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West

Major civil construction between The Bays and Sydney CBD

Environmental Impact Statement 2021

Technical Paper 2

Noise and vibration

SYDNEY METRO WEST

Major Civil Construction Work between The Bays and Sydney CBD
Technical Paper - Noise and Vibration

Prepared for:

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BASIS OF REPORT

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610.18331-R06-v1.0	18 October 2021	Jordan McMahon	Antony Williams	Antony Williams

EXECUTIVE SUMMARY

Sydney Metro is proposing to construct and operate Sydney Metro West. Stage 2 of the planning approval process for Sydney Metro West includes all major civil construction work between The Bays and Hunter Street (Sydney CBD) and is the subject of this Technical Paper.

This Noise and Vibration Technical Paper has been prepared to address the Secretary's Environmental Assessment Requirements. The report describes the existing noise environment in the study area, outlines the method used in the assessment and identifies the likely impacts from the proposal on the nearby communities and sensitive receivers. Where impacts are predicted, appropriate measures have been identified to mitigate and manage the impacts.

Construction Noise from Construction Sites

The proposal would involve excavation of future metro stations at The Bays, Pyrmont and Hunter Street (Sydney CBD) construction sites. The impacts during construction vary across the study area depending on how close the nearest receivers are to the construction sites, the expected level of amenity, and the facade construction of the receiver buildings. Consistent with most major infrastructure projects in urban areas, where receivers are close, the noise impacts during some of the work are expected to be 'high' during sensitive periods, particularly when noise intensive equipment such as rockbreakers are being used.

Construction noise impacts are predicted to be 'high' at the nearest receivers in the Pyrmont and Hunter Street (Sydney CBD) study areas during some of the noisiest scenarios. Acoustic sheds would be used to mitigate the noise impacts, where feasible.

The worst-case impacts are generally predicted to occur in the early stages of the work which are completed at surface level and require noise intensive equipment to be used prior to the construction of acoustic sheds. This early stage work would be limited to daytime hours and would not occur during the evening or night-time.

Noise intensive work at construction sites during the night-time would generally only be completed inside acoustic sheds. This work would also be underground and while the impacts are predicted to be substantially lower than for surface work, receivers that are close to construction sites are predicted to be impacted at times.

Noise intensive equipment would not be in use continuously. There would be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

Construction Ground-borne Noise and Vibration from Construction Sites

The main potential sources of construction ground-borne noise and vibration during excavation work at the Pyrmont and Hunter Street (Sydney CBD) construction sites are rockbreakers. Ground-borne noise and vibration impacts from station shaft excavation work at The Bays construction site were assessed as part of the approved *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a).

The worst-case ground-borne noise impacts during station shaft excavation are predicted to be 'moderate' or 'high' at receivers adjacent the excavation work at the Pyrmont and Hunter Street (Sydney CBD) construction sites. Receivers which are further back are generally predicted to comply with the management levels. The nearest receivers at Pyrmont are generally residential, where at Hunter Street (Sydney CBD) they are commercial or 'other sensitive'.

Exceedances of the cosmetic damage vibration screening criteria are predicted at Pyrmont and Hunter Street (Sydney CBD), due to vibration sensitive buildings or structures being adjacent to these sites. These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the site and in close proximity to the affected buildings. In reality, smaller equipment or alternative demolition methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.

Exceedances of the human comfort vibration criteria are also predicted at the nearest receivers, meaning occupants of affected buildings may be able to perceive impacts at times when vibration intensive equipment is in use nearby.

The vibration predictions assume the work is relatively near surface level. As progress is made further underground the impacts would be expected to reduce.

Construction Ground-borne Noise and Vibration from Tunnelling

The tunnel alignment would mostly be excavated using tunnel boring machines, with roadheaders and rockbreakers also used to excavate stations, station shafts, crossover caverns, cross passages, turnback cavern, stub tunnels and adits. The ground-borne noise impacts during tunnelling would depend on the depth of the tunnel and the alignment is sufficiently deep in most locations for ground-borne noise impacts to generally be compliant with the management levels or result in only 'low' impacts.

'High' or 'moderate' impacts are, however, predicted at receivers above the tunnel in the Pyrmont and Hunter Street (Sydney CBD) study areas where the tunnel depth is shallowest.

The tunnel boring machines are expected to progress at a rate of around 20 to 30 metres per day. This means the worst-case ground-borne noise impacts at a particular receiver would likely only last for a few days as each tunnel boring machine passes beneath.

No cosmetic damage vibration impacts are expected during tunnelling, although vibration impacts may be perceptible at times.

Construction Road Traffic Noise Impacts

Construction traffic is unlikely to result in a noticeable increase in noise levels on the proposed construction haulage routes due to high existing traffic volumes on these roads. There is potential for increased annoyance near to entrances/exits of the construction sites if heavy vehicles accelerate/decelerate, however, this is expected to be limited to a relatively small area adjacent to each site.

Cumulative Impacts

Cumulative impacts may occur if the proposal is constructed at the same (or similar) time as other nearby major projects. Concurrent construction noise and vibration impacts can occur where multiple work is being completed near to a particular receiver at the same time. Additionally, if more than one project occurs in the same area consecutively, there may be a prolonged effect from the extended duration of construction impacts. This effect is termed 'construction fatigue'.

Concurrent cumulative impacts are considered unlikely to substantially alter the worst-case predictions in this report. Where concurrent construction work is being completed near to a particular area, the worst-case noise levels could theoretically increase by around 3 dB (ie a logarithmic adding of two sources of noise at the same level).

Consecutive construction impacts, or 'construction fatigue', from extended impacts from the proposal and other major projects may occur in The Bays study area due other nearby projects, including other stages of Sydney Metro West, WestConnex M4-M5 Link and Western Harbour Tunnel. Multiple stages of Sydney Metro would also be constructed at or near to the Hunter Street Station (Sydney CBD) construction sites. While each project would apply mitigation measures that are suitable for controlling impacts from that project in isolation, the measures may not be sufficient to address prolonged impacts from multiple projects.

The potential for 'construction fatigue' would be investigated further as the project progresses. Specific additional management and mitigation measures designed to address potential consecutive impacts would be developed to minimise the impacts as far as feasible and reasonable.

Management of Impacts

All feasible and reasonable work practices would be applied to reduce the potential impacts during construction. Project specific mitigation has been recommended based on the predicted impacts.

The exact mitigation strategies would be determined as the project progresses when detailed planning information becomes available. The principal contractors would be required to prepare a Construction Noise and Vibration Management Plan for their scope of work in line with the requirements of the *Interim Construction Noise Guideline* and the *Sydney Metro Construction Noise and Vibration Standard*.

Site specific Detailed and General Construction Noise and Vibration Impact Statements would also be prepared for all work outside Standard Construction Hours likely to exceed the relevant management levels. These assessments would confirm the predicted impacts and specify the mitigation and management measures that would be used to minimise the impacts as far as practicable.

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DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

Glossary and Abbreviations

Item	Description / Definition
Attended noise monitoring	Operator attended noise monitoring which is completed to determine the various contributors to the noise environment of an area. It is usually done over a short period, such as 15 minutes.
AVaTG	*Assessing Vibration: a technical guideline*
CEMF	Construction Environmental Management Framework
CEMP	Construction Environmental Management Plan
CNVS	Sydney Metro *Construction Noise and Vibration Standard*. Replaces the *Sydney Metro Construction Noise and Vibration Strategy* (Sydney Metro, 2017)
CNVMP	Construction Noise and Vibration Management Plan
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own.
dBA	Decibel, A-weighted
DEC	Department of Environment and Conservation (now EPA)
DECC	Department of Environment and Climate Change (now EPA)
DECCW	Department of Environment, Climate Change and Water (now EPA)
DNVIS	Detailed Noise and Vibration Impact Statement
EIS, the	Sydney Metro West Environmental Impact Statement
EPA	Environment Protection Authority
GNVIS	General Noise and Vibration Impact Statement
Heavy vehicles	A heavy vehicle is classified as a Class 3 vehicle (a two-axle truck) or larger, in accordance with the Austroads Vehicle Classification System.
HNA	Highly Noise Affected. Relates to construction noise levels of ≥75 dBA and is the point above which there may be strong community reaction to noise construction noise levels.
ICNG	*Interim Construction Noise Guideline*
INP	*Industrial Noise Policy*
L_{Aeq}	The average noise level during a measurement period, such as the daytime or night-time
L_{AFmax}	The maximum noise level measured during a monitoring period, using 'fast' weighting
LGA	Local government area
mm/s	Millimetres per second
NATA	National Association of Testing Authorities
NCA	Noise Catchment Area
NML	Noise Management Level
Noise intensive equipment	Some construction equipment can be particularly noisy and can cause excessive annoyance. This may include items such as rockbreakers and concrete saws
NPfI	*Noise Policy for Industry*
OOH	Out of Hours

Item	Description / Definition
OOHW	Out of Hours Work
PPV	Peak particle velocity
RBL	Rating Background Level. This is the background noise level measured at a particular location. The method for calculating the RBL is defined in the NSW *Noise Policy for Industry*.
Realistic worst-case scenarios	Realistic worst-case construction scenarios have been developed to assess the potential impacts from the proposal. These scenarios are based on the noisiest items of equipment which would likely be required to complete the work.
RMS	Root Mean Square
RNP	*Road Noise Policy*
Secretary's environmental assessment requirements (SEARs)	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning and Environment under section 115Y of the Environmental Planning and Assessment Act 1979 (NSW).
SLR	SLR Consulting Australia Pty Ltd
SSI	State significant infrastructure. Major transport and services infrastructure considered to have State significance as a result of size, economic value or potential impacts.
Standard Construction Hours	Monday to Friday 7am to 6pm and Saturdays from 8am to 1pm
Study area	The study area is defined as the wider area including and surrounding the construction sites, with the potential to be affected by noise and vibration impacts from the proposal. The actual size and extent of the study area varies relative to the potential for impacts.
SWL	Sound Power Level
TBM	Tunnel boring machine
Unattended noise monitoring	Noise monitoring which is typically completed over a seven day period using unattended noise monitoring equipment. The equipment is left in a certain location to measure the existing background noise levels during the daytime, evening and night-time.
VC	Vibration Criterion
VDV	Vibration Dose Value
Worst-case impacts and noise levels	The worst-case (i.e. highest) impacts or noise levels predicted in this report

1 Introduction

1.1 Sydney Metro West

Sydney Metro West will double rail capacity between Greater Parramatta and the Sydney CBD, transforming Sydney for generations to come. The delivery of Sydney Metro West is critical to keeping Sydney moving and is identified in a number of key strategic planning documents including the *Greater Sydney Region Plan: A Metropolis of Three Cities – connecting people* (Greater Sydney Commission, 2018a).

The once-in-a-century infrastructure investment will have a target travel time of about 20 minutes between Parramatta and the Sydney CBD, link new communities to rail services and support employment growth and housing supply.

Stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD). The main elements of Sydney Metro West are shown in **Figure 1**.

Figure 1 Sydney Metro West

The planning process for Sydney Metro West is being assessed as a staged infrastructure application under section 5.20 of the *Environment Planning and Assessment Act 1979* (EP&A Act).

The Sydney Metro West Concept and major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval process for Sydney Metro West), application number SSI-10038, were approved on 11 March 2021.

The Concept is described in Chapter 6 of the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a) and includes:

- Construction and operation of new passenger rail infrastructure between Westmead and Sydney CBD, including:
  - Tunnels, stations (including surrounding areas) and associated rail facilities
  - Stabling and maintenance facilities (including associated underground and overground connections to tunnels)
- Modification of existing rail infrastructure (including stations and surrounding areas)
- Ancillary development.

Major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval process) is described in Chapter 9 of the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a) and includes:

- Tunnel excavation including tunnel support activities between Westmead and The Bays
- Station excavation for new metro stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays
- Shaft excavation for services facilities
- Civil work for the stabling and maintenance facility at Clyde.

Stage 2 of the planning approval process (this proposal) includes all major civil construction work including station excavation and tunnelling between The Bays and Sydney CBD.

