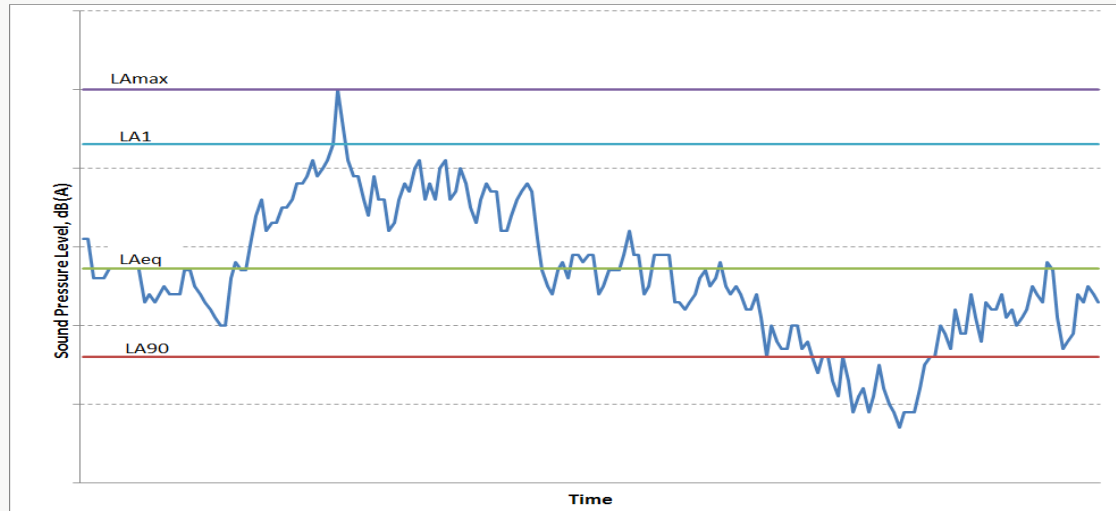
Noise level statistics

L_{A90} – The A-weighted sound pressure level exceeded 90% of the monitoring period. This is considered to represent the background noise.

L_{Aeq} – The equivalent continuous A-weighted noise level—the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

L_{A1} – The A-weighted sound pressure level exceeded 1% of the monitoring period.

L_{Amax} – The maximum A-weighted noise level associated with the measurement period.



NML Noise Management Level

PPV Peak Particle Velocity – Measurement of ground-borne vibration in units of mm/s

RBL Rating Background Level - a single figure that represents the background noise level for assessment purposes

ROL Road Occupancy Licence – granted by Transport for NSW and required for any activity likely to impact on traffic flow.

Sound Power Level (SWL) The A-weighted sound power level is a logarithmic ratio of the acoustic power output of a source relative to 10-12 watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.

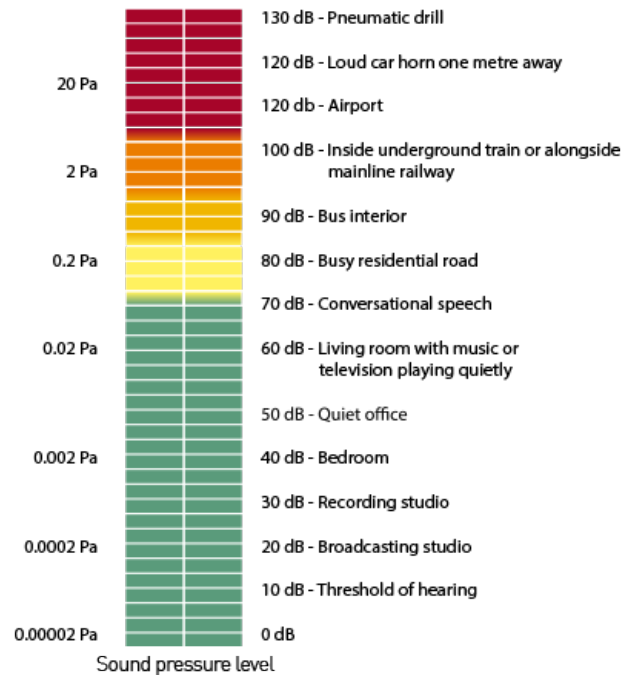
Work Any physical work to construct or facilitate the construction of the CSSI, including Low Impact Work, environmental management measures and utility work. However, does not include activities that informs or enables detailed design of the CSSI or generates noise that is not more than 5 dB(A) above the RBL at any sensitive land user(s)

Sound Pressure Level (SPL)

This is the level of noise, usually expressed in dB(A), as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dB(A) gives a close indication of the subjective loudness of noise.

A technical definition for the sound pressure level, in decibels, is 20 times the logarithm (base 10) of the ratio of any two quantities related to a given sound pressure to a reference pressure (typically 20 μ Pa equivalent to 0 dB). Examples of typical sound pressure levels are shown below.

Threshold of pain



Source: https://www.osha.gov/dts/osta/otm/noise/health_effects/soundpropagation.html

Tonal noise

Noise with perceptible and definite pitch or tone

VDV

Vibration dose value – used when assessing intermittent vibration as it is sensitive to peaks in vibration acceleration and accumulates the vibration energy received over the daytime and night-time periods

1. Introduction

1.1 Project overview

Sydney Metro is Australia's biggest public transport program comprising four main packages of work including Metro North West Line, Sydney Metro City and Southwest, Sydney Metro West and Sydney Metro Greater West. The Sydney Metro West component involves the construction and operation of a metro rail line, around 24km in length, between Westmead and the Sydney CBD.

The planning approvals and environmental impact assessment for Sydney Metro West has been split into a number of stages recognising the size of the project. This includes:

- Stage 1 – Concept and all major civil construction works including station excavation and tunnelling between Westmead and The Bays. Planning approval for this stage was granted in March 2021.
- Stage 2 – All major civil construction works including station excavation and tunnelling from The Bays to Sydney CBD
- Stage 3 – Tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line

Acciona Ferroviaria Joint Venture (AFJV) was commissioned to deliver the Central Tunnel Package of Stage 1, comprising excavation of five station boxes and around 11.5 kilometres of twin-bore tunnel between The Bays and Sydney Olympic Park (the Project). An overview of the Project is presented in Figure 1-1, which includes the tunnel alignment and location of the station boxes at:

- The Bays
- Five Dock
- Burwood North
- North Strathfield
- Sydney Olympic Park

Construction of North Strathfield Station box would take place adjacent to the existing North Strathfield train station and will include a number of phases:

1. Site establishment
2. Excavation of the station box
3. Load out and nozzle excavation
4. Tunnelling and support
5. Demobilisation

An overview of the site layout of North Strathfield is presented in Figure 1-2.

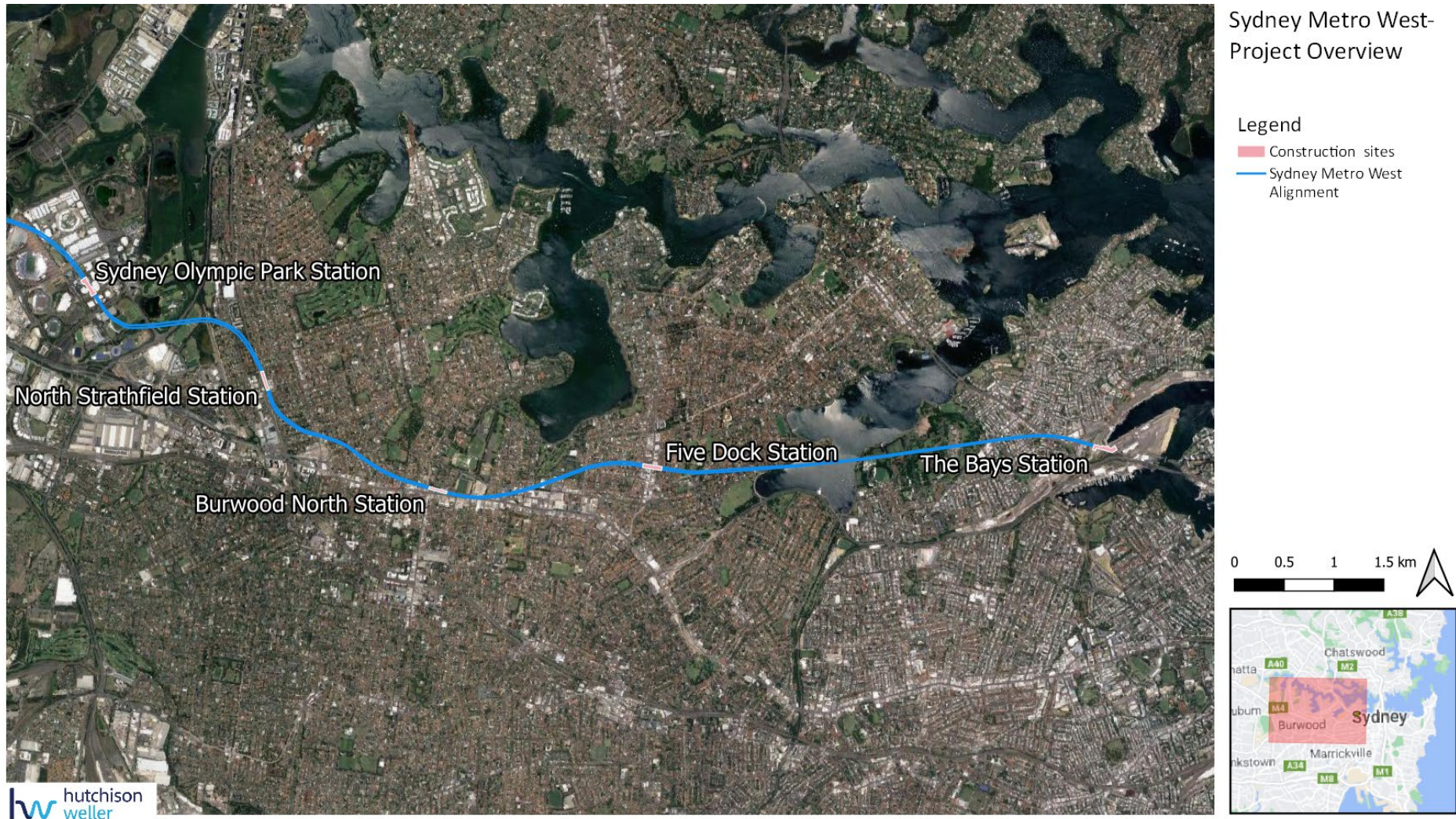


Figure 1-1 Overview of the CTP of Stage 1 of the Sydney Metro West Project.



Figure 1-2 North Strathfield construction site

1.2 Detailed noise and vibration impact statement

Considering the risk of noise and vibration impact is necessary to ensure appropriate mitigation and management measures can be applied. This Detailed Noise and Vibration Impact Assessment (DNVIS) has been prepared in accordance with the Sydney Metro (2020) Construction Noise and Vibration Standard, v 4.3 (CNVS) and supplements the Project's Construction Noise and Vibration Management Plan (CNVMP) as required in the Project's Condition of Approval (CoA) D43.

The objective of the DNVIS is to establish the location, nature and scale of proposed works, assess the level of impact on the community's amenity and include mitigation measures identified through consultation with affected sensitive land users.

This DNVIS addresses Phases 4 and 5 of the construction program.

The structure of this DNVIS meets the requirements of the Condition of Approval D43 and the CNVS and includes:

- Section 2 – Construction works and hours
- Section 3 – Identification of noise and vibration sensitive receivers and existing noise levels
- Section 4 – Construction noise and vibration objectives
- Section 5 – Description of planned works, equipment and sound power levels
- Section 6 – Construction noise assessment – predicted noise levels and exceedances of objectives, including sleep disturbance
- Section 7 – Summary, mitigation and management, consultation

2. Construction works and hours

2.1 Planned works

Activities associated with the North Strathfield station box are summarised in Table 2-1 and completed in 4 main phases generally following activities around establishment, excavation and tunnelling and support; and finally demobilisation.

Construction phases up to tunnelling support have now been completed. Once tunnelling is finalised, the project site will be demobilised in preparation for the next stage of the project, which will include civil construction works. The anticipated program to project completion is illustrated in Table 2-2.

Once piling activities were completed, shaft excavation started with excavation works lasting around 18-19 months. Tunnel support activities would occur with TBM walk through and use of conveyors for spoil management.

As described in Section 1.2, this DNVIS addresses phases 4 & 5. The arrival of the TBMs at the North Strathfield station box will trigger the next phase of works associated with TBM tunnelling and support, which will include:

- TBM traverse
- TBM maintenance
- TBM relaunch
- Cross passage ramp pull-through
- Spoil handling and ventilation (below surface level)
- Materials deliveries (below surface level)
- Concrete deliveries during standard construction hours (surface level)

A discussion of tunnelling definitions used for this DNVIS and details of the TBM operation and support activities have been included below.

In addition to the tunnelling support activities at North Strathfield included in the scope of this DNVIS, the TBMs will also continue be supported by activities at Burwood North, Five Dock and The Bays. Those activities are covered in their respective DNVIS's.