Future planning applications for Sydney Metro West will include tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line, between Westmead and Sydney CBD. The associated potential impacts are being assessed and will be presented within the Environmental Impact Statement currently being prepared for 'Sydney Metro West - Rail infrastructure, stations, precincts and operations' (Stage 3 of the planning approval process for Sydney Metro West). Sydney Metro West - Rail infrastructure, stations, precincts and operations have been assessed in this Environmental Impact Statement only in relation to potential cumulative impacts with this proposal, where relevant.

1.1.1 Overview of the Proposal

This proposal would be located largely underground in twin tunnels. Indicative locations of the proposed alignment and stations are shown in **Figure 2**.

Figure 2 Overview of Sydney Metro West between The Bays and Sydney CBD

The proposed major civil construction work between The Bays and Sydney CBD would include:

- Enabling work such as demolition, utility supply to construction sites, utility adjustments, and modifications to the existing transport network
- Tunnel excavation including tunnel support activities
- Station excavation for new metro stations at Pyrmont and Hunter Street, in the Sydney CBD.

Components of this proposal are subject to further design, and changes may be made during the ongoing design which take into account the outcomes of community and stakeholder engagement and environmental field investigations.

The surface construction work at station and shaft excavation sites are intended to occur across a period of about three years.

The proposal is further described in Chapter 5 (Project description) of the Environmental Impact Statement.

It is important to note that this description states that The Bays Station construction site is being established under the existing approval (Stage 1 of the Sydney Metro West planning approval process) as described in *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a). This included the use of the site to:

- Carry out the excavation of The Bays Station
- Launch and support two tunnel boring machines for the drive west to the Sydney Olympic Park metro station construction site.

The Bays Station construction site will be established under the existing approval.

This technical report only assesses the proposed use of the eastern and southern part of The Bays Station construction site to launch and support two tunnel boring machines for the drive east to the proposed Hunter Street Station (Sydney CBD) construction sites. There would be minimal surface ground disturbance associated with this work.

1.2 Purpose and Scope of this Technical Paper

This Technical Paper is one of a number of Technical Papers that form part of the Environmental Impact Statement for major civil construction work between The Bays and Sydney CBD. The purpose of this Technical Paper is to identify and assess the potential impacts of the proposal in relation to noise and vibration. It responds directly to the Secretary's Environmental Assessment Requirements outlined in **Section 1.2.1**.

The objectives of this Technical Paper include:

- Describing the existing environment with respect to noise and vibration
- Assessing the noise and vibration impacts of the proposal on the nearby communities and receivers
- Evaluating the potential cumulative impact of the proposal with other major infrastructure projects
- Identifying measures to mitigate and manage the predicted impacts.

This Technical Paper presents indicative environmental impacts for the purpose of project approval and is not intended to be used for any other purpose.

1.2.1 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements were issued on 7 July 2021. The requirements specific to noise and vibration, and where these requirements are assessed in this Technical Paper, are outlined in **Table 1**.

In support of seeking the Secretary's Environmental Assessment Requirements, the *Sydney Metro West Scoping Report – Major civil construction from The Bays to Sydney CBD* (Sydney Metro, 2021) identified a number of investigations and further assessments relevant to this Technical Paper. How the Technical Paper addresses these matters is provided in **Table 2**.

Table 1 Secretary's Environmental Assessment Requirements – Construction Noise and Vibration

Secretary's Environmental Assessment Requirements	Where Addressed
Noise and Vibration	
1. **Construction noise and vibration** impacts in accordance with relevant NSW noise and vibration guidelines	**Section 5**
2. The assessment must clearly differentiate between tunnel activities, and the tunnel support or ancillary activities in the assessment and describe their impacts and proposed hours of work.	**Section 5**
3. The assessment of **construction noise and vibration** must address:	
(a) the nature of construction activities and related noise characteristics using typical and worst-case scenarios;	**Section 4.1**
(b) the intensity and duration of noise (both air and ground borne) and vibration impacts. This must include consideration of the construction program, high noise generating activities and extended construction impacts associated with ancillary facilities (and the like) and construction fatigue;	**Section 5** **Section 5.6**
(c) the identification and nature of receivers, existing and proposed, during the construction period;	**Section 2**
(d) the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	**Section 3.5.3.3**
(e) the nature of the impact and the sensitivity of receivers and level of impact including for out of hours work;	**Section 5**
(f) the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	**Section 6.3**
(g) a statement of the proposed hours of construction. Justification must be provided where these are not consistent with standard construction hours stated in the *Interim Construction Noise Guideline*;	**Section 4.4**
(h) noise impacts of out-of-hours works (including utility works and works associated with the proposal including those undertaken under another assessment pathway), possible locations where out-of-hours works would be undertaken, the activities that would be undertaken, the estimated duration of those activities, the relevant stage the activities are proposed and justification for these activities;	**Section 4.4** **Section 5.2** **Section 5.4**
(i) assessment of construction traffic noise on public roads must include consideration of gradient, construction vehicle type, acceleration and deceleration and potential annoyance;	**Section 5.5**
(j) sleep disturbance (including the number of noise-awakening events);	**Section 5.2**
(k) a cumulative noise and vibration assessment inclusive of impacts from the proposal, including concurrent construction activities within the proposal, the Sydney Metro West scheme and the construction of other relevant development in the vicinity of the proposal when considering feasible and reasonable mitigation;	**Section 5.6**
(l) qualitative assessment of the predicted effectiveness of management and mitigation measures to manage identified, including impacts as identified in (h); and	**Section 5,** **Section 6.3**
(m) any potential residual noise and vibration impacts following application of mitigation measures; and	**Section 6.3**
(n) a description of how receiver feedback received during the preparation of the EIS has been taken into account (and would be taken into account post exhibition of the EIS) in the design of mitigation measures, including any tailored mitigation, management and communication strategies for sensitive receivers.	**Section 6.3**

Secretary's Environmental Assessment Requirements	Where Addressed
4. The process for community engagement should be included or referenced in the noise and vibration assessment as part of the mitigation strategy and assessment.	**Section 6.3**
5. If **blasting** is required, demonstration that blast impacts can comply with current guidelines.	n/a

Table 2 Investigations and further assessments identified in Scoping Report – Noise and vibration

Investigation and Further Assessments	Where Addressed
Noise and Vibration	
• Identification of the nature of construction activities and related noise characteristics	**Section 4.1.2**
• The intensity and duration of temporary construction noise and vibration impacts. This will include a 'typical level' or 'typical range' in noise levels which would be expected as construction works move around the site as well as a realistic 'peak' noise level from each activity	**Section 5**
• The correlation between the likely noise impacts and the anticipated duration and timing of the activity	**Section 5.2**
• The nature, sensitivity and impact on potentially affected receivers, including consideration of particularly sensitive receivers if present within the vicinity (such as schools, hospitals, aged care facilities) and sensitive structures (particularly heritage structures and key utilities/infrastructure)	**Section 2**
• Identification of possible locations where out-of-hours works would be carried out, the activities that would be carried out, the estimated duration of those activities and justification for these activities	**Section 4.4**
• Potential temporary impacts associated with any works proposed to be carried out outside standard daytime construction hours	**Section 5**
• The potential impacts associated with long term construction noise	**Section 5** and **5.6**
• Explanation of how the extent of potential impacts on sensitive receivers have been balanced against the duration of impacts	**Section 5** and **6.3**
• Other factors that may influence the timing and duration of construction activities (such as traffic management)	**Section 4.1.2** and **6.3**
• Identification and assessment of feasible and reasonable mitigation and management measures to address potential temporary construction noise and vibration impacts, taking into consideration the implementation of the *Sydney Metro Construction Noise and Vibration Standard* (Sydney Metro, 2020c)	**Section 6**
• Consistent with the philosophy described in Case Study D5 of the EPA's *draft Construction Noise Guideline*, an alternate methodology to the ICNG approach to assessing and managing construction noise may be proposed.	n/a

1.3 Structure of this Technical Paper

The structure of the Technical Paper is outlined below:

- **Section 1** – provides an introduction to the report
- **Section 2** – details the existing noise environment in the study area
- **Section 3** – presents relevant legislative and policy context to this proposal
- **Section 4** – documents the methodology for this assessment
- **Section 5** – provides an assessment of the potential noise and vibration impacts of this proposal during construction, including cumulative impacts
- **Section 6** – identifies mitigation and management measures
- **Section 7** – provides a conclusion for the noise and vibration assessment of the proposal.

1.4 Terminology

The assessment has used specific acoustic terminology and an explanation of common terms is included in **Appendix A**. A glossary is also provided at the start of this document which lists the various terms used throughout this document.

2 Existing Environment

2.1 Study Area

The proposed study area (see **Figure 3**) extends from the boundaries of The Bays tunnel launch and support site to the end of the turnback and stub tunnel east of the Hunter Street Station (Sydney CBD) construction site. The study area for the construction noise and vibration assessment has been defined on the basis of the likely noise and vibration impacts from the proposal using the following approach:

- Ground-borne noise and vibration from tunnelling and station excavation at surface construction sites has been assessed to receivers within 150 metres of the tunnel alignment and construction sites
- Airborne noise has been assessed to receivers within 600 metres of the surface construction sites (including the power supply route)
- Construction road traffic noise impacts on public roads have been assessed for roads between the surface construction sites and the nearest arterial road(s).

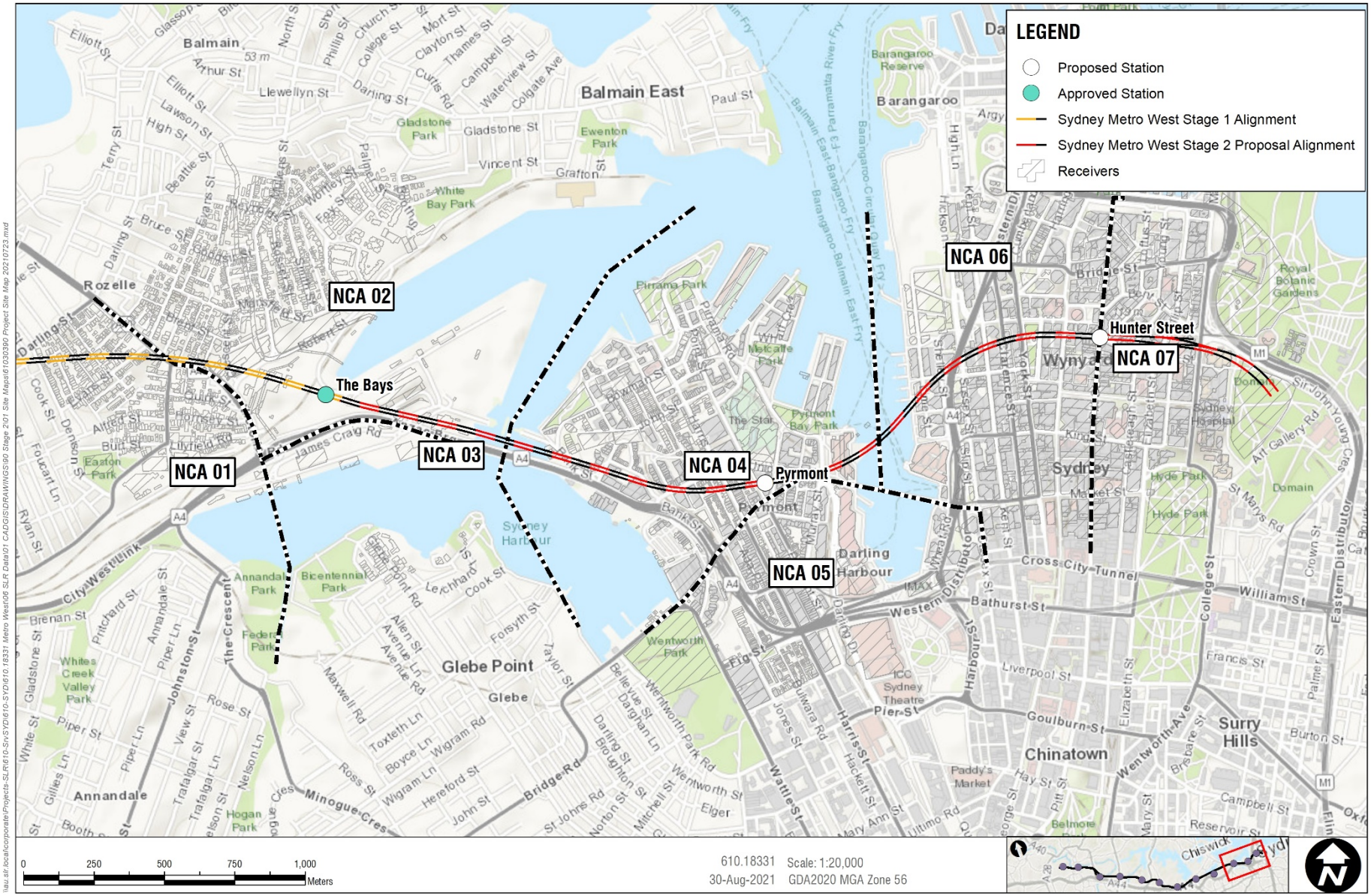
Existing noise levels vary across the study area. The alignment is close to major sources of existing transport noise, such as the Victoria Road in Rozelle, and Anzac Bridge and Western Distributor near Pyrmont. Other sources of existing noise include commercial noise in Pyrmont and Sydney CBD, and industrial noise in Rozelle and White Bay/Glebe Island.