Demobilisation of the North Strathfield site is also included in this update and is expected to take around 10 months (not continuous) and will include:

- Removal of temporary works not required for handover at completion
- Dismantling and removal of site offices/cribs
- Asphalt restoration

TBM tunnelling

Under Planning Approval Condition D37 (d) tunnelling is considered a prescribed activity and permitted 24/7.

Within EIS Technical Paper 2 Noise and Vibration Table 25, TBM launch, support and extraction; mucking out and spoil handling; and construction traffic for material supply to and spoil removal from tunnelling and underground excavation (station and ancillary facility sites) were considered aboveground construction activities proposed 24 hours per day, seven days per week. Additionally, tunnelling works were proposed 24 hours per day, seven days per week and the table noted "activities that support tunnelling may need to occur 24 hours per day, up to seven days per week."

This is also supported by Table 13 of the SSI Assessment Report (DPIE, March 2021) which notes that aboveground long term activities to support tunnelling will be undertaken 24 hours a day seven days a week / outside standard construction hours.

EIS Technical Paper 2 Noise and Vibration Table 26 provides the following justification for out of hours work for tunnelling (including cross passages) and tunnelling support activities (including tunnel boring machine launch/retrieval and spoil handling):

Tunnelling and excavation works would define the overall Stage 1 duration. Earlier completion would bring considerable benefits to the community and would reduce the duration of construction related disruption.

Other aspects of the justification for out of hours tunnelling and support operations include:

- Need to install ground support systems immediately following excavation
- Need to construct cross passages closely following the progress of the TBMs to provide a critical secondary egress for people to evacuate and access for emergency services in the event of an incident
- Reducing peak demand on the electricity network
- Need to handle the spoil produced by the 24/7 operation of the tunnel boring machines and the proposed out of hours transport of spoil

On this basis, the proposed activities required for TBM tunnelling, both aboveground and underground, are considered tunnelling under condition D37 (d) and therefore permissible outside Condition D35 construction hours.

Following the arrival and relaunch of the TBM, tunnelling activities proposed at North Strathfield outside Condition D35 construction hours below ground level will include:

- spoil transfer via conveyor,
- Multi Service Vehicles (MSV) delivering segments/personnel to the TBM
- use of other support vehicles as required.

The TBM is scheduled to arrive at the North Strathfield station box in mid-2024. After breaking through into the station box, the TBM will traverse the station box towards the relaunch face in the North. This operation will take approximately 2-3 weeks for each TBM to complete required 24 hour work.

During the traverse, the TBM will progress by pushing against specialised steel structure (TBM rails) that simulates the tunnel lining segments, which will be located on the station box floor. The TBM rails are assembled progressively at the rear of the TBM shields after each push phase of the TBM. This continues until the TBM reaches the end of the nozzle where ring segments can once again be installed.

During the TBM traverse, general maintenance will be carried out on the TBM's in the station box, to ensure they are ready to relaunch and complete tunnelling works towards Sydney Olympic Park. This maintenance is likely to include, but not limited to; replacement or refurbishment of cutting tools, cutting and welding of steel, replacement of components, use of oils and greases to replenish the machine. For this maintenance to be carried out, the team will require the use of mobile plant and hand tools. This could include forklifts, cranes, telehandler, EWP's and people moving light vehicles. Hand tools are likely to include welding equipment, electric saws and grinders, torque wrenches, drills and non-powered tools. Maintenance may occur outside standard construction hours but will be undertaken within standard construction hours where reasonable and feasible.

To complete the traverse, assembly of the TBM rails will need to be continuous and will include the use of hand tools, which may include noise generating activities such as hammering metal components. These activities have the highest potential to generate noise impacts until the TBM recommences tunnelling.

When the TBM is relaunched from the nozzles at the northern (western heading) end of the station box, the cutting head will be inside the pre-excavated nozzle. Noise from the operation of the TBM gantries, plant and maintenance activities during the relaunch will be the only audible noise source from the station box during this time.

The TBM tunnelling phase of the project at North Strathfield will include TBM tunnelling support to transport spoil from the tunnel face and transport personnel and materials including ring segments to the TBM for installation. Segments and materials will be transported using MSV's that will operate up to 24 hours 7 days per week. This will include activities that are permitted by condition D37(d).

The spoil will be transported via a continuously operating conveyor system terminating at The Bays compound where spoil is stockpiled and transported off site. With the length of the conveyor increasing as the TBM progresses, additional booster systems will need to be installed periodically along the conveyor path. One booster system per conveyor/tunnel drive will be installed at North Strathfield. Noise modelling for this DNVIS includes the operation of the conveyors and boosters in the main station box shaft without any additional attenuation as a conservative assessment scenario. The conveyor system will be turned off when not in use and maintained as per manufacturer's specifications to reduce potential noise from rollers and motors.

Fresh air ventilation for the TBM tunnels will be provided from axial fans at Burwood North, however, ducting will run through the North Strathfield station box near the conveyors.

Alarms and sirens are important for the safety of personnel working in or near the TBMs and conveyors. A risk assessment was undertaken to identify routine TBM alarms that can be replaced with beacon lights as a visual administration control rather than an audible siren during evening and night shift. Evacuation and emergency alarms are still required to be audible in the event of an emergency.

During TBM operation periodic maintenance may be required on the spoil conveyor and boosters which could involve the use of EWP's, hand tools and plant such as forklifts/telehandlers

Table 2-1 and Table 2-2 present a summary the activities for each of the North Strathfield construction sites.

Table 2-1 Summary of proposed activities at North Strathfield Station Box

Construction phase	Activity			Outside approved hours?
1. Site Establishment Completed	1a	Daily activities		No
	1b	Construction utilities and facilities		No
	1c	Temporary fencing/ hoardings		No
	1d	Utilities disconnection/relocation		No
2. Station Box Excavation Completed	2a	Piling		No
	2b	Capping beams	Detailed excavation, break back & capping beam	No
	2c	Active anchors	Ground stabilisation	No
	2d	Excavation & Retention	Other Than Rock (OTR) - Dozer (No ripping)	No
	2e		Rippable - Dozer (Ripping), Rock hammering	No
	2f		Retention - Rockbolts	No
	2g		Grouting	No

3. Load out and Nozzle excavation	3a	Load out – All excavation	No
	3b	Tunnel Nozzle Excavation	No
	3c	Tunnel Nozzle Concrete Lining	No

Table 2-2 Summary of activities tunnelling support

Construction phase	Activity			Outside approved hours?
4 Tunnelling	4a	TBM Traverse	TBM traverse from east to west of the station box. Maintenance activities will be completed during traverse.	Yes
	4b	TBM maintenance		Yes
	4bi	Maintenance (Stn box and Surface)		Yes
	4c	TBM relaunch	TBM relaunch (within the cavern)	Yes
	4d	Tunnelling support	Segment deliveries and spoil transport	Yes
	4e	Cross passage ramps	Traverse of ramps within station box area	Yes
5 Demobilisation	5a	Removal of modules	Site decommissioning*	No
	5b	Demolition of concrete plinths		No
	5ci	Plant and equipment removal.		No
	5d	Site clean-up/removal of demolition materials		No
	5e	Permanent asphalt restoration (site compound)		No
	5f	Road works		No

*Out of hours work may be required for oversized vehicle movements or road closures only approved for night periods which is allowed under D37 and the EPL. These activities would be assessed and managed through the out of hours work process.



Table 2-3 Anticipated program for North Strathfield

North Strathfield		2024												2025											
Phase	Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Station box	3. Tunnel Nozzle																								
	4. TBM Enabling																								
	4. TBM traverse and relaunch																								
	4. TBM support																								
All sites	5. Demobilisation																								

2.1.1 Approved construction hours

Working hours are set by CoA D35 to D36 as summarised in Table 2-3. Use of power saws, rock breakers, drills and other tonal or impulsive activities are defined as annoying under the Interim Construction Noise Guideline (ICNG) and are 'highly noise intensive works'.

Table 2-4 Approved construction hours

CoA	Construction activity	Monday to Friday	Saturday	Sunday / Public holiday
D35	Approved construction	7:00 am to 6:00 pm	8:00 am to 6:00 pm	No work (unless approved under out-of-hours work protocol)
D36	Highly noise intensive works	8:00 am to 6:00 pm ¹	8:00 am to 1:00 pm ¹	No work (unless approved under out-of-hours work protocol)

Notes:

1. if continuously, then not exceeding three hours, with a minimum cessation of work of not less than one hour.

2.1.2 Variations to work hours

In some circumstances, the planned construction activities would be undertaken outside the hours described in CoA D35 and D36. As specified in the Conditions of Approval, these activities include those which are:

- Low impact as described in CoA D37b), including:
 - i. construction that causes LAeq(15 minute) noise levels:
 - no more than 5 dB(A) above the rating background level at any residence in accordance with the ICNG, and
 - no more than the 'Noise affected' NMLs specified in Table 3 of the ICNG at other sensitive land user(s); and
 - ii. construction that causes LAFmax(15 minute) noise levels no more than 15 dB(A) above the rating background level at any residence; or
 - iii. construction that causes:
 - continuous or impulsive vibration values, measured at the most affected residence are no more than the preferred values for human exposure to vibration, specified in Table 2.2 of Assessing Vibration: a technical guideline (DEC, 2006), or
 - intermittent vibration values measured at the most affected residence are no more than the preferred values for human exposure to vibration, specified in Table 2.4 of Assessing Vibration: a technical guideline (DEC, 2006).
- By Prescribed Activity, as described in CoA D37d) and applying to North Strathfield construction scenarios:
 - i. tunnelling (excluding cut and cover tunnelling and surface works) which is permitted 24 hours a day, seven days a week; or
 - ii. delivery of material that is required to be delivered outside of standard construction hours in Condition D35 of this schedule to directly support tunnelling activities
 - iii. work within an acoustic shed where there is no exceedance of noise levels under Low impact circumstances identified in (b) above, unless otherwise agreed by the Planning Secretary.

Where out-of-hours work is necessary, appropriate respite would be identified in consultation with the affected community, in line with the NVMP. As per CoA D51, consultation would include providing:

- a) a progressive schedule for periods no less than three (3) months, of likely out-of-hours work;
- b) a description of the potential work, location and duration of the out-of-hours work;
- c) the noise characteristics and likely noise levels of the work; and
- d) likely mitigation and management measures which aim to achieve the relevant NMLs (See Section 4) including circumstances of when respite or relocation offers would be available and details about how the affected community can access these offers.

3. Existing environment

3.1 Existing environment

The North Strathfield Station Box construction site is sandwiched between the existing North Strathfield train station and rail corridor and Queen Street in North Strathfield, as illustrated in Figure 1-2. The site covers an area of around 1.2 ha.

Land uses adjacent to the site are characterised by educational facilities to the west, across the existing rail corridor, with some residential dwellings to the south west, also adjacent to the rail corridor. A group of mixed-use commercial/residential buildings are located to the east of the site on Queen Street, bounded by Wellbank St and Waratah St. To the north of these buildings are residential dwellings that extend past the roundabout at the northern extremity of the site.

The acoustic environment is described in the EIS as dominated by traffic along the surrounding road network and existing rail line.

To assess and manage construction noise and vibration impacts, a detailed land use survey was prepared for the Project in line with CoA D34, with results of the survey are provided in the Construction Noise and Vibration Management Plan (CNVMP) and relevant land uses to North Strathfield are presented in Appendix A of this DNVIS.

3.2 Sensitive receivers

To assess and manage construction noise and vibration impacts, a detailed land use survey was prepared for the Project in line with CoA D34, with results of the survey are provided graphically in the Construction Noise and Vibration Management Plan (CNVMP) and relevant land uses to North Strathfield are presented in Appendix A of this DNVIS.

In summary, a number of residential and non-residential receivers have been identified and include:

- Residential receivers immediately opposite the site on Queen Street
- Non-residential receivers including:
 - Our Lady of the Assumption Catholic Primary School in Hamilton Street
 - McDonald College George Street
 - Banter Speech and Language
 - Other businesses

Consultation with sensitive receivers is underway and continuing. Feedback to date is summarised in Section 7.1.5.

3.3 Heritage items

There are two items of heritage value area were identified in the EIS, which include the following. These items are not structural and haven't been considered further in the assessment of vibration impacts for this site.

- North Strathfield Railway Station Group – Gardens
- Heritage street trees along Queen Street

3.4 Noise catchment areas

To facilitate the assessment of noise impacts from the project and to apply representative Noise Management Levels (NMLs) to all receivers, receivers adjacent to the North Strathfield sites have been divided into Noise Catchment Areas (NCAs).

NCAs group individual sensitive receivers by representative traits such as existing noise environment and potential exposure to noise and vibration from the Project.

NCAs were established as part of the EIS, are summarised in Table 3-1 and illustrated in Figure 1-1. Background noise monitoring has been completed as part of the EIS to apply appropriate NML to each NCA (see Section 4.2).

Table 3-1 Summary of work areas, Noise Catchment Areas and land uses

NCA	Location	Description	Ambient noise influences
NCA10	North Strathfield, West of the existing rail corridor	A group of educational facilities to the which include McDonald College and Our Lady of the Assumption Primary School. Residential dwellings comprise the balance of sensitive receivers	Existing noise is influenced by the surrounding road network and existing rail line. The area surrounding the Construction Site is generally suburban with a mixture of residential, commercial and educational receivers.
NCA11	North Strathfield, East of the existing rail corridor	Mainly residential, with a small group of mixed-use commercial/ residential receivers along Queen Street	

3.5 Background noise survey

Background noise monitoring was undertaken as part of the wider Sydney Metro West Project EIS (Section 2, Technical Paper 2) through unattended background noise monitoring at representative locations. Monitoring was completed in March and July 2019 for each of the NCAs listed in Table 3-1.

The North Strathfield area is heavily influenced by traffic flows that generate lower noise levels during the night-time than the daytime and evening periods. This pattern of reduced noise levels in the evening and night time is characteristic of urban and suburban areas, where there is no industrial or infrastructure noise influences.

The baseline information was used to establish the Rating Background Level (RBL), which represents the average minimum background sound level for each measurement period, averaged over the measurement days. The RBL at each NCA is provided in Table 3-2.

Table 3-2 Background noise levels

NCA	Noise level (dBA) ¹		
	Day ²	Evening ²	Night ²
NCA10	47	47	44
NCA11	51	47	39

Notes:

1. The RBL values have been extracted from the EIS; refer to Table 4 in the EIS Technical Paper 2.
2. Daytime is 7:00am to 6:00pm, evening is 6:00pm to 10:00pm and night-time is 10:00pm to 7:00am.

4. Noise and vibration assessment criteria

4.1 Overview

Project CoA D43 requires planned works to be assessed within this DNVIS where any planned works may exceed the NMLs, vibration criteria and/or ground-borne noise levels specified in CoA D39 and D40 at any residence outside construction hours identified in CoA D35, or where receivers will be highly noise affected.

This DNVIS includes specific mitigation measures identified through consultation with affected sensitive land user(s) and these mitigation measures will be implemented for the duration of the early works investigations.

This DNVIS has been provided to the AA and ER before the commencement of the planned works.

CoA D39 requires noise and vibration from construction activity to be managed with guidance from:

- Noise: the Interim Construction Noise Guideline (ICNG, DECC 2009)
- Vibration for human exposure: Assessing Vibration: A Technical Guideline (DEC, 2006)
- Vibration for building damage: BS 7385 Part 2-1993 – Evaluation and measurement for vibration in buildings Part 2, and
- Vibration for damage of unsound heritage items: DIN 4150-3 Structural Vibration – effects of vibration on structures.

The over-arching document for assessment and management of noise and vibration impacts on this Sydney Metro project is the Sydney Metro *Construction Noise and Vibration Standard* (CNVS, vers. 4.3, Transport for NSW 2020). The following sections outline the framework of these guidelines and the way this DNVIS will assist to assess and manage impacts.

4.2 Noise

4.2.1 ICNG

The CNVS refers to the *Interim Construction Noise Guideline* (ICNG) (DECC 2009), which provides guidance on management of construction noise. The ICNG notes noise that exceeds background noise levels may result in adverse impacts and an increased likelihood of complaints.

During approved hours, where construction noise is within 10 dB(A) of the RBL, impacts are considered acceptable. Where construction noise is more than 10 dB(A) above the RBL, a residential receiver is taken to be noise affected and the proponent should undertake all reasonable and feasible steps to manage the impact and consult with the affected community.

Above a $L_{Aeq, 15 \text{ minute}}$ noise level of 75 dB(A), a residential receiver is considered to be highly noise affected, requiring respite to be given in consultation with the regulatory authority and the community.

Outside approved construction hours, construction noise at a residential receiver more than 5 dB(A) above the RBL is taken to be noise affected.

In addition, noise from activities/equipment such as rock hammers, impact piling, or other impulsive noise sources usually result in greater annoyance than continuous construction noise. A 5 dB(A) penalty is applicable to such activities prior to comparison with the NMLs and a 3 hours on, 1 hour off respite schedule applies.

A noise level above $L_{Aeq, 15 \text{ min}}$ 70 dB(A) at a commercial property is considered to warrant noise mitigation. Similarly, an industrial facility would warrant noise mitigation at $L_{Aeq, 15 \text{ minute}}$ noise levels above 75 dB(A).

Table 4-1 presents management levels for noise at other relevant sensitive land uses based on the principle that the characteristic activities for each of these land uses should not be unduly disturbed.

Internal noise levels are assessed at the centre of the occupied room. Where internal noise levels cannot be measured, external noise levels may be used. A conservative estimate of the difference between internal and external noise levels is 10 dB for buildings other than residences.

Table 4-1 NMLs for non-residential sensitive receivers

Sensitive receiver type	NML applicable when in use, LAeq, 15 min
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Childcare centres - sleeping areas - play areas	Internal noise level 45 dB(A) External noise level 65 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Community centres	Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

4.2.2 Sleep disturbance

The CNVS requires maximum noise levels to be analysed in terms of the extent and number of times the maximum noise exceeds specific noise trigger levels, in general accordance with the Noise Policy for Industry (NPfI) (EPA 2017). These triggers are:

- LAeq, 15 minute 40 dBA or the prevailing RBL plus 5 dB, whichever is greater, and the
- LAmx 52 dBA or the prevailing RBL plus 15 dB, whichever is greater.

The NPfI also recommends the DECCW (2011) Road Noise Policy (RNP) be reviewed for further risk assessment. The RNP recommends maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep and one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

4.2.3 Ground-borne noise

CoA D40 requires all reasonable and feasible mitigation measures to be applied when the following residential ground-borne noise levels are exceeded. These levels are only applicable when ground-borne noise levels are higher than airborne noise levels at residential receivers during the evening and night periods.

- evening (6:00 pm to 10:00 pm) — internal LAeq(15 minute): 40 dB(A); and
- night (10:00 pm to 7:00 am) — internal LAeq(15 minute): 35 dB(A).

4.2.4 Construction traffic

While operating within the construction site, construction vehicles are assessed as part of the construction activity of which they are a part. However, once these vehicles leave the construction site and enter public roads, they are assessed as road traffic.

The Road Noise Policy (RNP) is generally adopted to assess the impact of construction traffic on public roads. A screening test is first applied to establish whether existing road traffic noise levels will increase by more than 2 dB due to construction traffic. Where any noise increase is less than 2 dB, the objectives of the Road Noise Policy have been met.

The CNVS recommends, where the road traffic noise levels are predicted to increase by more than 2 dB as a result of construction traffic, consideration should be given to feasible and reasonable noise mitigation measures to reduce the potential noise impacts and preserve acoustic amenity.

In considering feasible and reasonable mitigation measures, the actual noise levels associated with construction traffic and whether these levels comply with the road traffic noise criteria in the RNP would be reviewed.

- 60 dB LAeq(15hour) day and 55 dB LAeq(9hour) night for existing freeway/ arterial/ sub-arterial roads.
- 55 dB LAeq(1hour) day and 50 dB LAeq(1hour) night for existing local roads.

4.2.5 Additional mitigation measures

The CNVS builds on the guidance provided by the ICNG and recommended further mitigation measures where all reasonable and feasible mitigation measures to minimise noise at the nearest receivers have been implemented and construction noise is still predicted to exceed the noise or vibration objectives. The Additional Mitigation Measures Matrix (AMMM) for airborne and ground-borne noise taken from the CNVS are presented in Table 4-2 and Table 4-3.

Table 4-2 Additional Mitigation Measures Matrix for airborne noise (CNVS)

Construction hours	dB above NML	Additional management measures
Approved hours Monday – Friday: 7am – 6pm Saturday: 8am to 6pm	0 to 10	-
	10 to 20	LB
	20 to 30	LB, M, SN
	>30	LB, M, SN
Evening Monday – Friday: 6pm – 10pm Saturday: 7am – 8am, 6pm – 10pm Sunday / PH: 8am – 6pm	0 to 10	LB
	10 to 20	LB, M
	20 to 30	LB, M, SN, RO
	> 30	LB, M, SN, IB, PC, RO
Night Monday – Saturday: 10am – 7am Saturday: 10pm – 8am) Sunday / PH: 6pm – 7am	0 to 10	LB
	10 to 20	LB, M, SN, RO
	20 to 30	LB, M, SN, IB, PC, RO, AA
	> 30	LB, M, SN, IB, PC, RO, AA

Notes: PC = Phone Calls and emails
M = Monitoring
IB = Individual briefings
AA = Alternative accommodation
SN = Specific notification
LB = Letterbox drops
RO = Project specific respite offer

Table 4-3 Additional Mitigation Measures Matrix for ground-borne noise (CNVS)

Construction hours	dB above NML	Additional management measures
Approved hours Monday – Friday: 7am – 6pm Saturday: 8am to 6pm	No NML for ground-borne noise during standard hours (refer to Table 4-7)	
Evening Monday – Friday: 6pm – 10pm Saturday: 7am – 8am, 6pm – 10pm Sunday / PH: 8am – 6pm	0 to 10	LB
	10 to 20	LB, M, SN
	> 20	LB, M, SN, IB, PC, RO
Night Monday – Saturday: 10am – 7am Saturday: 10pm – 8am) Sunday / PH: 6pm – 7am	0 to 10	LB, M, SN
	10 to 20	LB, M, SN, IB, PC, RO, AA
	> 20	LB, M, SN, IB, PC, RO, AA

Notes: PN = Project notification SN = Specific notification
M = monitoring LB = Letterbox drops
IB = Individual briefings DR = Duration reduction
AA = Alternative accommodation RO = Project specific respite offer

4.3 Project-specific construction noise management levels

Based on the measured RBLs for each NCA and requirements of the ICNG and CNVS, project-specific NMLs are summarised in Table 4-4. NMLs for non-residential receivers are described in Table 4-1.

Table 4-4 Noise management levels

NCA	Noise Management Level, L_{Aeq} 15 minute						
	Approved hours		Outside approved hours				
	Noise affected	Highly noise affected	Day	Evening	Night	Sleep disturbance (CNVS)	
						L_{Aeq} , 15 minute	L_{Amax}
NCA10	57	75	52	52	49	49	59
NCA11	61	75	56	52	44	44	54

4.4 Vibration management

4.4.1 Human comfort

When assessing human exposure to construction-related vibration, the CNVS requires vibration goals to be established using *Environmental Noise Management Assessing Vibration: A Technical Guideline* (AVATG) (DECC 2006), which provides criteria for the assessment of vibration impacts on humans. Note, the CNVS adopts an 8-hour period for the night time human comfort criteria whereas the AVATG nominates a 9-hour period. To ensure consistency with the CNVS, 8 hours has been adopted for the project.

Construction activities typically generate vibration of an intermittent nature, which is assessed using a Vibration Dose Value (VDV). Acceptable values of vibration doses are presented in Table 4-5 for sensitive receivers.

Table 4-5 VDV Vibration criteria

Receiver type	Low probability of adverse comment (m/s ^{1.75})	Adverse comment possible (m/s ^{1.75})	Adverse comment probable (m/s ^{1.75})
Residential buildings – 16 hour day (7am to 11pm) ¹	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings – 8 hour night (11pm to 7am) ¹	0.13	0.26	0.51

Note 1: Day time and night time as described in BS6472:1992 (as referenced in the CNVS), i.e. a daytime period of 16 h or a night time period of 8 h, for example 23.00 h to 07.00 h.

4.4.2 Buildings

Potential building damage from construction vibration requires the application of values in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings* Part 2. These values are presented in Table 4-6 and relate to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

Table 4-6 Guideline values for vibration velocity for the effects of short-term vibration on structures (BS 7385).

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz to 50 mm/s at 40 Hz and above

Where vibration may give rise to magnification due to resonance, especially at lower frequencies where lower guide values apply, the guide values may be reduced by 50%. The CNVS describes rock breaking/hammering and sheet piling activities as having potential to cause dynamic loading in some structures (e.g. residences).

For activity involving rock breakers, piling rigs, vibratory rollers, excavators, vibration predominantly occurs at frequencies in the 10 Hz to 100 Hz range. On this basis, a conservative vibration damage screening level is:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

4.4.3 Heritage

Undocumented heritage structures would be assessed under a conservative cosmetic damage objectives of 2.5 mm/s peak component particle velocity (from DIN 4150). Where vibration levels at heritage items are identified as exceeding this screening level, structural assessment would be completed by the Project team to confirm the structure's sensitivity to vibration. If a heritage structure is found to be structurally unsound (following inspection) the conservative criterion would stand. Where the structure is suitably sound, the guideline values from Table 4-6 would be applicable.

4.4.4 Additional mitigation measures

The CNVS recommends additional mitigation measures where all standard mitigation measures to minimise vibration at the nearest receivers have been implemented and vibration is still predicted to exceed the maximum guideline values. The Additional Mitigation Measures Matrix (AMMM) for vibration from the CNVS is presented in Table 4-7. Acronyms are defined at Table 4-2.