The tunnel alignment runs through areas of industrial, commercial and urban residential receivers. Receivers surrounding the construction sites are generally a mix of residential and various commercial uses, depending on location.

The construction impacts are summarised on the basis of several study areas centred around each surface construction site. Each study area is divided into one or more Noise Catchment Areas (NCAs) that reflect the ambient noise environment of that area, as well as the noise and vibration sensitivity of the surrounding land uses.

The study areas and NCAs are shown in **Figure 3**. A detailed map of each study area is provided in **Section 5.2**.

Figure 3 Study Area



2.2 Sensitive Receivers

Receivers potentially sensitive to noise and vibration have been categorised as residential buildings, commercial/industrial buildings, or 'other sensitive' land uses which includes educational institutions, child care centres, medical facilities, places of worship, outdoor recreation areas, etc.

This assessment identifies the likely maximum impacts for each receiver in the study area. Some buildings contain more than one use, such as where residential apartments have commercial uses on ground floor. Where this occurs, the building is generally categorised using the most stringent criteria.

Receiver types and locations are shown in study area maps in the discussion of the impacts in **Section 5.2**.

2.2.1 New Developments

A review of recently approved potentially noise and vibration sensitive developments in the study area has been completed and the identified developments have been included, where appropriate.

2.3 Noise Surveys and Monitoring Locations

Unattended ambient noise monitoring was completed in the study area in 2021. Ambient noise data measured on other recent projects has also been used, resulting in a total of six representative monitoring locations across the study area. The measured noise levels have been used to determine the existing noise environment and to set criteria to assess the potential impacts from the proposal.

The ambient noise monitoring locations were selected with reference to the procedures outlined in the NSW EPA *Noise Policy for Industry* (NPfI). The measured existing noise levels are representative of receivers in each NCA that would likely be most affected by the construction of the proposal.

The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time. All equipment carried current National Association of Testing Authorities (NATA) calibration certificates and the calibration was checked before and after each measurement.

The results of the noise monitoring have been processed with reference to the NPfI to exclude noise from extraneous events and/or data affected by adverse weather conditions, such as strong wind or rain (measured at Observatory Hill Weather Station), to establish representative existing noise levels for each NCA.

The monitoring results are summarised in **Table 3**. Maps showing the monitoring locations are provided in the study area discussions in **Section 5.2** and in **Appendix B**. Descriptions of each monitoring location and the measured noise environment, together with graphs of the daily measured noise levels are also in **Appendix B**.

Table 3 Summary of Noise Monitoring Results

Study area	Location ID	Address	Noise Level (dBA)[1,2]					
			Background Noise (RBL)			Average Noise Level (L_{Aeq})		
			Day	Evening	Night	Day	Evening	Night
The Bays[3]	B.01	21 Mansfield Street, Rozelle	43	43	35	56	54	47
	B.02	22 Lilyfield Road, Rozelle	51	51	45	57	57	54
	B.03	308 Glebe Point Road, Glebe	48	47	39	59	58	51
Pyrmont	B.04[4]	200 Paternoster Row, Pyrmont	50	47	45	56	50	47
	B.05	1-5 Harwood Street, Pyrmont	52	49	46	61	59	56
Hunter Street (Sydney CBD)[5]	B.06	1 Hosking Place, Sydney	61	56	52	66	62	63

Note 1: The RBL and L_{Aeq} noise levels have been determined with reference to the procedures in the NPfI.

Note 2: Daytime is 7am to 6pm, evening is 6pm to 10pm and night-time is 10pm to 7am.

Note 3: Data taken from *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020). See **Appendix B** for details.

Note 4: Data based on several attended ambient noise measurements. See **Appendix B** for details.

Note 5: Data measured as part of *Sydney Metro Chatswood to Sydenham Environmental Impact Statement* in 2015. Noise levels in the CBD are typically elevated due to relatively constant sources of noise and the measured levels are considered representative of current ambient noise conditions. See **Appendix B** for details.

Short-term attended noise monitoring was also completed at each ambient monitoring location. The attended measurements allow the contributions of the various noise sources at each location to be determined. Detailed observations from the attended measurements are provided in **Appendix B**.

The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and showed that the existing noise environment varies in the study area. The noise sources that influence background levels include:

- Road traffic noise from busy roads adjacent to all construction sites
- Noise generated by commercial areas at Pyrmont and Sydney CBD
- Noise generated by industrial areas at Rozelle and White Bay
- Urban hum generated by mechanical plant in Sydney CBD.

3 Legislative and Policy Context

The legislative and policy context in the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a) would broadly apply to the noise and vibration assessment for the major civil construction work between The Bays and Sydney CBD. The legislation, policy and guidelines that are relevant to this proposal are summarised below.

3.1 Relevant Construction Guidelines

The guidelines used to assess construction noise and vibration impacts from this proposal are listed in **Table 4**. The guidelines aim to protect the community and environment from excessive adverse noise and vibration impacts as projects are constructed.

Table 4 Construction Noise and Vibration Guidelines

Guideline/Policy Name	Where Guideline Used
Interim Construction Noise Guideline (ICNG), Department of Environment and Climate Change (DECC), 2009	Assessment of airborne noise and ground-borne noise impacts on sensitive receivers
Assessing Vibration: a technical guideline, Department of Environment and Conservation (DEC), 2006	Assessment of vibration impacts on sensitive receivers
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces
Road Noise Policy (RNP), Department of Environment, Climate Change and Water (DECCW), 2011	Assessment of construction traffic impacts
BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993	Screening assessment of vibration impacts (cosmetic damage) to sensitive buildings and structures
DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999	Screening assessment of vibration impacts (cosmetic damage) to vibration sensitive heritage buildings and structures, where the structure is found to be unsound
Sydney Metro Construction Noise and Vibration Standard (CNVS), Sydney Metro, 2020 (version 4.3)	Assessment and management protocols for construction of Sydney Metro projects. This Sydney Metro standard is based on the requirements of the ICNG and Transport for NSW *Construction Noise and Vibration Strategy*, as appropriate to Sydney Metro, and is the guiding strategy for assessing and managing the potential impacts during construction of the proposal.
Noise Policy for Industry (NPfI), Environmental Protection Agency (EPA), 2017	Ambient noise monitoring and analysis procedures, and assessment of sleep disturbance
Guideline for Child Care Centre Acoustic Assessment Version 2.0 (GCCCAA), Association of Australasian Acoustical Consultants (AAAC), 2013	Contains reference criteria for child care centres

3.2 Construction Airborne Noise Guidelines

The *Sydney Metro Construction Noise and Vibration Standard* (CNVS) references the NSW *Interim Construction Noise Guideline* (ICNG) for assessing and managing impacts from construction noise on Sydney Metro.

The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers. The realistic 'worst-case' noise levels from construction of a project are predicted and then compared to the NMLs in a 15-minute assessment period to determine the likely impacts.

The NMLs are not mandatory limits, however, where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions are to be investigated.

3.2.1 Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in **Table 5**.

Table 5 ICNG NMLs for Residential Receivers

Time of Day	NML $L_{Aeq(15minute)}$	How to Apply
Standard Construction Hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

	Highly Noise Affected
	75 dBA
		The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise.
		• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:
		  ◦ Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences.
		  ◦ If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside Standard Construction Hours:	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1: The RBL is the Rating Background Level and the ICNG refers to the calculation procedures in the NSW *Industrial Noise Policy* (INP). The INP has been superseded by the NSW EPA *Noise Policy for Industry* (NPfI). The RBLs have been determined in accordance with the calculation procedures outlined in the NPfI as described in **Section 2.3**.

Work is recommended to be completed during Standard Construction Hours where possible. More stringent requirements are placed on work that is required to be completed outside of Standard Construction Hours (i.e. during the evening or night-time) which reflects the greater sensitivity of communities to noise impacts during these periods.

3.2.1.1 Sleep Disturbance

Major infrastructure projects often require certain work to be completed during the night-time. Where night work is located close to residential receivers there is potential for sleep disturbance impacts.

The ICNG lists five categories of work that might be required to be undertaken outside the Standard Construction Hours:

- The **delivery of oversized equipment or structures** that require special arrangements to transport on public roads
- **Emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
- **Maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- **Public infrastructure work** that shortens the length of the project and are supported by the affected community
- Work where a proponent demonstrates and justifies **a need to operate outside the recommended standard hours**.

Where construction work is planned to extend over more than two consecutive nights, the ICNG recommends that an assessment of sleep disturbance impacts should be completed.

The most current method for assessing sleep disturbance from NSW transport infrastructure projects is contained in the EPA's *Noise Policy for Industry* (NPfI). Although the NPfI sleep disturbance criteria relate to industrial noise, they are considered relevant for reviewing potential impacts from construction noise.

The NPfI defined sleep disturbance criteria is 52 dBA L_{AFmax} or the prevailing background level plus 15 dB, whichever is the greater.

3.2.1.2 Summary of Residential NMLs

The residential NMLs for the proposal have been determined using the results from the unattended ambient noise monitoring (see **Section 2.3**) and are shown in **Table 6**.

Maps showing the monitoring locations are provided in the study area discussions in **Section 5.2** and in **Appendix B.**

Table 6 Residential Receiver Construction NMLs

Study area	NCA	Representative Background Monitoring Location	NML ($L_{Aeq(15minute)}$ – dBA)				Sleep Disturbance Screening Criteria (52 dBA or RBL +15 dB whichever is higher)
			Standard Construction (RBL +10 dB)	Out of Hours (RBL +5 dB)			
			Daytime	Daytime[1]	Evening	Night-time	
The Bays	NCA01	B.02	61	56	56	50	60
	NCA02	B.01	53	48	48	40	52
	NCA03	B.03	58	53	52	44	54
Pyrmont	NCA04	B.04	60	55	52	50	60
	NCA05	B.05	62	57	54	51	61
Hunter Street (Sydney CBD)	NCA06	B.06	71	66	61	57	67
	NCA07	B.06	71	66	61	57	67

Note 1: Daytime out of hours is 7am to 8am and 1pm to 6pm on Saturday, and 8am to 6pm on Sunday and public holidays.

The noise monitoring locations were selected to measure background noise levels representative of the potentially most affected receivers in each NCA. These locations would likely be most affected during construction of this proposal and while background noise levels may be lower at receivers which are further back from the construction sites, construction noise tends to reduce at a faster rate than background noise with increasing distance. The worst-case noise impacts are, therefore, generally at the front row receivers and control the mitigation requirements.

3.2.2 'Other Sensitive' Land Uses and Commercial Receivers

Non-residential land uses have been identified in the study area. These include 'other sensitive' land uses such as educational institutes, medical facilities, outdoor recreational areas and commercial properties. The NMLs for 'other sensitive' receivers are shown in **Table 7**.

Table 7 NMLs for 'Other Sensitive' Receivers

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (dBA) (applied when the property is in use)	
	Internal	External
ICNG 'Other Sensitive' Receivers		
Classrooms at schools and other educational institutions	45	55[1]
Hospital wards and operating theatres	45	65[2]
Places of worship	45	55[1]
Active recreation areas (characterised by sporting activities and activities which generate noise)	-	65
Passive recreation areas (characterised by contemplative activities that generate little noise)	-	60
Commercial	-	70
Industrial	-	75

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (dBA) (applied when the property is in use)	
	Internal	External
Non-ICNG 'Other Sensitive' Receivers		
Hotel – daytime & evening[3]	50	70[2]
Hotel – night-time[3]	40	60[2]
Café/Bar/Restaurant[3]	50	70[2]
Child care centres – sleeping areas[4]	40	50[1]
Public building[3] (when in use)	50	60[1]
Recording studio[3] (when in use)	25	45[2]
Theatre / auditorium[3] (when in use)	30	50[2]

Note 1: It is assumed that these receivers have windows partially open for ventilation which results in internal noise levels being around 10 dB lower than the external noise level.

Note 2: It is assumed that these receivers have fixed windows which conservatively results in internal noise levels being around 20 dB lower than the external noise level.

Note 3: Taken from AS2107.

Note 4: Taken from Association of Australian Acoustical Consultants *Guideline for Child Care Centre Acoustic Assessment*.

3.3 Construction Traffic Noise Guidelines

The potential impacts from construction traffic associated with the proposal when travelling on public roads are assessed under the NSW *Road Noise Policy* (RNP).

An initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than 2.0 dB due to construction traffic. Where this is considered likely, further assessment is required using the RNP base criteria shown in **Table 8**.

Table 8 RNP Criteria for Assessing Construction Traffic on Public Roads

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am - 10 pm)	Night-time (10 pm - 7 am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

Where the criteria are exceeded the proposal would consider the use of all feasible and reasonable mitigation and management measures to minimise the impacts.

3.4 Construction Ground-borne Noise Guidelines

Construction work can cause ground-borne (or regenerated) noise impacts in nearby buildings when vibration intensive equipment is in use, such as during tunnelling or excavation work using tunnel boring machines, roadheaders or rockbreakers. Vibration can be transmitted through the ground and into nearby buildings, which can then create audible noise impacts inside the building.

Ground-borne noise NMLs are applicable where ground-borne noise levels are likely to be higher than airborne noise levels, which can occur where work is underground or where surface work is shielded by noise barriers or other structures.

Residential and Commercial Receivers

The internal ground-borne noise NMLs used in the assessment for residential and commercial receivers are shown in **Table 9**.

Table 9 Construction Ground-borne NMLs

Period	Residential	Commercial
Daytime[1]	45 dBA $L_{Aeq(15minute)}$	50 dBA $L_{Aeq(15minute)}$
Evening	40 dBA $L_{Aeq(15minute)}$[2]	n/a
Night-time	35 dBA $L_{Aeq(15minute)}$[2]	n/a

Note 1: Daytime ground-borne noise NMLs taken from preceding Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Note 2: Specified in the Sydney Metro CNVS.

Other Sensitive Land Uses

The ICNG and Sydney Metro CNVS do not provide ground-borne noise NMLs for 'other sensitive' receivers. For these receivers, the ICNG internal airborne noise NMLs listed in **Table 7** have been used to identify potential ground-borne noise impacts from the proposal.

3.5 Construction Vibration Guidelines

The effects of vibration from construction work can be divided into three categories:

- Those in which the occupants of buildings are disturbed (human comfort)
- Those where building contents may be affected (building contents)
- Those where the integrity of the building may be compromised (structural or cosmetic damage).

The criteria for these categories are taken from a number of guidelines and are discussed in the following sections. It is noted that a number of assessment parameters are used to assess the various vibration impacts.

3.5.1 Human Comfort Vibration

People can sometimes perceive vibration impacts when vibration generating construction work is located close to occupied buildings.

Vibration from construction work tends to be intermittent in nature and the EPA's *Assessing Vibration: a technical guideline* (2006) provides criteria for intermittent vibration based on the Vibration Dose Value (VDV). The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in **Table 10**.

Table 10 Vibration Dose Values for Intermittent Vibration

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (e.g. operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods, and is dependent on the level of vibration as well as the duration.

3.5.2 Effects on Building Contents

People perceive vibration at levels well below those likely to cause damage to building contents. For most receivers, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents.

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes, is located in buildings near to construction work. Criteria for vibration sensitive equipment are discussed in **Section 3.5.4**.

3.5.3 Cosmetic Damage Vibration

If vibration from construction work is sufficiently high it can cause cosmetic damage to elements of affected buildings. Examples of damage that can occur includes cracks or loosening of drywall surfaces, cracks in supporting columns and loosening of joints. The levels of vibration required to cause cosmetic damage tends to be at least an order of magnitude (10 times) higher than those at which people can perceive vibration.

Industry standard cosmetic damage vibration limits are specified in Australian Standard AS 2187-2, British Standard BS 7385 and German Standard DIN 4150, which are referenced in the Sydney Metro CNVS. Cosmetic damage vibration limits for residential and commercial buildings, heritage structures, and utilities are provided below.

3.5.3.1 General Cosmetic Damage Vibration Screening Criterion

The Sydney Metro CNVS recommends the following conservative cosmetic damage screening limits shown in **Table 11**.

Table 11 Transient Vibration Values for Minimal Risk of Cosmetic Damage

Type of Building	Peak Particle Velocity[1]
Reinforced or framed structures. Industrial and heavy commercial buildings	25 mm/s
Unreinforced or light framed structures. Residential or light commercial type buildings	7.5 mm/s

Note 1: Cosmetic damage vibration limits are reduced by 50 per cent to account for dynamic loading caused by continuous vibration dynamic magnification due to resonance.

The CNVS recommends that a more detailed analysis of the potential vibration impacts should be completed where the predicted and/or measured vibration levels are greater than the screening values.

3.5.3.2 Utilities and Other Vibration Sensitive Assets

Construction of the proposal could potentially affect other utilities and assets which may be sensitive to vibration. Examples include pipelines, tunnels, fibre optic cable routes and high pressure gas pipelines.

German Standard DIN 4150 provides the guideline vibration limits for buried pipework shown in **Table 12**.

Table 12 DIN 4150 Guideline Values for Short-term Vibration on Buried Pipework

Line	Pipe Material	Guideline Values Vibration Velocity at the Pipe (mm/s)
1	Steel, welded	100
2	Vitrified clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For other potentially affected assets, specific vibration limits should be determined on a case-by-case basis in consultation with the asset owner.

3.5.3.3 Heritage Buildings and Structures

The Sydney Metro CNVS states that heritage buildings and structures should be assessed using the cosmetic damage screening criteria in **Table 11** and should not be assumed to be more sensitive to vibration unless found to be structurally unsound.

Where heritage buildings or and structures are found to be structurally unsound a more conservative cosmetic damage objective of 2.5 mm/s Peak Particle Velocity (PPV) (from DIN 4150) should be considered. The only heritage building or structure identified to require consideration of the 2.5 mm/s cosmetic damage screening criterion is the former White Bay Power Station in The Bays study area.

3.5.4 Sensitive Scientific Equipment

Some scientific equipment, such as electron microscopes and microelectronics manufacturing equipment, can require more stringent vibration objectives. Other sensitive equipment used for various business requirements, such as medical equipment, may also have specific vibration goals. Vibration sensitive equipment is, however, often housed in buildings/rooms specifically designed and constructed for that purpose, which can help mitigate any potential impacts.

Vibration limits for the operation of sensitive scientific and medical equipment should be taken from manufacturer's data. Where this is not available the Vibration Criterion (VC) curves shown in **Table 13** can be used.

Table 13 VC Curves for Vibration Sensitive Equipment

Criterion Curve	Max Level (µm/sec, RMS)	Detail Size (microns)	Description of Use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note: Vibration Criterion curves as published by the Society of Photo-Optical Instrumentation Engineers (Colin G. Gordon – 28 September 1999).

Where the criteria are exceeded all appropriate feasible and reasonable mitigation and management measures would be considered to minimise the impacts.

4 Methodology

This section describes the methodology used to assess the potential noise and vibration impacts from the proposal.

4.1 Construction Airborne Noise Assessment

4.1.1 Computer Noise Modelling

A noise model of the study area has been used to predict noise levels from the various construction sites to the surrounding receivers. The model uses ISO 9613 algorithms in SoundPLAN software to predict noise levels at external building facades and outdoor recreation areas.

Local terrain, receiver buildings and structures were digitised in the noise model to develop a three-dimensional representation of the construction sites and surrounding areas.

4.1.2 Assessment Approach and Construction Work Descriptions

The proposed construction work includes the following:

- Site clearing of currently occupied construction sites (including demolition of existing structures) and site establishment at Pyrmont and Hunter Street (Sydney CBD)
- Excavation of station shafts at Pyrmont and Hunter Street (Sydney CBD)
- Excavation of station caverns at The Bays, Pyrmont, and Hunter Street (Sydney CBD)
- Excavation of the tunnels between The Bays and Sydney CBD.

Representative scenarios have been developed to assess the likely impacts from the various construction activities. The scenarios required at the surface construction sites are discussed in **Section 4.1.2.1**. Tunnelling and ancillary work is discussed in **Section 4.1.2.2**. Equipment lists for each scenario and sound power level data is provided in **Appendix C**.

The assessment uses ‘realistic worst-case’ scenarios to predict the potential airborne noise impacts from the noisiest 15-minute period for each work scenario, as required by the ICNG. The impacts represent construction noise levels with project specific base-case mitigation applied (see **Section 4.6.1**).

Scenarios have been categorised into ‘peak’ and ‘typical’ work which have been used to define the likely range of potential noise impacts:

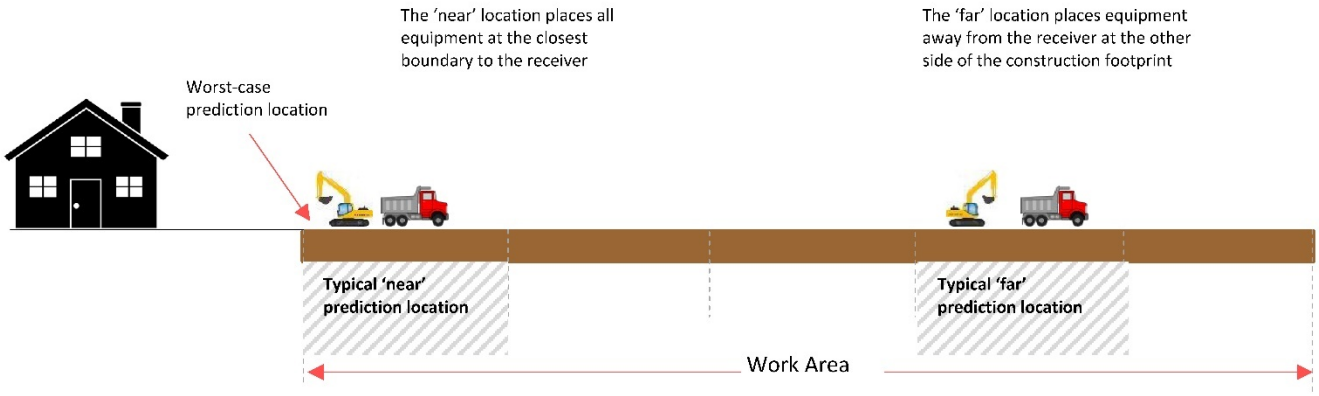
- ‘**Peak**’ work represents the noisiest stages and can require noise intensive equipment, such as rockbreakers or concrete saws. While ‘peak’ work would be required at times in most locations, the noisiest activities would not occur for the full duration of the work.
- ‘**Typical**’ work represents typical noise emissions when noise intensive equipment is not in use. The ‘typical’ work generally includes items of equipment that are less noisy than the ‘peak’ scenario.

Construction activities would generally occur sequentially at each site and it is expected that there would be relatively long periods where construction noise levels are much lower than the 'peak' and 'typical' worst-case levels presented in this assessment. There would also be times when work is not audible at receivers due to less noisy items of equipment being used or where work is in distant parts of the construction site.

Certain construction scenarios would require the concurrent operation of several construction teams (or 'construction faces') performing the same work in different areas of the site. The 'peak' scenarios include the maximum anticipated number of construction faces at each construction site. The assessment is generally considered conservative as the calculations assume several items of equipment at each construction face are in use at the same time.