Table 4-7 Additional Vibration Mitigation Measures (CNVS)

Construction hours	Mitigation measures where predicted vibration levels exceed maximum levels
Approved hours Monday – Friday: 7am – 6pm, Saturday: 8am to 6pm	LB, M, RO
Evening Monday – Friday: 6pm – 10pm; Saturday: 7am – 8am, 6pm – 10pm; Sunday / PH: 8am – 6pm	LB, M, IB, PC, RO, SN
Night Monday – Saturday: 10am – 7am Saturday: 10pm – 8am); Sunday / PH: 6pm – 7am	LB, M, IB, PC, RO, SN, AA

Notes

PN = Project notification
M = monitoring
IB = Individual briefings
AA = Alternative accommodation

SN = Specific notification
LB = Letterbox drops
DR = Duration reduction
RO = Project specific respite offer

5. Impact assessment

5.1 Plant and equipment

A summary of proposed activities at the North Strathfield sites was provided in Table 2-1. Nominal equipment and estimated sound power levels of each item and activity are presented in Appendix B.

Over the day, evening and night periods, equipment types and numbers will vary, with no works proposed outside standard hours, except TBM tunnelling support activities and activities assessed in OOHWP permit.

When considering activities at each receiver, noise levels will vary during the construction period based on:

- the number of plant items operating at any one time
- plant and equipment location on site and relative to a sensitive receiver
- the actual SWLs of plant and equipment and their operating durations in an assessment period

5.2 Noise modelling

SoundPlan noise modelling software was used to calculate noise impacts in accordance with the ISO9613 prediction method at all identified noise-sensitive receivers. The model included:

- Topography – 1 metre DEM based on LPI Lidar data.
- Individual buildings for façade calculations and to account for shielding and reflections. Building heights are also taken from Lidar data.
- Individual sensitive receivers – One receiver location representing each residential dwelling and located 1.5 metres above most affected floor level (e.g. level 2) and most-affected façade at up to around 600 metres radius.
- Construction noise sources –Activities and equipment included in the noise model as area sources in locations specified by AFJV. SoundPlan takes the worst-case point within each area to perform its calculations, a conservative approach. Sound power levels in Appendix B. Source is modelled at 1.5 metres above ground.
- Each phase of work was modelled to account for the benefit from site hoarding during the establishment phase.
- Meteorology –worst-case conditions: gentle breeze (3-5 m/s) source to receiver and stable conditions (conducive of temperature inversion).

5.3 Mitigation measures included in the modelling

Mitigation measures would be implemented to ameliorate noise impacts as standard practice throughout the works. Mitigation measures, which may affect the predicted levels include the following, which have been incorporated in the assessment as base assumptions for noise predictions.

- Source noise control strategies:
 - Where the NML outside approved hours cannot be achieved, work is not proposed to be undertaken unless unavoidable and completed under the procedures contained in the CNVMP.
 - Equipment sound power levels will not exceed those described in Table 13 of the CNVS.
 - Residential grade mufflers fitted to all mobile plant, with equipment maintained and operated effectively.
 - Use of rock hammers would be minimised where possible during excavation of the North Strathfield site

- Where non percussive drill rigs are used, a reduction of around 10 dB in comparison to similar percussive models
- No shouting or swearing or playing of loud radios
- Engine and exhaust brakes avoided
- Stationary plant placed behind larger objects or as far from receivers as possible
- Engines switched off when not in use for extended periods (15 minutes) and no idling trucks in front of residences
- Dropping of heavy objects or metal-on-metal impacts avoided
- Non-tonal reverse alarms installed on all mobile equipment regularly used on the project.

The above measures have been included in the assessment and are reiterated in Section 7.

- Noise barrier control strategies:
 - Hoarding of 3 metres in height that doubles as a security barrier and has been included in the model between the site entry and exit gates on Queens Road (see Figure 5-1). This location directly impacts commercial and residential receivers opposite the load out and temporary access area. Hoarding from the exit gate up to Pomeroy Road is a minimum of 2.4 metres in height with fencing around the rest of the site modelled as chain/screen fencing.
- Acoustic sheds
 - No acoustic sheds are proposed at this site.



Figure 5-1 North Strathfield Hoarding Layout



Figure 5-2 North Strathfield Hoarding in situ

6. Predicted noise levels

6.1.1 Overview

Construction work at North Strathfield is programmed during approved construction hours for all activities, except TBM tunnelling activities. A summary of predicted noise levels is provided in the following sections for each construction phase. Detailed results for all sensitive receivers are provided in Appendix D.

Noise contours for typical noisy activities are presented in Appendix C. The contours demonstrate the extent of the worst-case cumulative impacts and illustrate how local topography provides additional screening for nearby receivers, which improves with additional depth gained in the excavation phase of the works.

6.1.2 Phase 1 - Site establishment

Site establishment works have been completed. See earlier revisions of this document for detail of completed activities.

6.1.3 Phase 2 and 3 - Station Box construction and nozzle excavations

Station box excavations have been completed. See earlier revisions of this document for detail of completed activities. Nozzle concrete pours during standard construction hours are not predicted to exceed NML criteria.

6.1.4 Phase 4 - TBM tunnelling and support phase

During the TBM traverse, noise impacts are expected to exceed the NML criteria for all periods with around 6 receiver locations exceeding in the 0-10 dB(A) range during the night. The predicted exceedances are based on the noisiest activities using torque wrenches to tighten bolts on TBM rails. Mitigation measures such as using handheld torque wrenches rather than rattle guns during out of hours periods would be implemented to minimise impacts.

During the TBM traverse, TBM maintenance will generally be conducted within the footprint of the station box or nozzle however, some works lifting components to and from the station box will be required during this activity. Lift will be via a 60 t mobile crane located at the northern end of the station box at street level.

For works inside the station box, the depth of the station box will provide acoustic shielding to the surrounding receivers. Noise impacts associated with the maintenance of a single TBM are expected to exceed the night criteria in the 0-10 dB(A) range at up to 22 receiver locations. Where the mobile crane is operational on the surface during OOHW periods, the number of expected exceedances increases to 37 in the 0-10 dB range and up to 8 receivers in the 10-20 dB range.

During the TBM relaunch, the TBM will be only partially in the station box. Noise impacts associated with the relaunch of a single TBM are not expected to exceed the project criteria during any period of operation.

At North Strathfield, ongoing tunnelling support will be a requirement for spoil removal and segment deliveries for the tunnelling lining and concrete deliveries for cross passage construction. Tunnel support will include a conveyor system for each of the TBMs, as well as conveyor boosters to maintain tension in the conveyor belts, which will deliver spoil to The Bays site. The conveyor booster stations will comprise of electric motor and drive units, which will be the noisiest components for the conveyor system but are able to meet operational NML for the North Strathfield station box due to their location and depth of the cutting.

As per condition D39 any work identified as exceeding the noise management levels and / or vibration criteria will be managed through application of reasonable and feasible mitigation measures and in accordance with the

Noise and Vibration CEMP Sub-plan. Additional mitigation measures from Sydney Metro's CNVS will be applied where NML's are not achieved (refer to section 4.2.5 and 4.4.4).

A summary of noise level impacts for this phase of works is presented in Table 6-3.

6.1.5 Phase 5 - Demobilisation

Most demobilisation activities will commence shortly after the relaunch of the TBM from the North Strathfield Station Box. Demolition of the temporary platform decks and other infrastructure may, however, commence prior to the TBM arrival at Burwood site. Demolition of concrete within the station box would begin once the TBM has been relaunched and would utilise up to two 30 tonne excavators with hammers located in different areas when the TBM traverse slab is being demolished. Demolition impacts during hammering have considered the worst case for one rock hammer operational over a 15 minute period anywhere within the station box. Most of the high noise impact demolition will be completed during the initial stages of demobilisation with work expected to continue until the end of October 2024.

Complete site demobilisation will be undertaken using a crane to remove demolition materials from the station box area, which will then be loaded into trucks and transported from the site. The highest impacts will occur where works are completed at surface level along Queen Street and in the site compound.

Activities that require the use of rock hammers and vibratory compaction such as equipment removal and road works are expected to have the highest noise impacts with up to 21 receivers in the 0-10 dB(A) range and 22 receivers in the 10-20 dB(A) range during road works. These impacts will reduce where hammering and or jack hammering are not undertaken close to residences. The demobilisation works and therefore all noisy activities are programmed for standard construction hours only.

Demobilisation of the whole site is expected to be completed by about April 2025.

Table 6-1 Summary of predicted NML exceedances for TBM tunnelling activities

Activity		Maximum level, dBA			Predicted no. receivers with exceedance of NML														
					Approved hours			Outside approved hours - Day				Outside approved hours - Evening				Outside approved hours - night			
		Res	Non-res	Rec. >75	0-10	10-20	20+	0-10	10-20	20-30	30+	0-10	10-20	20-30	30+	0-10	10-20	20-30	30+
3c	Nozzle headwall/arches	57	43					Daytime only											
4a	TBM Traverse	47	39													6			
4b	TBM Maintenance	53	45					2				2				22			
4bi	Maint (Stn box & Surface)	59	51					15				15				37	8		
4c	TBM Relaunch	41	34																
4d	TBM Operational support	44	36																
4e	Cross passage	47	39													6			
5a	Demob - Removal of modules	58	42					Daytime only											
5b	Demob Stn box demolition	65	56		6														
5bi	Demob concreting	62	46		7														
5c	Demob Equipment removal	72	56		29	8													
5d	Demob Site clean-up	64	49		26														
5e	Demob Asphaltting	66	51		13														
5f	Demob – Road works	81	62	21	21	22													

6.1.6 Sleep disturbance

Activities outside approved hours any work within the North Strathfield station box would aim to be NML compliant using reasonable and feasible mitigation measures. Some activities during this time may generate noise levels above the L_{Amax} screening level. The activities having a higher risk of sleep disturbance will be identified and mitigated during night shift pre-starts and where appropriate alternative methods for these works will be investigated/implemented.

Activities external to the station box, such as utilities or oversized deliveries, undertaken outside of approved hours is covered separately under the project OOHW protocol.

Other out of hours work such as utility relocations and oversized plant, may be undertaken where they comply with CoA D37 and EPL 21610 and these works would be assessed through the out of hours works process.

6.2 Ground-borne noise

The requirement to consider ground-borne noise is applicable to tunnelling or other subterranean works which have the potential to generate internal noise impacts within a sensitive receiver. However, as discussed in Section 4.2.3, ground-borne noise is only assessed for the evening and night periods in residential locations. During excavation of the station box, vibration-intensive equipment such as vibratory rollers and drill rig/rock bolters would be used but these would only be during standard hours and airborne noise is expected to result in noise levels greater than the ground-borne noise component.

Therefore, ground-borne noise has not been considered further in this DNVIS.

6.3 Vibration impact assessment

6.3.1 Assessment method and reference data

Vibration-intensive surface works will form part of ongoing excavation works for the duration of the Project. Potential items of plant that can generate vibration impacts are:

- Rock hammers
- Vibratory rollers
- Percussive drills
- Dozer with ripper

To assess the likelihood of impacts on human comfort and structures, reference vibration levels are summarised in Table 6-3 and curves of vibration with distance are presented in Figure 6-1. Reference vibration levels are based on previously measured levels.

Table 6-2 Summary of vibration-intensive activities

Activity	Typical equipment	Typical PPV vibration emission levels	Source
Rock hammer (large)	47 t Excavator with hammer	4.8 mm/s at 10 m	Site measurement
Rock hammer (medium)	20 t Excavator with hammer	2.9 mm/s at 10 m	Site measurement
Percussive drilling	Airtrack drill or similar	1.5 mm/s at 10 m	Site measurement
Rock bolting	Jumbo bolter	0.4 mm/s at 2.5 m	Site measurement

Based on the estimated vibration emission levels of each activity and the following equation for geometric damping (conservatively ignoring material damping), levels of vibration with distance can be estimated.

$$PPV_2 = PPV_1 \left(\frac{R_1}{R_2} \right)^n$$

Where:

PPV – Peak Particle Velocity at the source (PPV₁) and Receiver (PPV₂)

R – distance from source of reference level (R₁) and distance from source of receiver (R₂)

n – ground factor assumed as 1.7 for body waves near the ground surface

Predicted levels of vibration over distance are summarised in the following sections.

6.3.2 Risk of cosmetic damage

Predicted levels of vibration over distance are illustrated in Figure 6-1. Considering the vibration guideline values prescribed in the CNVS of 7.5 mm/s for unreinforced or light framed structures such as the residential buildings near the site, the risk of cosmetic damage is low for equipment outside 7.5 metres from the source. Where unsound heritage items are present, with a guideline value of 2.5 mm, the risk of damage increases below about 15 metres.