For a particular construction site, the potential construction noise impacts can vary greatly, with a key factor being the distance of the work from the nearest receivers. For work that move around the site (such as site clearing and piling), a receiver would be affected by a range of noise levels depending on how close the work is. This concept is illustrated in **Figure 4**.

Figure 4 Illustration of Work Position in Relation to Receiver



The above illustration shows that work which is close to a receiver would result in higher impacts than work which is further away. The assessment presents the expected range of impacts for each construction scenario based on work being both 'near' and 'far' from the nearest potentially affected receivers.

Work within a confined area, such as excavation inside the acoustic sheds, would be limited to one location and no range has been presented for these scenarios.

4.1.2.1 Construction Site Work Descriptions

The representative scenarios required to construct the proposal are listed and described in **Table 14**. The scenarios represent one possible way that the proposal could be constructed and may not necessarily be the same methodology that the contractor engaged to construct the proposal would use.

Table 14 Construction Scenario Descriptions – Construction Site Activities

Scenario	Description
Enabling and site establishment work	This work would be required at Pyrmont and Hunter Street (Sydney CBD) to demolish existing buildings and structures, clear or protect trees, establish access points and erect hoarding. Relocation of services or third party assets may also be required. This work may include provision of high voltage power supplies for excavation equipment, which is required early in the program. The assessed scenarios are: - 'Typical': work generally includes operation of supporting equipment such as generators, cranes, compressors, etc, and loading of heavy vehicles with equipment such as excavators. - 'Peak': work includes the use of noise intensive equipment such as rockbreakers or concrete saws at times, especially during demolition of existing structures. The number of construction faces doubles during 'peak' work for most construction sites.
Piling	Piling would be required at Pyrmont and Hunter Street (Sydney CBD) for the foundations of future structures and to support linings for the stations and shafts. The assessed scenarios are: - 'Typical': work would include operation of supporting equipment such as excavators and cranes, as well as concreting equipment such as concrete mixer heavy vehicles and concrete pumps. - 'Peak': work would use all supporting equipment plus a piling rig. The number of piling faces doubles during 'peak' work, with most construction sites requiring up to four piling faces where there is sufficient space. Bored piling would be used as opposed to impact piling, where possible. Bored piling is significantly less noisy.
Surface construction	Following site establishment and piling, civil work and surface structures such as abutments, roads, hardstand areas, and facilities such as water treatment equipment and site offices would be constructed. This work would be required at Pyrmont and Hunter Street (Sydney CBD). Acoustic sheds would be constructed over excavation and spoil handling areas as early as possible at Pyrmont, prior to excavation and tunnelling work. The assessed scenarios are: - 'Typical': work would include the use of general construction equipment such as cranes, generators and hand tools. - 'Peak': work would use all supporting equipment plus noise intensive equipment such as grinders. The number of construction faces would double during 'peak' work.

Scenario	Description
Excavation	Station shafts would need to be excavated at Pyrmont and Hunter Street (Sydney CBD) from the surface down. Excavation would begin after the piling work and surface construction work, where applicable. Excavation would be completed within acoustic sheds at Pyrmont, where 24/7 excavation work is proposed. Excavation at Pyrmont would be staged in two phases – 'initial excavation' and 'main excavation'. 'Initial excavation' involves a smaller acoustic shed at the eastern portion of the site to allow early shaft excavation and 'main excavation' involves a longer-term and larger acoustic shed that would be in place for the majority of the excavation work. Shaft excavation would be completed without acoustic sheds at Hunter Street (Sydney CBD). This is consistent with excavation work completed at the Sydney Metro City & Southwest construction sites in Sydney CBD, given the high existing background noise levels. The existing acoustic shed would need to be dismantled once cavern excavation is complete (see below) to allow shaft excavation, as it is currently only over part of the Hunter Street Station (Sydney CBD) eastern construction site. The assessed scenarios are: - 'Typical': work would include the use of support equipment for spoil handling and a process called 'mucking out' which occurs at times when excavation work would pause so the loose spoil can be removed using excavators and transferred to heavy vehicles. - 'Peak': work would involve the concurrent operation of supporting equipment and excavation using rockbreakers. The number of construction faces would double during 'peak' work for most construction sites with most sites requiring concurrent use of two rockbreaking faces. Construction equipment outside the acoustic sheds would include heavy vehicles and fixed ancillary equipment such as ventilation systems and water treatment facilities.
Mined caverns	Once shafts have been excavated, areas of the underground station caverns and tunnels would be mined using roadheaders. This work would be required at The Bays tunnel launch and support site for the crossover cavern near the start of the tunnel alignment, Pyrmont construction sites and Hunter Street (Sydney CBD) construction sites. Mined cavern work would be launched from within acoustic sheds at all sites, with the Hunter Street (Sydney CBD) using the existing Bligh Street acoustic shed. The assessed scenarios are: - 'Typical': work would generally include operation of supporting equipment associated with spoil removal. - 'Peak': work include the concurrent use of supporting equipment and roadheaders. The number of construction faces would double during 'peak' work with up to two roadheaders operating at the same time.

Scenario	Description
TBM launch, retrieval and support	The tunnel boring machines are proposed to be launched and supported from The Bays tunnel launch and support site, and retrieved from Hunter Street Station (Sydney CBD) construction sites. Tunnel boring machine assembly and launch activities would occur 24/7, however, the majority of this work would be completed inside an acoustic shed or at the bottom of The Bays Station box excavation (constructed as part of Sydney Metro West between Westmead and The Bays). Tunnel boring machine retrieval would also occur 24/7, however, the majority of this work would be completed at the bottom of the Hunter Street (Sydney CBD) Station box excavation. Some less noisy work would be required outside the shed, such as loading and unloading of heavy vehicles. Support activities would also be required to provide tunnel ventilation, supply high voltage power and extract/stockpile spoil. The assessed scenarios are: - 'Typical': work would include spoil handling and removal. The work requires heavy vehicles, spoil conveyors, loading activities, tunnel ventilation fans, dust collectors, materials and equipment deliveries and onsite stockpiling. - 'Peak': work would include the concurrent use of some supporting equipment and tunnel boring machine launch or retrieval activities.

4.1.2.2 Tunnelling and Ancillary Work

The proposed tunnelling and ancillary activities are listed and described in **Table 15**.

Table 15 Construction Scenario Descriptions – Tunnelling and Ancillary Activities

Scenario	Description
Tunnelling – excavation and construction	The tunnelling work would occur 24/7. Depending on the rate of progress, noise and vibration impacts from tunnelling would likely only be apparent for relatively short periods at most locations. At this stage, tunnel boring machines are proposed to be used for the majority of the alignment with roadheaders and rockbreakers used at stations, stub tunnels, cross passages and crossover and turnback caverns.
Tunnelling – work trains	Consistent with the tunnelling methodology used on previous Sydney Metro projects, work trains would likely be used to supply materials, such as precast tunnel lining segments, and workers to the workface. Spoil would be removed via conveyor. Work trains are anticipated to operate on bespoke underground wheeled vehicles, with an alternative of a temporary narrow gauge rail with resilient mounts and/or rubber wheels. The work trains would be loaded at the launch site and unloaded at the tunnel boring machines. The operating speed of work trains would be around 10 km/h and they would be required 24/7 to support tunnelling. Work trains are not expected to result in any significant noise and vibration impacts.
Spoil and materials transport	Spoil and materials transport via heavy vehicles would be required to and from all construction sites. The use of other methods of transport, such as a barge from The Bays tunnel launch and support site, may be possible subject to further investigation.

Scenario	Description
Utility work	Utilities would need to be adjusted, relocated and/or protected where there is a possibility they would be impacted during construction. Access to a source of electrical power would be required for the construction sites, tunnel boring machines and future metro facilities. High voltage power supply would be provided to The Bays tunnel launch and support site under existing arrangements as approved within Stage 1 of the planning approval. The power supply route for Hunter Street (Sydney CBD) would be provided through the existing Sydney Metro City & Southwest power supply route in place. Pyrmont Station construction sites would require a new power supply route to be constructed, as provided in Figure 5 18 in Chapter 5 (Project description) of the Environmental Impact Statement. The construction of this power supply route at Pyrmont is discussed in **Section 5.4**.

4.2 Construction Ground-borne Noise and Vibration Assessment

Ground-borne noise and vibration impacts at receivers above the proposed tunnelling work or near to station excavation work have been predicted using a three-dimensional model which includes receiver elevation data and the shaft locations/tunnel alignment.

Vibration is discussed in terms of potential ground-borne vibration and ground-borne noise impacts. Ground-borne vibration refers to vibration impacting buildings from work being completed at ground level or below ground. Ground-borne noise refers to the 'rumble-like' noise generated from the vibration of the building's internal surfaces.

Ground-borne vibration is assessed in terms of Peak Particle Velocity (PPV) and period Vibration Dose Value (VDV), and ground-borne noise is assessed in terms of the 15-minute average noise level.

Ground-borne noise is only required to be assessed where ground-borne noise levels are higher than the corresponding airborne noise levels.

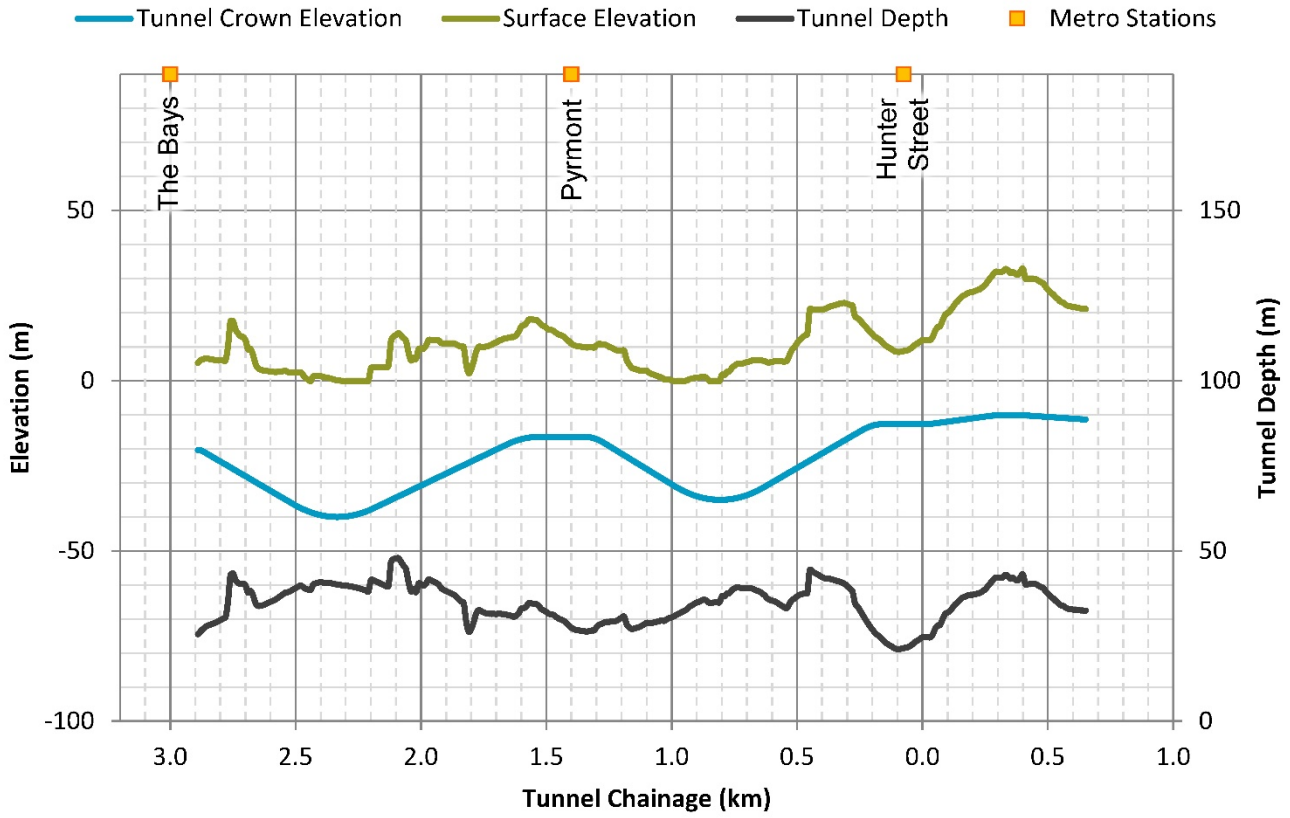
4.2.1 Key Vibration Sources

The main sources of vibration generating equipment are:

- Tunnel boring machines, which excavate rock and construct the tunnel exterior structure
- Roadheaders (which scrape/grind rock) and rockbreakers which are used to excavate stations, station shafts, crossover caverns, cross passages and adits.

The proposed tunnel depth is shown in **Figure 5**. The figure shows that the depth generally varies between 30 and 50 metres for most of the alignment. The shallowest parts are near to metro stations, which are around 20 to 30 metres below the surface.

Figure 5 Proposed Tunnel Depth and Existing Ground Elevation



4.2.2 Modelling Approach

The prediction of ground-borne noise and vibration from underground construction sites is a complex and developing technical field. While much research has been undertaken, there is currently no universally accepted modelling approach.

The modelling has been carried out using a combination of theoretical and empirical relationships which use the 3D slant distance from the potentially affected receivers to the closest section of the tunnels or excavation work. The modelling also includes the following assumptions:

- The tunnel boring machines are seven metres in diameter, has a double shield configuration and is in use for 25 to 50 per cent of the assessment period (the rest of the time is spent assembling the tunnel lining and repositioning)
- The tunnel boring machines typically progress at a rate of around 20 to 30 metres per day
- Rockbreakers are 900 kilograms in size, have a 16 Hz drive frequency, are mounted to 12-22t tracked excavator and in use for 33 per cent of the assessment period
- Spoil would be transported from the tunnel boring machines to the surface via conveyor
- Tunnelling would occur 24/7
- Large buildings with substantially greater mass than a typical residential house have conservatively been assumed to have no additional coupling loss

- A conservative crest factor of 3.0 has been used for rockbreakers and 3.5 for tunnel boring machines.

4.2.3 Source Levels versus Distance

The PPV and ground-borne noise levels used in the modelling are shown in **Figure 6** and **Figure 7** for tunnel boring machines and rockbreakers, respectively. Reference information sources are provided for comparison.

Figure 6 Levels versus Distance for Tunnel Boring Machines – Vibration (left), Ground-borne Noise (right)

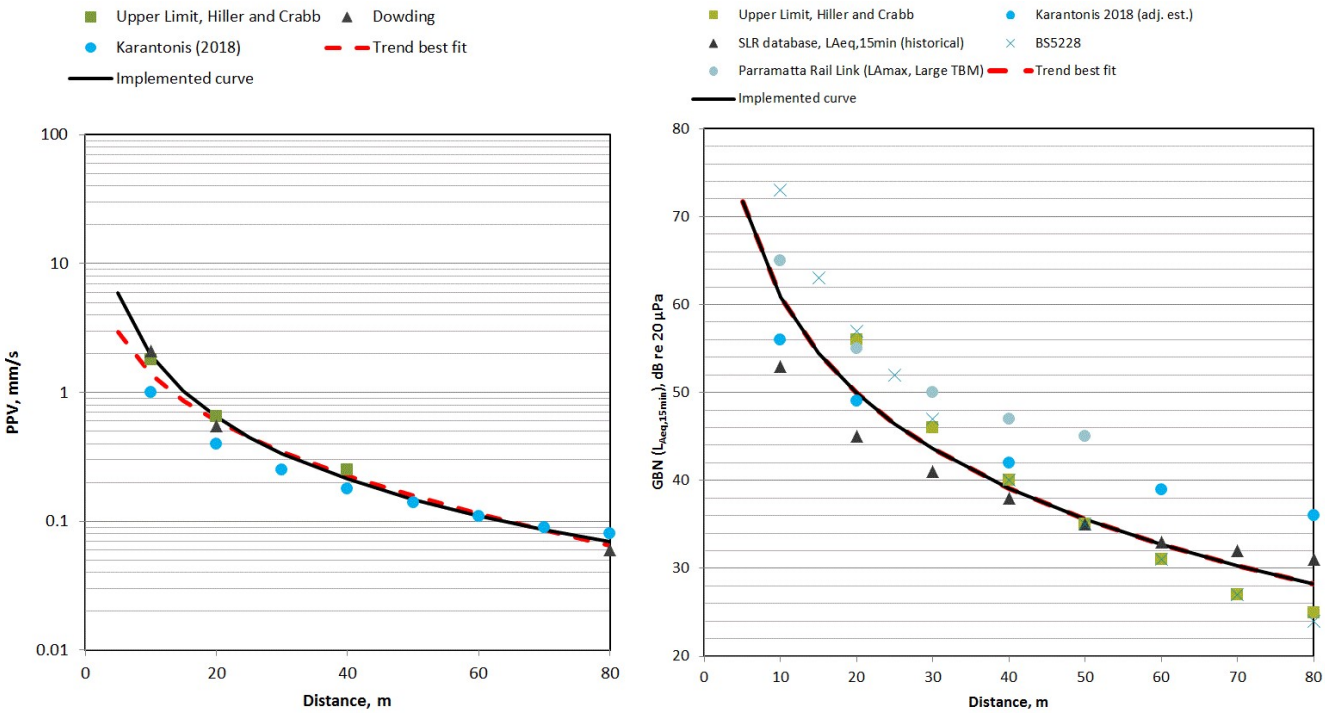
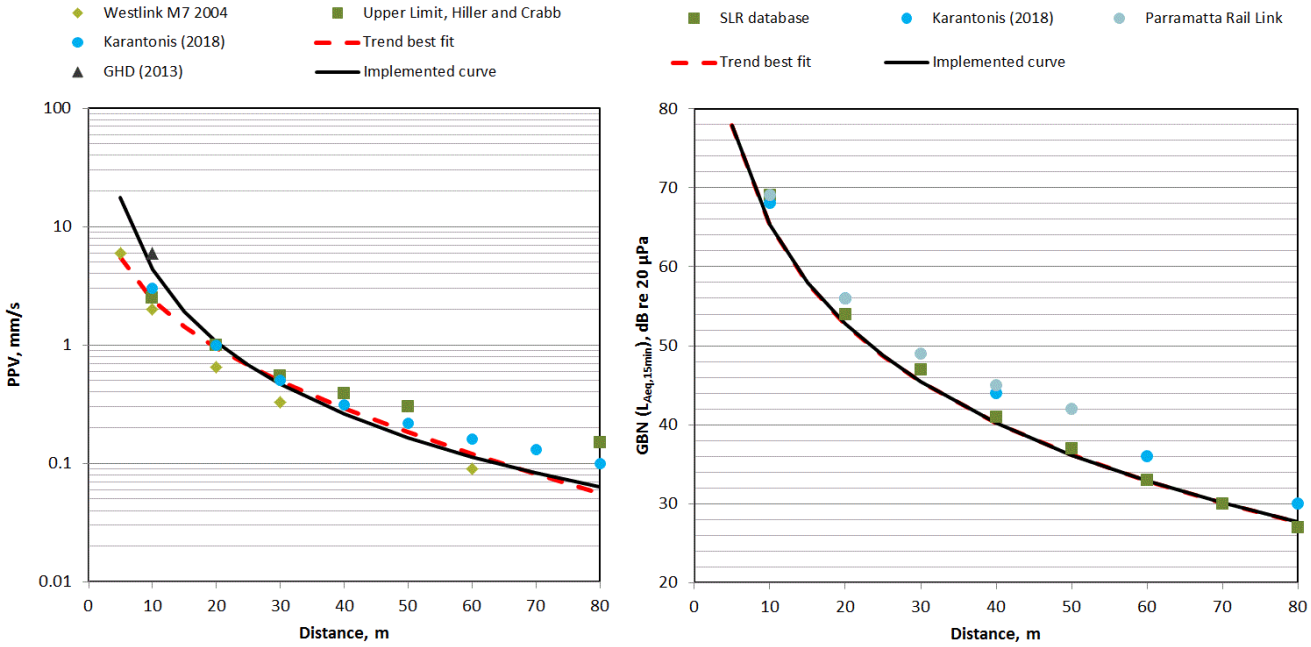


Figure 7 Levels versus Distance for Rockbreakers – Vibration (left), Ground-borne Noise (right)



4.3 Construction Traffic Noise Assessment

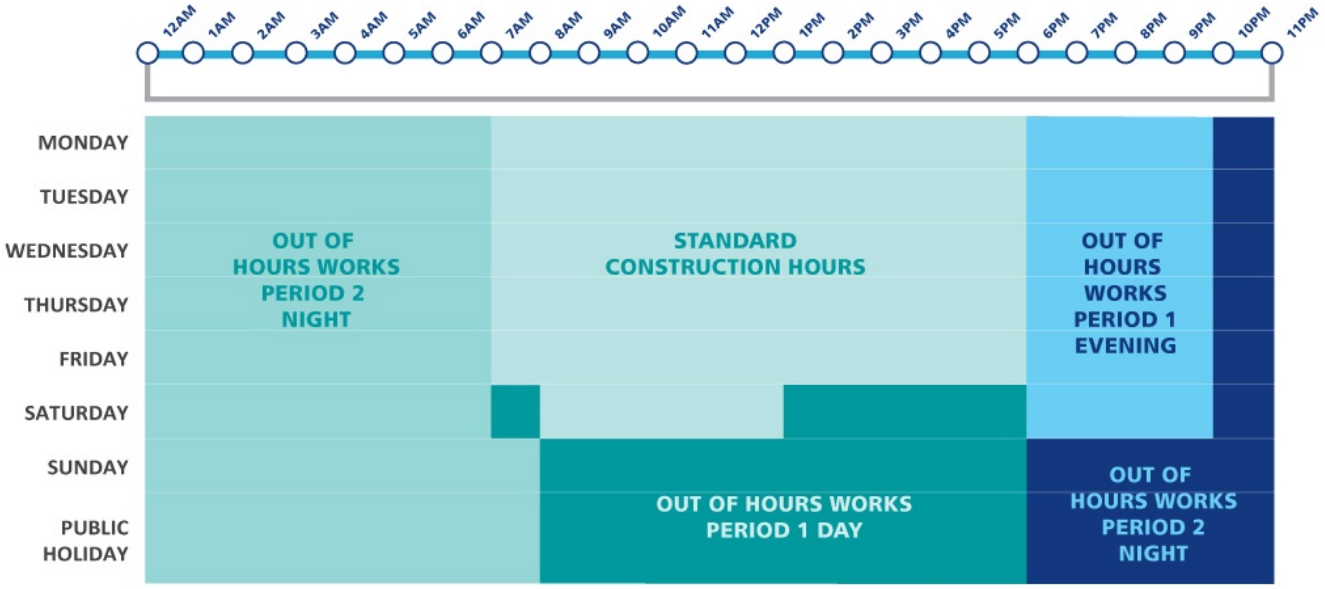
The potential impacts from construction traffic on public roads have been predicted using the *Calculation of Road Traffic Noise* (CORTN) algorithm.

Where the criteria are found to be exceeded, feasible and reasonable mitigation and management measures should be considered.

4.4 Working Hours

Construction of the proposal would be carried out during Standard Construction Hours where practicable. Standard Construction Hours are defined in the ICNG and shown in **Table 16.**

Table 16 Standard Construction Hours[1, 2, 3]



Note 1: Taken from the Transport for NSW *Construction Noise and Vibration Strategy*.

Note 2: Standard Construction Hours are Monday to Friday 7am to 6pm and Saturdays from 8am to 1pm, as defined in the ICNG.

Note 3: Work outside of Standard Construction Hours is defined as 'out of hours work' (OOHW) and can be divided into two periods of sensitivity. OOHW Period 1 which relates to evening (and weekend daytime) work, and OOHW Period 2 which relates to night-time (and weekend evening) work.

The ICNG Standard Construction Hours are proposed to be extended to include work during the Saturday out of hours work period 1, from 1pm to 6pm, consistent with the approval for Sydney Metro West Stage 1 to reduce the overall program. Earlier completion of the proposal would bring considerable benefits to the community and would reduce the duration of construction related disruption. Appropriate acoustic mitigation measures would be in place to minimise impacts, as outlined in **Section 6**. All work scenarios have, therefore, been assessed as occurring during this period.

Project specific constraints would require evening and night-time work at certain times. A summary of the proposed construction hours for the proposal is shown in **Table 17**.