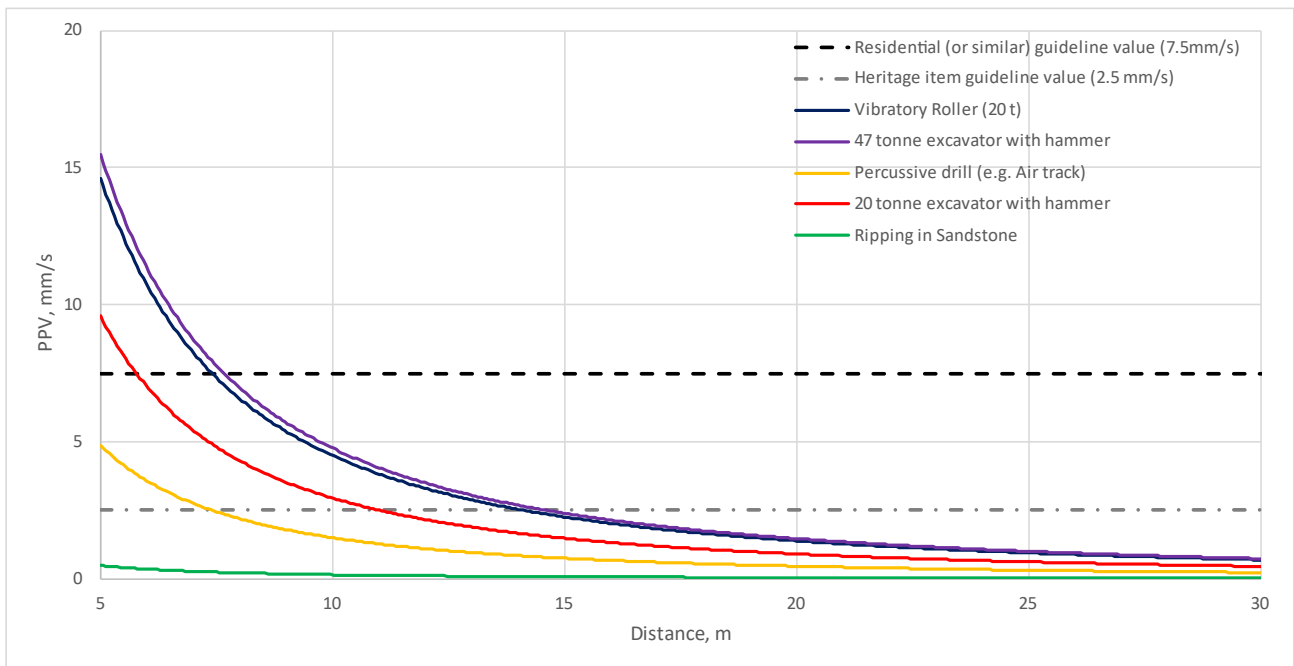


Figure 6-1 Curves of vibration with distance from the source

Contours representing the distance at which the vibration guideline values for each item are predicted to be achieved are presented in Appendix C. Where sensitive structures are within the buffer distance, trial monitoring should be undertaken prior to any works commencing to determine actual vibration levels.

The nearest buildings are commercial structures, outside the nominal buffer distances and the risk of vibration impact is low. There are no heritage structures that have been identified for the site.

Where equipment changes, monitoring and establishment of a site-specific vibration curve would be undertaken.

Consideration of vibration generating activities should include alternative methods where necessary to minimise vibration risk, such as:

- Employ non-vibratory (static) rolling methods for compaction where practicable.
- Use a ripper and bucket in place of a hammer where possible.
- Use smallest available vibration generating equipment for activities close to the site boundary.

6.3.3 Human exposure

The CNVIS applies vibration dose value (VDV) criteria to residential buildings over the day and night periods. Acceptable VDV for intermittent vibration from *Assessing Vibration: A technical Guideline* (DEC 2006) have been referred to assess potential impacts for vibratory rolling near the boundary of the site, closest to residential buildings. These guidelines require a maximum VDV of 0.2 m/s^{1.75} in for habitable areas during the daytime.

Over site establishment, typical vibration-intensive activities such as vibratory rolling and soil/rock drilling are unlikely to result in extended periods of vibration that would exceed the nominal VDV. To estimate the vibration dose value of a vibratory roller, the estimated VDV (eVDV) equation from DEC 2006 has been used:

$$eVDV = 1.4 \times a \times t^{0.25}$$

where a represents the root mean square (rms) vibration acceleration in m/s² and t is the duration of the activity in seconds. Since we only have velocity values for vibration, acceleration is substituted for velocity by the following equation:

$$a_{rms} = 2 \times \pi \times f \times v_{rms} / 1000$$

where f is the dominant frequency of the vibration and v is the root mean square (rms) velocity.

The rms velocity was derived from the peak particle velocity assuming a crest factor (the ratio of the peak value to its rms value) of 4.

eVDVs for durations of between 1 hour and 8 hours, are presented in Figure 6-2 and show the VDV at various distances from the source for a range of exposure durations. From the graph, impacts during the daytime would result in possible adverse comment within about 15 metres from the source for a total of up to 4 hours of work. For shorter durations, the buffer distance would be smaller. It is unlikely that total rolling activities would exceed 4 hours at any one location for this site.

Human exposure to vibration applies when a sensitive receiver is impacted in a habitable room, where no receiver is present, human comfort criteria would not apply. In addition, where the work moves further from the impacted building a reduced impact would be predicted and duration of exposure would increase proportionally.

Human comfort should be assessed inside the residence at the centre of a habitable room. Therefore, the building's construction, how many floors, how the building is coupled to the ground and the distance to the nearest habitable room would influence the actual levels measured during compaction and would likely be lower than predicted.

Vibration contours are presented in Appendix C and illustrate the receivers that may fall within the 15 metre contours for possible adverse comment during daytime hours. No receivers are predicted to experience vibration in excess of human comfort criteria.

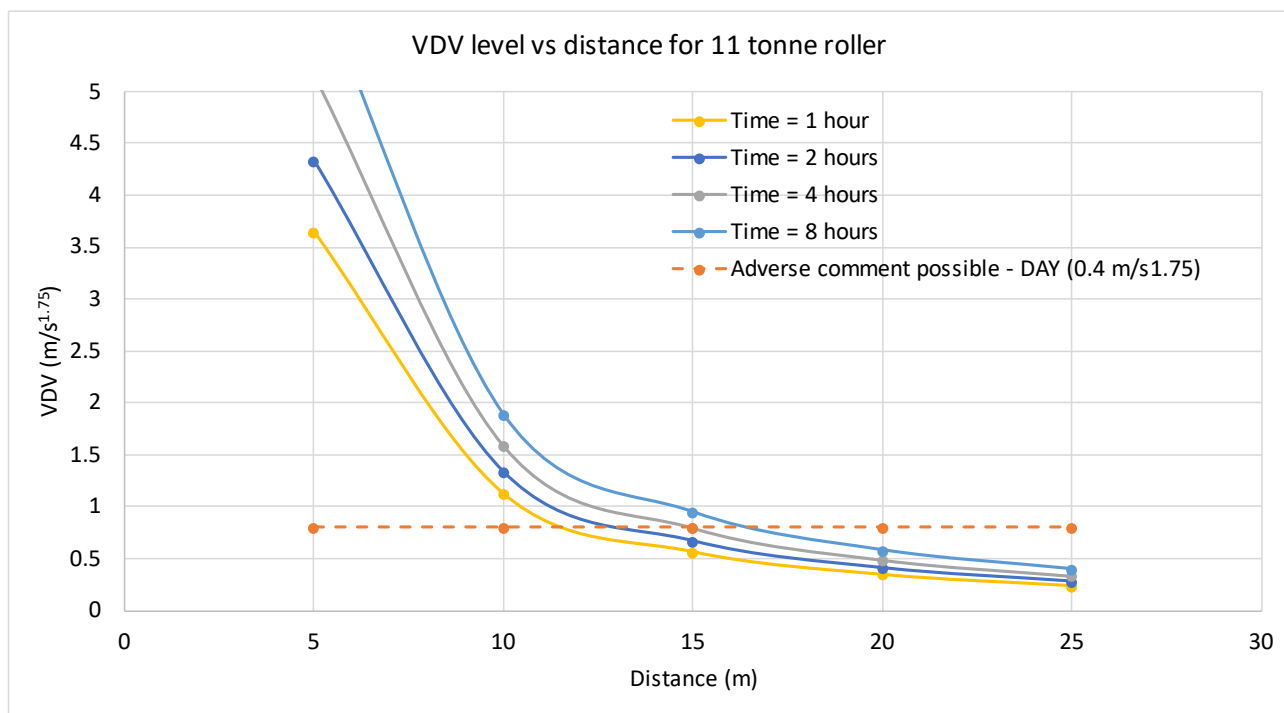


Figure 6-2 VDV curves for excavator and hammer

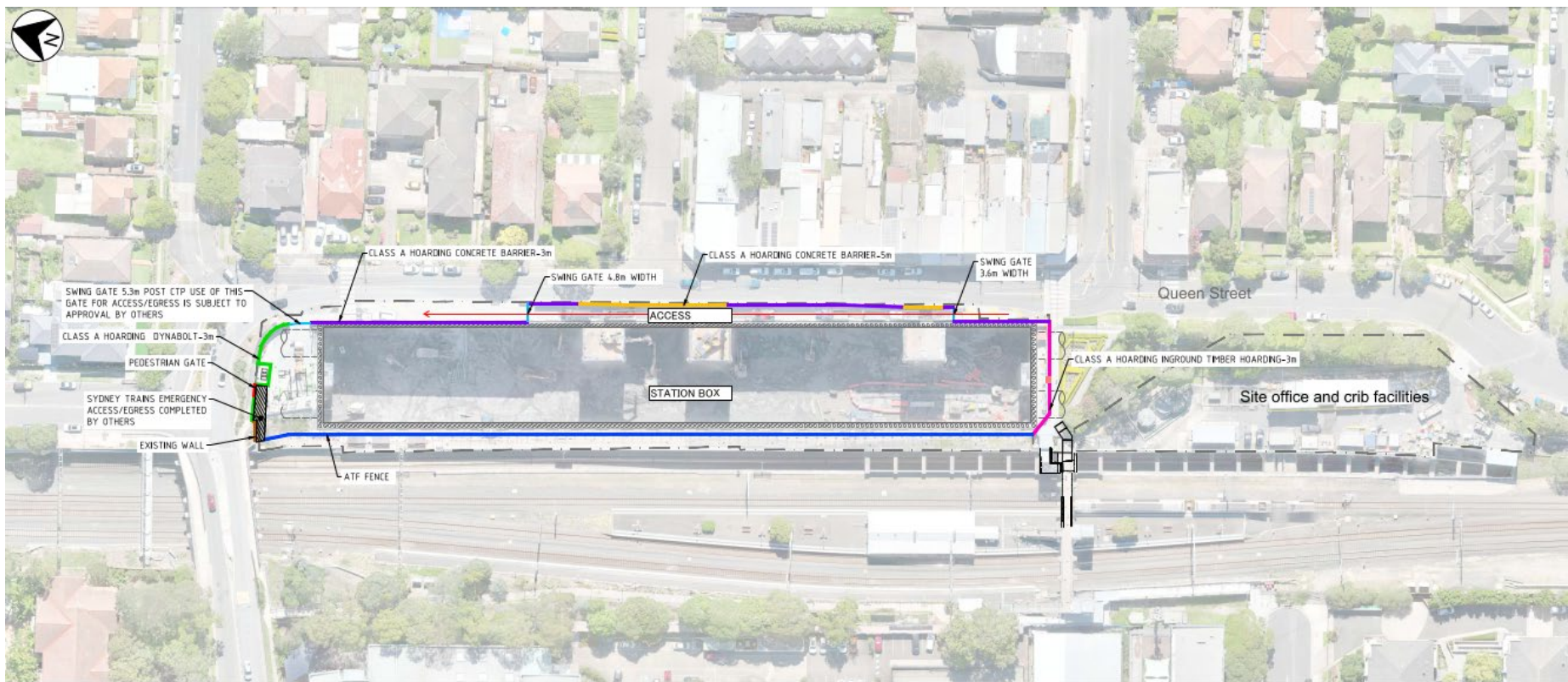
6.4 Construction traffic

Heavy vehicle movements related to the North Strathfield site activities will comprise deliveries of materials and equipment as well as spoil haulage during excavation.

All heavy vehicles would enter the site via Concord Avenue then down Wellbank Street past existing residential receivers, entering the site at the corner of Wellbank and Queen Street at Gate NST02. After loading or unloading, the vehicles exit via Gate NST03 to create a circular traffic flow as indicated in Figure 6-3. Exiting vehicles would continue north along Queen Street and turn left onto Pomeroy Street.

Approximately 8 heavy vehicles are expected to access and leave the site each hour during the peak construction period. These movements would be during approved hours only unless under an approved out of hours work permit.

The EIS noted that no roads around the North Strathfield site are anticipated to have a greater than 2 dB increase in road traffic noise. However, this conclusion should be verified by obtaining site-specific traffic data.



LEGEND:	
	CLASS A HOARDING DYNABOLT-3m (REFER TO DRAWINGS SMWSTCTP-AFJ-INL-SN000-TW-DRG-307018 TO 307021)
	CLASS A HOARDING CONCRETE BARRIER-3m (REFER TO DRAWINGS SMWSTCTP-AFJ-NST-SN350-TW-DRG-100131)
	CLASS A HOARDING CONCRETE BARRIER-5m (REFER TO DRAWINGS SMWSTCTP-AFJ-NST-SN350-TW-DRG-100132 TO 100133)
	CLASS A HOARDING INGROUND TIMBER HOARDING-3m (REFER TO DRAWINGS SMWSTCTP-AFJ-INL-SN000-TW-DRG-307026 TO 307030)
	SWING GATE (REFER TO DRAWINGS SMWSTCTP-AFJ-NST-SN350-TW-DRG-307500 TO 307502)
	ATP FENCE (REFER TO DRAWINGS SMWSTCTP-AFJ-INL-NL000-TW-DRG-200200 TO 200204)
	EXISTING WALL
	PEDESTRIAN GATE (REFER TO DRAWINGS SMWSTCTP-AFJ-INL-NL000-TW-DRG-307512 TO 307513)
	SITE BOUNDARY
	TURNSTILE (REFER REPORT SMWSTCTP-AFJ-NST-SN350-TW-RPT-307500 - APPENDIX C)

Figure 6-3 North Strathfield construction traffic movement and indicative site layout

7. Summary and recommendations

7.1.1 Impact summary

This DNVIS has established that during some construction activities during the arrival of the TBM and the demobilisation of the site, construction noise is likely to result in limited adverse impacts on the local community, with residents directly adjacent to the works to experience the greatest level of impact. In NCA 10 and 11 the NMLs at night reduce to very low levels; however, work outside of approved hours is only programmed TBM tunnelling activities.

Out of hours work will be required for works outside the scope of this DNVIS such as out of hours utility relocations and oversized plant deliveries and this will be assessed through the out of hours work process. These activities may cause impacts above NML and sleep disturbance levels and mitigation measures such as offering alternative accommodation will be implemented as required. Out of hours work may also occur for work that is predicted to be below NML.

Predicted noise levels for this assessment identify likely equipment combinations from the overall equipment list, working near the most affected location for each receiver. This provides a typical 'worst case' noise level that may be reasonably expected over the course of the modelled construction activity. The impacts from these activities will vary based on the location and type of building for each noise sensitive receiver.

The mix of residential, commercial and transport infrastructure in this location provides a range of impacts against the ambient daytime noise levels. Some activities such as the TBM traverse and relaunch and elements of the demobilisation will only be temporary providing a limited duration of impact for the closest receivers in Queen Street.

Airborne noise mitigation for the closest receivers on the eastern side of the site that will experience extended exposure from the ongoing tunnelling support is provided in the form of a 3 metre high noise wall for residences directly opposite the load area and a 2 metre high noise wall along other sections of Queen Street. Residential receivers across the train line have higher NMLs and will benefit from lower noise levels due to the separation distance.

Vibration impacts are not expected during the demolition phase of the works due to the offset distances of vibration generating equipment such as rock hammering, therefore cosmetic damage and human exposure risks are very low.

Based on predicted noise levels, proposed construction program and sensitivity of the community to noise and vibration, the tunnelling phase of the work is classed as a low risk and mitigation measures in line with this classification are proposed. During site demobilisation, noise impacts will be higher however, these impacts will be limited to standard construction hours only.

Predicted noise levels during the TBM arrival and relaunch phase of works are predicted to have noise impacts above NML on the surrounding receivers. Where both TBMs arrive at North Strathfield at the same time, these impacts increase to a moderate level, but are expected to last for only a short time and any noise impacts during this period will be monitored and managed in accordance with the NVMP.

Tunnelling support predictions indicate no exceedances from the operation of associated activities and facilities. A verification impact assessment will be completed during the commencement of TBM tunnelling activities and reasonable and feasible mitigation measures will be implemented where noise levels are predicted to exceed the NML at affected residences.

7.1.2 Standard mitigation

Standard noise mitigation measures described in **Table 7-1** should be implemented at all stages of the project in addition to those described in the project Construction Noise and Vibration Management Plan (CNVMP).

In line with CoA D42 best practice construction methods will be implemented where reasonable and feasible to ensure noise is maintained at a practical minimum. Practices will include:

- use of regularly serviced low sound power equipment;
- Permanent and temporary noise barriers (including the arrangement of plant and equipment) around noisy equipment and activities; and
- use of alternative construction techniques.

Equipment would be selected with consideration of noise emissions and the quietest equipment that can do the job would be chosen. Ripping will be used as an alternative to rock hammers during excavation where possible.

As part of the monitoring program, equipment would be regularly reviewed against expected sound power and maximum levels given in the CNVS. The quietest versions/models of commonly available equipment, such as compressors, generators, vacuum trucks and excavators would be selected preferentially where practicable.

Use of noise mats and hoarding around noisy activities provides both an acoustic benefit and a visual indicator to the public that all reasonable and feasible measures are being undertaken.

Hoarding has been recommended where it provides a material benefit. Additional noise mats will be installed in all reasonable and feasible situations where a discernible benefit to sensitive receivers is achievable.

Table 7-1 Standard mitigation measures

Measure	Description
Administrative	
Construction hours	• As much work as possible will be programmed during approved hours. Where work outside approved hours is proposed, this will be completed in line with the CNVMP and Out of hours works protocol. • When working near schools, regard for exam periods and other noise/vibration sensitive times will be given, with programming considering feedback from consultation • When working outside churches, particularly noisy activities will be undertaken outside scheduled service times where reasonable and feasible. • In accordance with CoA D36, noisy activities as defined in the ICNG, such as concrete cutting, will be undertaken on a 3 hours on, with a minimum cessation of work of not less than one (1) hour., unless otherwise approved.
Community consultation	• In line with the CNVMP, nearby receivers should be notified of the upcoming works, including the duration and predicted level of impact. • In line with the CNVS, community consultation will be undertaken regarding the DNVIS and proposed mitigation such as respite offers
Site induction	• Site Environmental Induction should be delivered to the team and should include consideration and awareness of noise impacts.
Cumulative impacts	• Programming for works undertaken outside approved hours will also consider works being undertaken by third parties
Behaviour	• Avoid yelling and swearing near sensitive receivers.

Measure	Description
Noise control	
Equipment selection	• Priority will be given to the use of quieter and less vibration emitting construction methods and plant alternatives where feasible and reasonable. • All equipment shall be well maintained, including mufflers and any noise suppression • All equipment will meet the maximum sound power requirements of Table 13 of the CNVS. • Trucks approaching construction sites will avoid the use of compression braking • Traffic management signage vehicles shall be padded to reduce rattling as much as possible.
Noise barriers	• Use temporary noise screens and enclosures as much as possible to reduce noise emissions from equipment when stationary or operating in one location for a reasonable duration. Screens (such as Echobarrier) should be placed between source and receivers, be continuous (without gaps) and installed according to manufacturer directions.
Use and siting of plant	• Plant used intermittently to be throttled down or shut down. Switch engines off when not in use for a short time (e.g. 15 minutes) • Noise-emitting plant to be directed away from sensitive receivers where possible. • Stationary plant should be located behind a structure or enclosed if practicable. • Avoid compression breaking on approach to the site.
Non-tonal reversing alarms.	• Non-tonal reversing beepers (or equivalent) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Monitoring	
Noise monitoring	• Noise monitoring shall be completed to: - verify assumptions of this DNVIS regarding estimated equipment noise emissions, - ensure compliance with the NMLs, - as required by the AMM for each assessed activity and - as required by the NVMP and associated monitoring program.
Vibration monitoring	• Attended vibration measurements would be undertaken at the commencement of vibration generating activities within safe working distances shown in Appendix B. Where there is potential for exceedances of criteria vibration, site law investigations would be undertaken to determine site-specific safe working.

7.1.3 Additional mitigation measures

Additional noise mitigation measures described in the CNVS AMMM should also be implemented as indicated in Appendix A for each receiver. AMM for each receiver is indicated by colour-coding as per the AMMM in Table 4-2.

Based on the timing of the construction activities in this DNVIS, which are predominantly during approved hours, AMMM would be largely limited to notifications and monitoring. Where works are undertaken outside approved hours, additional notification would likely be required as well as ensuring appropriate respite is provided. Alternative Accommodation is not likely to be needed; for works assessed in this DNVIS however, this will be reviewed on a case-by-case basis. Alternative accommodation is likely to be offered for work outside the scope of this DNVIS such as out of hours utility relocations and this will be assessed through the out of hours work process.

For vibration, AMM should be applied for sensitive receivers where measurement indicates it is applicable. In this case, measurement means either at a single location, which also indicates the likely level (and relevant AMM) at other similarly exposed locations or as established by site law measurements to indicate which receivers would be within the site-specific safe working distances.

7.1.4 Monitoring

Several assumptions have been made in this assessment to provide representative predictions, such as work location, equipment types, numbers, intensity of operation and noise screening options and these will be verified once works commence and regularly throughout the program.

Noise and vibration monitoring will be undertaken in line with the Noise and Vibration Monitoring Program and out-of-hours protocol as appropriate, with the following monitoring to be completed as a minimum.

- Sound power level verification to ensure equipment meets the requirements of the CNVS
- Compliance monitoring at nearby sensitive receivers to verify predictions at various stages of construction.
- Ground-borne noise and vibration monitoring to verify predicted levels and maintain compliance with objectives.

Vibration

- Monitoring locations will be at the nearest sensitive receiver or at the closest boundary if private property access is unavailable.

Continuous monitoring

- Locations for long-term noise and vibration monitoring are indicated in the monitoring program. Following the DNVIS assessment, these locations remain relevant. Specific locations will be selected in consultation with the land holder and AA and will be based on power requirements, security and access. Data from this monitoring will be readily available as required in the CNVMP and Monitoring Program.

7.1.5 Consultation

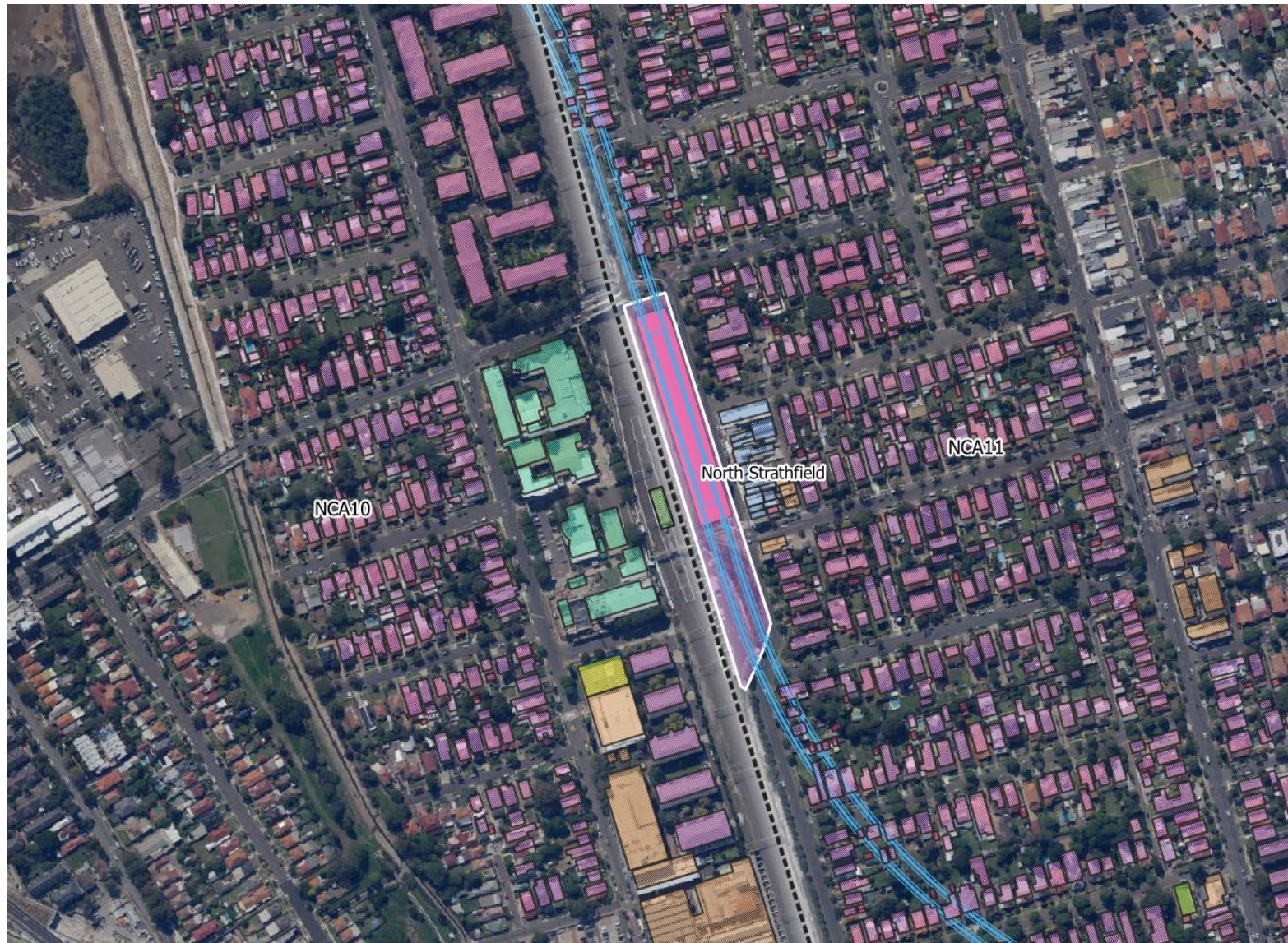
Condition of Approval D43 requires mitigation measures presented in this DNVIS to be identified through consultation with the affected community. This applies to standard hours and works outside standard hours and all mitigation measures developed as part of this DNVIS have been formed around community needs and concerns established through the community consultation process, as required by CoA D43. This process will continue for further phases of work.