As the tunnel boring machines operate continuously, tunnelling and associated support activities would need to be carried out on a 24/7 basis. The majority of the construction site activities would, however, be carried out during daytime hours including Standard Construction Hours and Saturday out of hours work period 1.

Table 17 Proposed Construction Hours

Activity	Construction hours	Comments or exceptions
Aboveground construction activities		
Enabling work	ICNG Standard Construction Hours and daytime OOHW period 1 (i.e. 1pm to 6pm on Saturdays).	Noisy work generally restricted to extended Standard Construction Hours. Noise mitigation would be used where practicable.
Piling		
Surface construction		
Tunnel boring machine launch, support and retrieval	24 hours per day, seven days per week.	Noise mitigation, including an acoustic shed at The Bays tunnel launch and support site, would be used where practicable.
Construction traffic for material supply to and spoil removal from tunnelling and underground excavation at station sites	24 hours per day, seven days per week at The Bays tunnel launch and support site and Hunter Street Station (Sydney CBD) construction sites. 7am to 10pm at Pyrmont (infrequent heavy vehicles may be required during the night-time to support concrete delivery during cavern lining pours for safety reasons).	Restrictions would be in place during sensitive periods. The majority of vehicle movements at Pyrmont would likely be restricted to between 7am and 10pm due to proximity of night-time sensitive receivers. Given the largely commercial environment of the Hunter Street Station (Sydney CBD) construction sites, extended construction hours for the removal of spoil are proposed during the night-time.
Utility work	24 hours per day, seven days per week.	Utility work requiring the temporary possession of roads may need to be carried out outside Standard Construction Hours during periods of low demand to minimise safety impacts and inconveniences to motorists.
Underground construction activities		
Station excavation and concrete lining	24 hours per day, seven days per week.	Out of hours underground excavation work at the Pyrmont Station construction sites would only occur once the acoustic sheds have been constructed. Mined cavern excavation works at the Hunter Street Station (Sydney CBD) eastern construction site would occur within the existing acoustic shed. The majority of vehicle movements at Pyrmont would likely be restricted to between 7am and 10pm due to proximity of night-time sensitive receivers. Infrequent heavy vehicles may, however, be required during the night-time at Pyrmont to support concrete delivery during cavern lining pours for safety reasons.
Tunnelling work	24 hours per day, seven days per week.	Activities that support tunnelling may need to occur 24 hours per day, up to seven days per week. Rockbreaking in the tunnel and cross passages between 10pm and 7am would not occur except where appropriate noise impact management measures have been established

Justification for Out of Hours Work

Standard construction hours outlined in the ICNG are proposed to be extended from 1 pm to 6 pm on Saturdays to reduce the overall program of the proposal. Earlier completion would bring considerable benefits to the community and would reduce the duration of construction related disruptions compared with the impacts.

At Pyrmont Station construction sites, the station cavern would need to be excavated prior to the tunnel boring machine passing through the underground station. If the cavern is not excavated prior to the arrival of the tunnel boring machine, the overall project duration at Pyrmont would need to be substantially increased to account for a more complex construction sequencing methodology, including the need to bring additional excavators on site resulting in high impact construction work over a longer period.

Extended construction hours on Saturday afternoons reduce the overall duration of high intensity excavation work and its potential impact on the community, as opposed to having various phases of intermittent high noise intensity excavation work over a longer period of time.

Detailed justification for work required to be completed outside of Standard Construction Hours is provided in **Table 18**. Further detail on the approach to out of hours work is provided in the Sydney Metro CNVS.

Table 18 Work Outside of Standard Construction Hours

Activity	Justification for Out of Hours Activities
Enabling and site establishment (including demolition and demobilisation), piling and surface construction work	Enabling and site establishment (including demolition), pilling and surface construction work are proposed between 1pm and 6pm on Saturdays (daytime out of hours work period 1) at the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites. Noise mitigation would be used where practicable. The receiver environment in the Sydney CBD is largely commercial with some distant residential receivers screened from view by intervening non-residential buildings, which limits the potential impacts.
Tunnelling (including associated excavation) and tunnelling support activities (including tunnel boring machine launch/retrieval and spoil handling)	Tunnelling and associated excavation work (cross passages, stub tunnels and turnback) would define the overall proposal 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 24/7 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 tunnel boring machines 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.

Activity	Justification for Out of Hours Activities
Construction traffic for material supply to and spoil removal from tunnelling and underground excavation at station sites	Tunnelling and excavation work would require 24/7 materials deliveries and the transport by road of substantial quantities of spoil. To avoid impacting the operation of the road network, construction vehicle movements during the AM and PM peak periods are to be minimised. Given the volumes of spoil and space constraints at construction sites, which limit the extent of on-site spoil storage, transport of materials and spoil cannot be limited to the hours between 10am and 3pm, meaning night-time and/or evening vehicle movements are necessary. Given the largely commercial receiver environment of the Hunter Street Station (Sydney CBD) construction sites, 24 hour work would be required for the removal of spoil during the night-time. At Pyrmont, where night-time sensitive receivers are close to construction sites, spoil haulage and material supply would be undertaken predominately between 7am and 10pm. A small number of heavy vehicles (up to one truck movement per hour) may be required outside these hours to ensure the safety of the construction site (e.g. shotcrete deliveries for the stability of the construction work and to minimise any potential ground movement or settlement). Construction work requiring the temporary possession of roads or to accommodate road network requirements may need to be carried out outside of the proposed construction hours during periods of low demand to minimise safety impacts and inconveniences to motorists. Restrictions may be in place during peak hours and special events. Heavy plant deliveries are likely to be restricted to outside of Standard Construction Hours during periods of low demand to minimise safety impacts and inconveniences to motorists.
Station and crossover cavern excavation, and concrete lining	For mined excavations, temporary support in the form of shotcrete, steel sets and rockbolts must be installed immediately to ensure stability of the work and to minimise any potential ground movement or settlement. Grouting is required to transfer load directly to the adjacent rock and needs to occur immediately after bolt installation for safety and quality reasons. 24/7 work would allow for the completion of the entire support system following excavation. Excavation would be completed within acoustic sheds at Pyrmont, where 24/7 excavation work is proposed. Excavation within the Pyrmont Station eastern construction site would be staged in two phases – 'initial excavation' and 'main excavation'. 'Initial excavation' involves a smaller acoustic shed at the eastern portion of the site to allow early shaft and cavern excavation and 'main excavation' involves a longer-term and larger acoustic shed that would be in place for the majority of the excavation work. The existing acoustic shed at the Hunter Street (Sydney CBD) eastern construction site would remain in place (erected as part of the Sydney Metro City and Southwest construction site) for the majority of the excavation, however, this would need to be dismantled once cavern excavation is complete to allow shaft excavation, as it is currently only over part of the Hunter Street Station eastern construction site. It is anticipated that shaft excavation would then be completed without acoustic sheds at both the Hunter Street (Sydney CBD) construction sites. Any high impact shaft excavation work undertaken outside an acoustic shed would only be completed during extended Standard Construction Hours. This is consistent with excavation work completed at the Sydney Metro City & Southwest construction sites in Sydney CBD. This is due to the high existing background noise levels and the minimal benefit of establishing an acoustic shed for shaft excavation only, compared with the time and noise impacts to build and remove an acoustic shed to complete this activity.

Activity	Justification for Out of Hours Activities
Utility management and power supply work	While most utility work and power supply route work would be carried out within extended Standard Construction Hours, work requiring the temporary possession of roads may need to be carried out outside of the standard daytime construction hours during periods of low demand to minimise safety impacts and inconveniences to motorists.

4.5 Work Schedule

Subject to planning approval, construction of the proposal is planned to commence in 2023, with completion expected in 2025. The total duration of the proposal construction work is expected to be around two and a half years. The indicative construction program is shown in **Table 19**.

Table 19 Indicative Construction Program

4.6 Construction Mitigation Measures

The ICNG acknowledges that due to the nature of construction work it is inevitable that there will be impacts where construction is near to sensitive receivers. Several approaches are used on major infrastructure projects to minimise the potential noise and vibration impacts as far as practicable and these are discussed below.

4.6.1 Base-case Mitigation Measures Included in Design

The proposed construction work include a number of base-case mitigation measures to minimise the potential airborne noise impacts. These measures are included in the construction impact assessment in **Section 5** and are used prior to consideration of any 'additional mitigation measures'.

Table 20 Project Specific Base-case Mitigation Measures

Included Mitigation Measures	Description
Bored piling	The construction activities assume that bored piling would be used as opposed to impact piling, wherever possible. Bored piling is significantly less noisy than impact piling.
Acoustic perimeter hoardings	For construction concentrated in a single area, such as at station construction sites, temporary acoustic hoardings around the site perimeter would be used where receivers are potentially affected and where feasible and reasonable. Acoustic hoarding of solid construction (as opposed to standard wire mesh fence) has been included in the assessment at The Bays tunnel launch and support site and Hunter Street Station (Sydney CBD) construction sites and is shown on the study area figures in **Section 5.2**. The acoustic hoarding has been assessed with a minimum height of three metres, with some areas adjacent to footpaths assessed as B-class overhead hoarding with a total height of five metres. However, in practice the same noise outcome at the receivers could be achieved through a range of mitigation measures and potentially different barrier heights.
Acoustic sheds (or other acoustic measures)	An acoustic shed is proposed to be used at The Bays tunnel launch and support site where mining and tunnelling work would occur on a 24/7 basis. Acoustic sheds are proposed at the Pyrmont Station construction sites where station excavation would occur on a 24/7 basis in close proximity to sensitive receivers. The existing Bligh Street acoustic shed would be retained at the eastern Hunter Street (Sydney CBD) construction site during mined cavern work only. The sheds are typically designed to cover all excavation and spoil handling activities with the exception of The Bays tunnel launch and support site where spoil handling would be outside the acoustic shed. At this stage, detailed designs have not been developed and a typical shed construction based on previous stages of Sydney Metro has been used with indicative shed dimensions. Shed ventilation would be required to be designed to maintain the integrity of the shed's acoustic performance, which indicatively would require attenuators for supply and return air ducting. Details on the acoustic properties assumed for the sheds are in **Appendix D.** When the main doors of the acoustic sheds are opened to allow heavy vehicle access, noise emissions would potentially increase. The assessment presents predicted noise levels for doors open and doors closed. The specific noise mitigation measures would be determined during detailed construction planning taking into account construction program, construction working hours and construction traffic management in accordance with the Sydney Metro CNVS and may include mitigation measures other than acoustic sheds.

4.6.2 Standard and Additional Mitigation Measures – Sydney Metro CNVS

The Sydney Metro CNVS contains a number of 'standard mitigation measures' for mitigating and managing construction impacts on Sydney Metro projects. Where impacts remain after the use of 'standard mitigation measures', the CNVS requires 'additional mitigation measures' to be applied, where feasible and reasonable.

The mitigation measures recommended to address noise and vibration impacts from the construction of the proposal are outlined in **Section 6**.

5 Construction Impact Assessment

5.1 Overview of Impacts from Construction Sites

The following overview is based on the predicted impacts at the most affected receivers in each study area and is representative of the worst-case noise levels that are likely to occur during construction.

The assessment shows the predicted impacts based on the exceedance of the management levels, as per the categories in **Table 21**.

Table 21 Exceedance Bands and Impact Colouring

Exceedance of Management Level	Subjective Classification[1]	Impact Colouring
No exceedance	Negligible	
1 to 10 dB	Low impact	
11 dB to 20 dB	Moderate impact	
>20 dB	High impact	

Note 1: This subjective classification is indicative and follows the approach outlined in the Sydney Metro CNVS for reporting of construction impacts in Detailed Noise and Vibration Impact Statements. The subjective response would vary and depends on the period in which the impacts occur (i.e. people are generally more sensitive to impacts during the evening and night-time).

5.1.1 Overview of Airborne Noise Impacts from Construction Sites

The predicted construction airborne noise impacts are presented for the most affected receivers. Receivers which are further away from the work and/or shielded from view would have substantially lower impacts. The assessment is conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

A summary of the predicted construction airborne noise levels (without additional mitigation) in each NCA for the various construction site activities is shown in **Table 22** for residential and commercial receivers. Results for 'other sensitive' receivers are presented in the various study area discussions in **Section 5.2**.