In reviewing sensitive land uses near the North Strathfield construction site, specific receivers requiring consultation has included nearby receivers on Queen, Waratah, Wellbank, Pomeroy and Beronga and George streets, as well as businesses, schools and places of worship, which may be sensitive to noise and/or vibration.

In anticipation of the upcoming works, AFJV's Place Manager will distribute a newsletter for the North Strathfield main site outlining the TBM arrival and any support works to follow at North Strathfield. AFJV has been conducting face-to-face consultation in conjunction with other notification methods.



Appendix A. Land use survey and NCA maps



Sydney Metro West
Central Tunneling Package
Land use survey

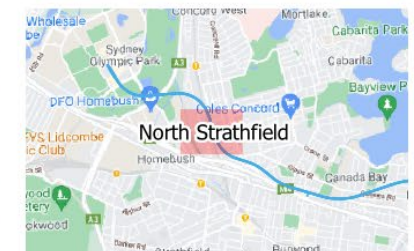
Site footprint

Sydney Metro West

North Strathfield NCAs

Land uses

- Childcare
- Commercial/Business
- Commercial/Residential
- Community Use
- Community/Residential
- Education
- Hotel
- Industrial/Utilities
- Recreational/Open Space
- Residential
- Medical
- Place of Worship
- Recreational Passive
- None
- Aged Care
- Transport/Infrastructure



0 50 100 150 m





Appendix B. Proposed equipment and sound power levels

B.1 Station box

Phase		Activity/ Work Area	Aspect		Plant/Equipment	Day	Evening	Night	SWL, dBA	Usage	Temp. barrier reduction, dB	Penalty, dB	SWL	Adjusted SWL, LAeq,15 minute			Activity LAeq, 15 min SWL		
						7am - 6pm	6pm - 10pm	10pm - 7am					Lmax	Day	Eve	Night	Day	Eve	Night
3	Tunnel nozzle	Nozzles	3c	concrete lining	Telehandler (at surface level)	2			100	0.4			105	99	0	0	106	0	0
					Elevated work platform	2			89	0.3			94	0	0	0			
					Diesel Concrete Line Pump	1			108	0.3			113	103	0	0			
					Concrete Trucks (at Surface level)	2			103	0.3			108	101	0	0			
					100 T crane	1			99	0.4			104	94	0	0			
					Hand tools	1			94	0.2			99	89	0	0			
					2 x concrete truck (in station box)	2			103	0.3			108	101	0	0			



B.2 TBM Tunnelling support & Demobilisation

Phase		Activity/ Work Area	Aspect		Plant/Equipment	Day	Evening	Night	SWL, dBA	Usage	Temp. barrier reduction, dB	Penalty, dB	SWL	Adjusted SWL, LAeq,15 minute			Activity LAeq, 15 min SWL				
						7am - 6pm	6pm - 10pm	10pm - 7am					Lmax	Day	Eve	Night	Day	Eve	Night		
4	Tunnelling support	TBM Traverse	4a	TBM Arrival and departure	Forklift	1	1	1	100	0.4			105	96	96	96	106	106	106		
					Hand tools	1	1	1	94	0.4			99	90	90	90					
					Hand held rattle gun	2	1	1	105	0.5			110	105	102	102					
		TBM Maintenance	4b		Excavator w bucket (30t)	2	2	2	109	0.5			114	109	109	109	110	110	110		
					Mobile Crane (60t - Surface)	1	1	1	105	0.4			110	101	101	101					
					Small Truck / 15 min	2	2	2	93	0.5			98	93	93	93					
		TBM Relaunch	4c		TBM (Gantries only)	1	1	1	102	1			105	102	102	102	102	102	102		
		Tunnelling support	4d	Support operations	Boosters	2	2	2	102	1			104	105	105	105	106	106	106		
					Conveyors (per m)	80	80	80	72	1			83	91	91	91					
					MSV Segment deliveries	2	2	2	105	0.1			108	95	95	95					
					Power conditioner	1	1	1	90	1			85	85	85	85					
		Cross passage ramps	4e	Temporary works	Same as traverse	1	1	1	106	1				110	106	106	106	106	106	106	
5	Demobilisation	Removal of modules/ TBM services and brackets	5a	Demolition	100 ton crawler crane	1			99	0.4			104	95	0	0	102	0	0		
					EWP	1			89	0.3			94	84	0	0					
					Telehandler (1 x Surface, 1 x Box)	2			100	0.4			105	99	0	0					
					Semitrailer	1			100	0.3			105	95	0	0					
		Demolition concrete decks/plinths	5b		30t excavator + hammer (Stn Box)	1			122	0.3		5	130	122	0	0	122	0	0		
					100t Crawler crane	1			99	0.4			104	94	0	0					
					25t Franna (Stn Box)	1			98	0.4			103	94	0	0					
					Positrak (Stn Box)	1			107	0.3			112	102	0	0					
					Telehandler (1 x Surface, 1 x Box)	2			100	0.4			105	99	0	0					
					Jackhammer	1			111	0.2		5	119	109	0	0					
					Concrete agis (surface)	2			103	0.3			108	101	0	0					
		Reinstate concrete foundations	5b (i)		Concrete pump (surface	1			108	0.3			113	103	0	0	105	0	0		
					Concrete vibrators	2			100	0.4			105	99	0	0					
		Plant and equipment removal	5c		Clean-up and restoration	80 ton Crane	1			99	0.4				104	95	0	0	116	0	0
						15t excavator + Hammer + Bucket;	1			118	0.2		5	126	116	0	0				
				Telehandler/ 25t Franna		2			100	0.4			105	96	0	0					
				EWP		2			89	0.3			94	84	0	0					
				Hand tools		1			94	0.2			99	87	0	0					
				Semi-trailer/Truck and dog		1			108	0.2			113	101	0	0					
		Site clean-up/removal of materials	5d	Watercart		1			103	0.4				108	99	0	0	106	0	0	
				Sweeper		1			109	0.2			114	102	0	0					
				Bobcat		1			107	0.3			112	102	0	0					
				Tipper truck		1			98	0.4			103	94	0	0					
		Permanent asphalt restoration (site compound)	5e	Spray seal/ Asphalt truck	1			108	0.4		0	113	104	0	0	110	0	0			
				Front end loader	1			110	0.4		0	115	106	0	0						
				8t Roller	1			105	0.4		5	113	106	0	0						
		Road works	5f	15t Excavator + Hammer	1			118	0.2		5	126	116	0	0	119	0	0			
				Potholing truck	1			98	0.4		0	103	94	0	0						
				Jack hammer	2			111	0.2		5	119	112	0	0						
				Whacker packer	2			108	0.2		5	113	109	0	0						



Appendix C. Construction noise and vibration contours



C.1 Construction noise contours

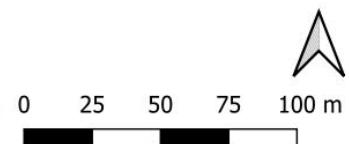


North Strathfield
Daytime noise contours
Nozzles - Concrete Lining

— Sydney Metro West
--- NCAs

Receiver types
 Childcare
 Commercial/Business
 Commercial/Residential
 Education
 Residential
 Transport/Infrastructure

Predicted Noise Level, dB(A)





North Strathfield
Noise contours
TBM - Traverse

— Sydney Metro West

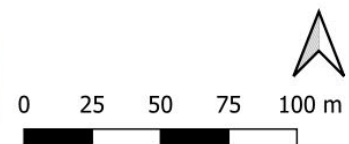
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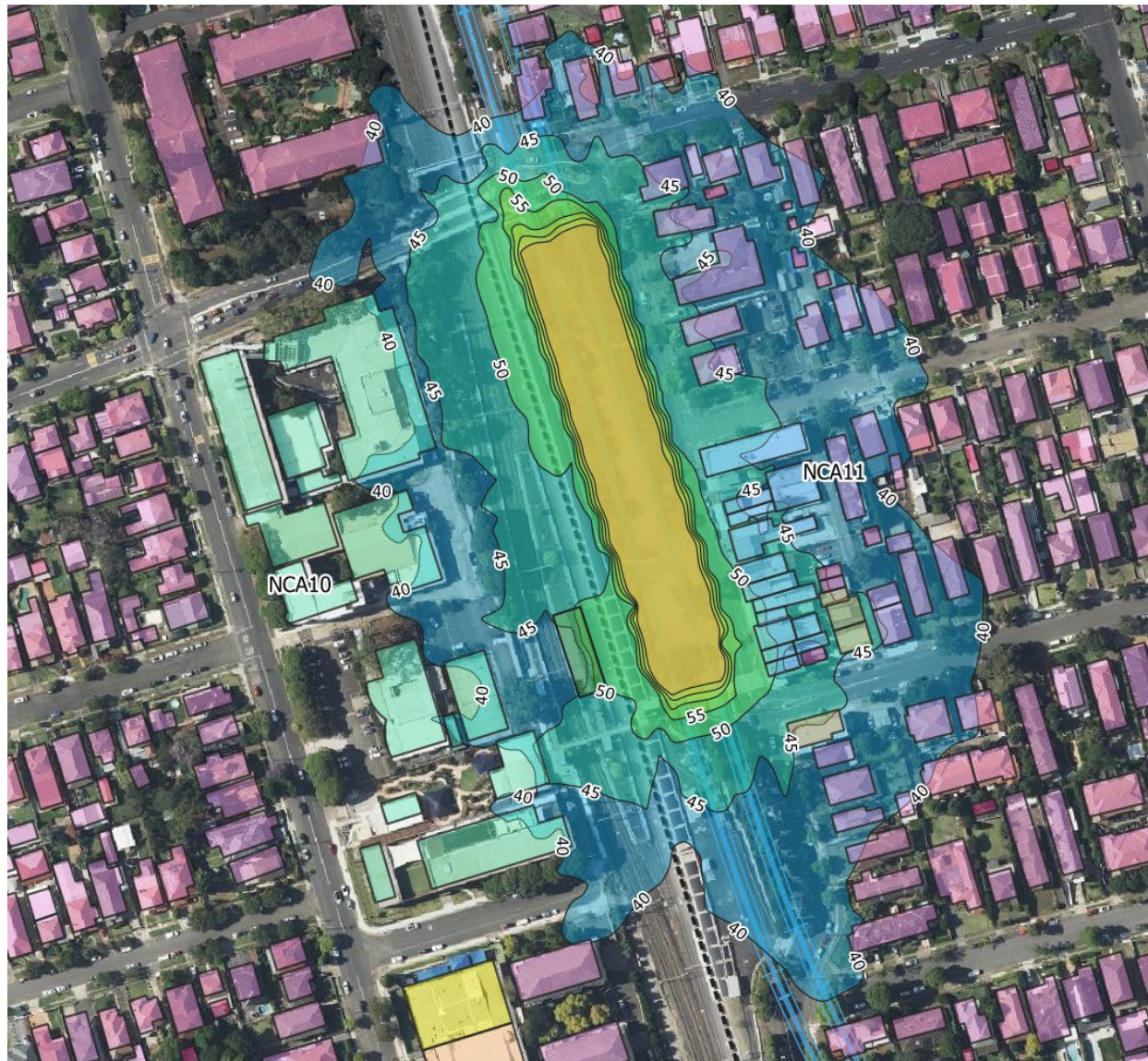
Receiver types

- Childcare
- Commercial/Business
- Commercial/Residential
- Education
- Residential
- Transport/Infrastructure

Predicted Noise Level, dB(A)

- 40.00
- 45.00
- 50.00
- 55.00
- 60.00
- 65.00
- 70.00
- 75.00





North Strathfield
Noise contours
TBM - Maintenance

— Sydney Metro West

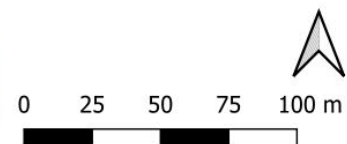
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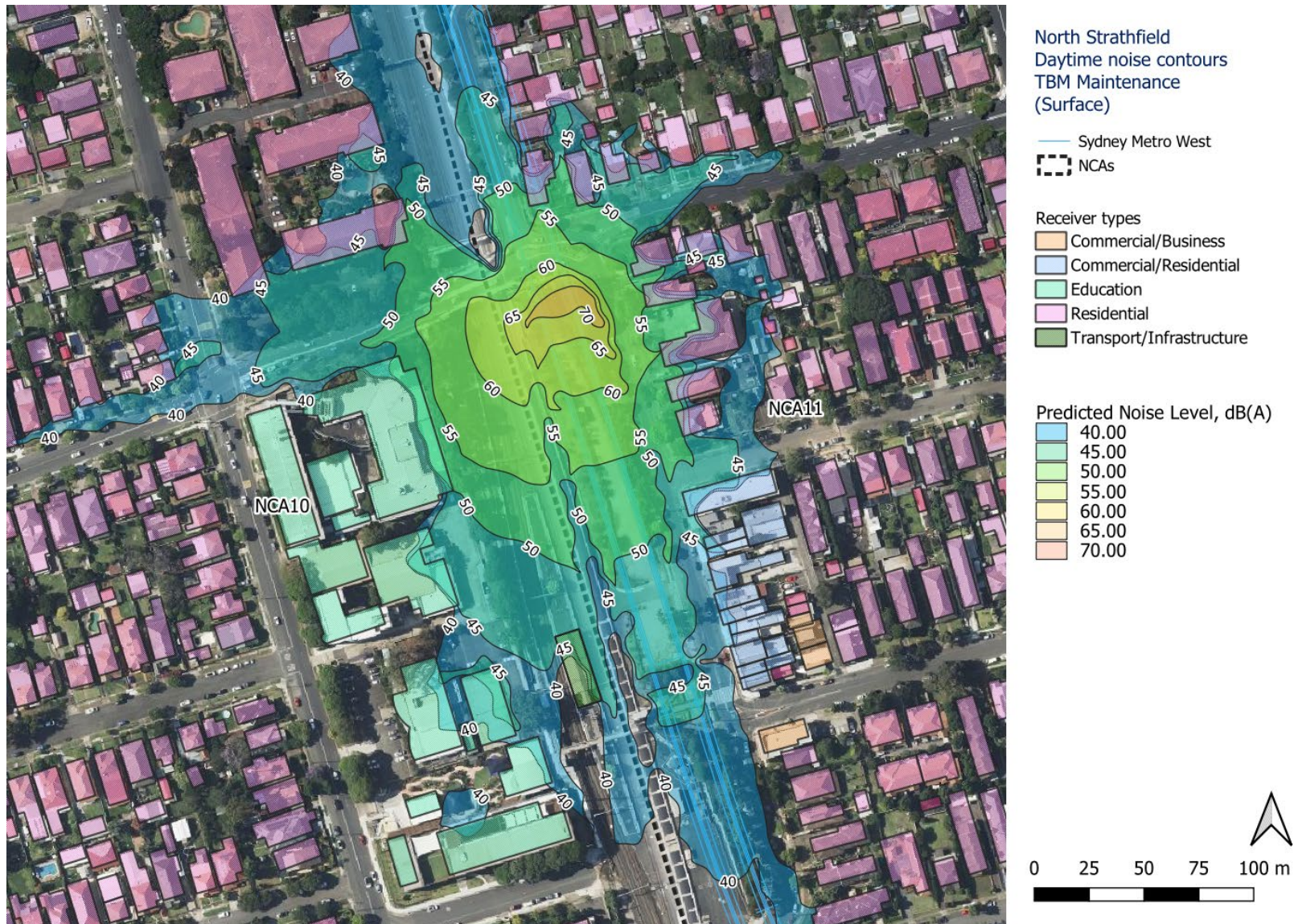
Receiver types

- Childcare
- Commercial/Business
- Commercial/Residential
- Education
- Residential
- Transport/Infrastructure

Predicted Noise Level, dB(A)

- 40.00
- 45.00
- 50.00
- 55.00
- 60.00
- 65.00
- 70.00
- 75.00







North Strathfield
Noise contours
TBM - Relaunch

— Sydney Metro West

--- NCAs

Receiver types

Childcare

Commercial/Business

Commercial/Residential

Education

Residential

Transport/Infrastructure

Predicted Noise Level, dB(A)

40.00

45.00

50.00

55.00

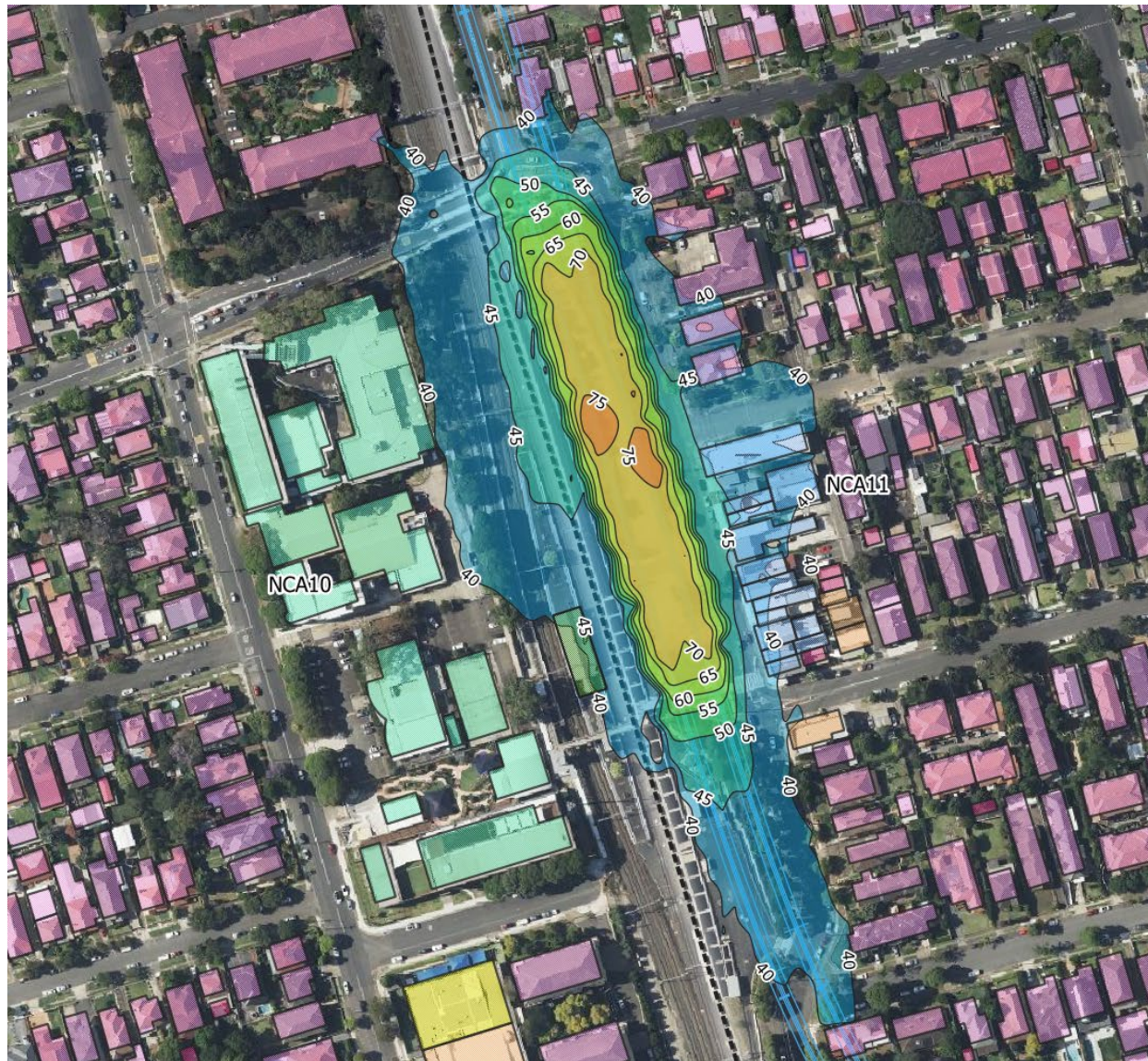
60.00

65.00

70.00

75.00

0 25 50 75 100 m



North Strathfield
Noise contours
TBM - Operational Support

— Sydney Metro West

--- NCAs

Receiver types

Childcare

Commercial/Business

Commercial/Residential

Education

Residential

Transport/Infrastructure

Predicted Noise Level, dB(A)

40.00

45.00

50.00

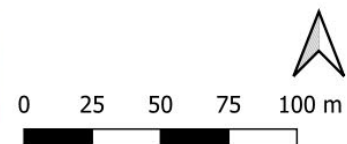
55.00

60.00

65.00

70.00

75.00





North Strathfield
Daytime noise contours
Demobilisation - Equipment
Removal

— Sydney Metro West

--- NCAs

Receiver types

Childcare

Commercial/Business

Commercial/Residential

Education

Residential

Transport/Infrastructure

Predicted Noise Level, dB(A)

40.00

45.00

50.00

55.00

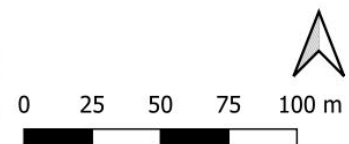
60.00

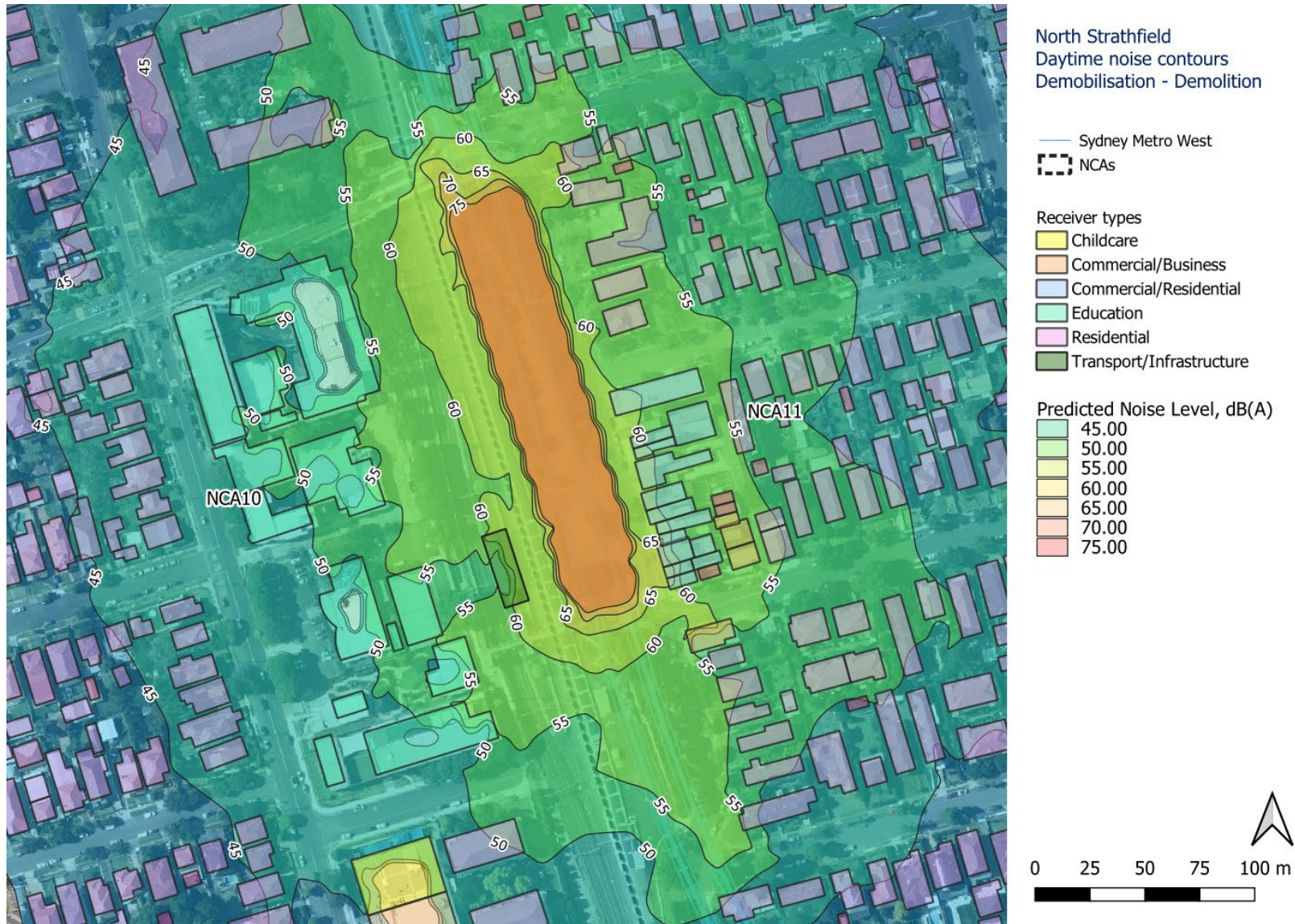
65.00

70.00

75.00

80.00







North Strathfield
Daytime noise contours
Demobilisation - Road works

— Sydney Metro West

--- NCAs

Receiver types

Childcare

Commercial/Business

Commercial/Residential

Education

Residential

Transport/Infrastructure

Predicted Noise Level, dB(A)

50.00

55.00

60.00

65.00

70.00

75.00

80.00

85.00

0 25 50 75 100 m





Appendix D. Detailed noise predictions for individual receivers

D.1 Phase 4 and 5 TBM Operation and Demobilisation

Supplied as Excel spreadsheets