'Typical' and 'peak' noise impacts are predicted for each scenario, where appropriate. The noise levels are also shown as a range (i.e. 55 to 68 dBA), which represents the likely noise levels when work is 'near' to 'far' from a particular receiver, as explained in **Section 4.1.2**.

The noise levels are based on a realistic worst-case assessment of each work scenario. For most construction activities, it is expected that the construction noise levels during less intensive activities would frequently be lower than predicted.

Impacts from ground-borne noise and vibration are summarised in **Section 5.1.2** and discussed in detail in the study area sections. Impacts from tunnelling are in **Section 5.3** and impacts from construction road traffic are in **Section 5.3.3**.

Table 22 Predicted Worst-Case Airborne Noise Impacts from Surface Construction Sites – All Work and All NCAs

Study area	NCA	NML	Predicted Worst-case $L_{Aeq(15minute)}$ Noise Level (dBA)													
			Surface Work (before construction of acoustic sheds)						Underground Excavation Work (in acoustic sheds)							
			Enabling work		Piling		Surface construction		Initial excavation		Excavation[1]		Mined cavern		TBM launch and support	
			Typical	Peak	Typical	Peak	Typical	Peak	Typical	Peak	Typical	Peak	Typical	Peak	Typical	Peak
			Supporting and loading or, delivery of equipment	Demolition using a rockbreaker/concrete saw	Supporting work	Bored piling with supporting plant	General work	Noise intensive work	Mucking out	Through rock using rockbreaker	Mucking out	Through rock using rockbreaker (doors closed)	Spoil removal	Mining with support equipment	TBM support and spoil removal or, deliveries and on/off loading	TBM assembly and launch/disassembly
Residential – Daytime																
The Bays	NCA01	61	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	39	46	39	46
	NCA02	53	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	41	46	41	46
	NCA03	58	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	30	38	30	38
Pyrmont	NCA04	60	46 to 81	64 to >90	43 to 80	51 to 88	41 to 78	47 to 84	58	67	54	67	54	60	n/a	n/a
	NCA05	62	57 to 70	75 to 88	55 to 67	63 to 75	53 to 65	59 to 71	62	67	62	68	62	64	n/a	n/a
Hunter Street	NCA06	71	32 to 54	50 to 72	31 to 52	39 to 60	<30 to 51	35 to 57	n/a	n/a	40	69	<30	30	n/a	n/a
	NCA07	71	35 to 56	53 to 74	34 to 39	42 to 47	32 to 53	38 to 59	n/a	n/a	<30	57	31	33	n/a	n/a
Residential – Night-time																
The Bays	NCA01	50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	39	46	39	46
	NCA02	40	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	41	46	41	46
	NCA03	44	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	30	38	30	38
Pyrmont	NCA04	50	n/a	n/a	n/a	n/a	n/a	n/a	58	67	54	67	55	60	n/a	n/a
	NCA05	51	n/a	n/a	n/a	n/a	n/a	n/a	62	67	62	68	62	64	n/a	n/a
Hunter Street	NCA06	57	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	40	69	<30	30	n/a	n/a
	NCA07	57	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<30	57	31	33	n/a	n/a
Commercial																
The Bays	NCA01	70	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	34	42	34	42
	NCA02	70	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	45	52	45	52
	NCA03	70	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	33	41	33	41
Pyrmont	NCA04	70	50 to 70	68 to 88	46 to 65	54 to 73	44 to 63	50 to 69	61	65	61	66	61	62	n/a	n/a
	NCA05	70	56 to 70	74 to 88	54 to 67	62 to 75	52 to 65	58 to 71	55	66	55	67	55	60	n/a	n/a
Hunter Street	NCA06	70	58 to 83	76 to >90	56 to 82	64 to 90	54 to 80	60 to 86	n/a	n/a	66	>90	64	67	n/a	n/a
	NCA07	70	54 to 82	72 to >90	53 to 80	61 to 88	51 to 78	57 to 84	n/a	n/a	65	>90	69	73	n/a	n/a

Note 1: Excavation at Hunter Street (Sydney CBD) would be completed without acoustic sheds.

Legend

No Exceedance | 1 - 10 dB above NML | 11 - 20 dB above NML | >20 dB above NML

The above assessment for the most affected receivers in each NCA during the worst-case impacts shows that:

- The airborne noise impacts from the construction sites vary depending on how close the nearest receivers are, and the type of work required. Certain receivers are close to the Pyrmont and Hunter Street (Sydney CBD) construction sites and 'moderate' to 'high' impacts are predicted during noisy surface level work. Work at The Bays tunnel launch and support site are generally below ground and receivers are relatively distant from the nearest receivers which results in the predicted the impacts being much lower and mostly compliant with the NMLs.
- The highest impacts are seen in the 'peak' scenarios, particularly where noise intensive equipment such as rockbreakers or concrete saws are used during surface work before the acoustic sheds are constructed. For most scenarios, the 'peak' work would only be required for relatively short periods of the total duration and noise impacts during 'typical' work, which do not require noise intensive equipment, are considerably lower. Noise intensive surface work would generally only occur during daytime hours.
- Individual receivers would be subject to a range of impacts. The highest impacts are seen when work is 'near' to receivers and are generally much lower when the work is 'far', due to the increased separation distance. This applies to *Enabling work*, *Piling* and *Surface construction* which are required to move around the construction sites before the acoustic sheds are constructed.
- During the daytime, the nearest residential receivers at the Pyrmont and Hunter Street (Sydney CBD) construction sites are predicted to have 'high' and 'low' impacts respectively when noisy surface work is being completed without acoustic sheds. When work is underground and within acoustic sheds (where proposed) the daytime impacts at residential receivers adjacent to all sites are mostly compliant with the NMLs.
- Night-time work at the Pyrmont construction sites and The Bays tunnel launch and support site would only be completed in acoustic sheds. *Mined cavern* work at the Hunter Street Station (Sydney CBD) eastern construction site would be completed in an acoustic shed and *Excavation* work would be completed without an acoustic shed. All night-time work at the Hunter Street Station (Sydney CBD) western construction site would be completed without acoustic shed. 'Moderate' worst-case night-time impacts are predicted at the nearest residential receivers to the Pyrmont and Hunter Street (Sydney CBD) construction sites during noise intensive work. 'Low' worst-case night-time impacts are predicted at the nearest residential receivers to The Bays tunnel launch and support site.
- Noise levels at commercial receivers are generally predicted to be compliant with the NMLs. 'Moderate' to 'high' impacts are, however, predicted at some of the nearest receivers when certain noisy work is being completed without acoustic sheds at the Pyrmont and Hunter Street (Sydney CBD) construction sites.

5.1.2 Overview of Ground-borne Noise and Vibration Impacts from Construction Sites

The predicted ground-borne noise and vibration impacts in each NCA during station excavation work are shown in **Table 23** and **Table 24**, respectively.

The predictions represent the likely highest ground-borne noise level inside sensitive receivers when excavation work using rockbreakers is being completed near surface level. The predicted ground-borne noise and vibration impacts are assessed against the appropriate management levels, with the number of exceedances presented.

Table 23 Overview of Ground-borne Noise Exceedances – All Receiver Types

Study area	NCA	Number of Receivers									
		Total	With Ground-borne NML Exceedance[1]								
			Excavation of Station Shafts								
			Daytime[2]			Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Pyrmont	NCA04	728	14	8	5	12	8	10	9	13	13
	NCA05	461	5	-	-	8	2	-	9	5	-
Hunter Street[3]	NCA06	399	3	-	6	-	-	1	1	-	1
	NCA07	250	7	1	2	1	-	-	-	1	-

Note 1: Based on worst-case predicted ground-borne noise levels.

Note 2: Daytime ground-borne noise NMLs taken from preceding Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Note 3: Excavation at Hunter Street (Sydney CBD) would be completed without acoustic sheds and airborne noise levels may be higher than ground-borne noise levels.

The above assessment in each NCA during the worst-case impacts shows that:

- 'High' ground-borne impacts are predicted at both the Pyrmont and Hunter Street (Sydney CBD) construction sites due to receivers being relatively near to the shaft excavation work. At Pyrmont, these impacts are generally at residential receivers and at Hunter Street (Sydney CBD) they are generally at commercial receivers.
- While daytime exceedances are predicted, it is noted that neither the ICNG nor CNVS specify daytime NMLs for ground-borne noise. The assessment has used daytime ground-borne noise NMLs from preceding Sydney Metro planning applications for consistency.
- The number of 'moderate' and 'high' exceedances during the evening and night-time at Pyrmont increase due to the lower residential ground-borne NML in these periods.
- During the night-time, the number of exceedances at Hunter Street (Sydney CBD) is marginally reduced due to most nearby receivers being commercial and not sensitive during this period.
- The ground-borne noise predictions are based on the nearest receivers at ground floor. The ground-borne noise impacts would reduce for sensitive receivers which are further away from the work or for receivers on high floors in multistorey buildings.
- The impacts are predicted for work being near surface level. The impacts would be expected to reduce as the excavation work progresses deeper.

Table 24 Overview of Vibration Exceedances – All Receiver Types

Study area	NCA	Number of Receivers			
		With Vibration Criteria Exceedance[1]			
		Vibration Intensive Work (with rockbreaker)			
		Cosmetic Damage	Human Comfort		Sensitive Equipment
		Day / Night	Day	Night	Day / Night
Pyrmont	NCA04	4	31	33	-
	NCA05	-	6	8	-
Hunter Street	NCA06	7	9	1	-
	NCA07	3	3	-	-

Note 1: Based on worst-case predicted vibration levels. The criteria are 25 mm/s and 7.5 mm/s for commercial buildings and residential properties, respectively (see Table 11).

The above assessment shows that:

- Exceedances of the cosmetic damage and human comfort criteria are predicted at the Pyrmont and Hunter Street (Sydney CBD) construction sites due to vibration sensitive structures being directly adjacent to the boundary of these sites.
- The predicted cosmetic damage exceedances are at residential properties adjacent to the Pyrmont Station construction sites and commercial buildings adjacent to the Hunters Street Station (Sydney CBD) construction sites. These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the site and in close proximity to the affected buildings. In reality, smaller equipment or alternative demolition methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.
- The number of exceedances at Pyrmont marginally increases during the night-time due to lower criteria for residential receivers during this period. Less exceedances are predicted during the night-time at Hunter Street (Sydney CBD) since most nearby receivers are commercial and not sensitive during this period.
- The construction activity with the greatest potential for vibration impacts is *Enabling work – Demolition using a rockbreaker* as this scenario requires the use of a rockbreaker in relatively close proximity to some of the structures surrounding the construction sites.
- No exceedances of the sensitive equipment screening criteria are predicted.

5.2 Detailed Noise and Vibration Impacts from Construction Sites

The following sections present a detailed assessment of the likely worst-case predicted noise and vibration impacts from each of the proposed construction sites.

The predictions represent the highest impacts when the work is closest to sensitive receivers. The assessment in **Section 5.1.1** indicates that when work is further away from receivers in the 'far' scenarios, the noise levels would generally be around 10 dB to 20 dB lower than the worst-case levels.

5.2.1 The Bays Study Area (NCA01 – NCA03)

The Bays Station construction site is being established as part of the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a). The site would be established, including construction of the acoustic shed, under this existing approval. This Technical Paper assesses the use of a part of the approved site for tunnel launch and support for this proposal.

The Bays study area cover areas of Rozelle, Balmain and Glebe. The Bays tunnel launch and support site would be located to the east of the former White Bay Power Station and north of Anzac Bridge. The NCAs are shown in **Figure 8**.

Existing noise levels in this study area are controlled by road traffic noise from Victoria Road and the Western Distributor, and industrial noise from White Bay and Glebe Island. The area surrounding the construction site is mainly commercial/industrial. The nearest receivers are close to the boundary of the site, however, they are not considered particularly sensitive to noise impacts given their commercial/industrial use. Residential receivers are located to the north and east of the site, however, they are generally behind existing commercial buildings.

5.2.1.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 25**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The site at The Bays is proposed to be used for tunnelling and launch support. Tunnel boring machine tunnelling and mined crossover cavern work would be launched from within an acoustic shed at this site. Spoil handling would be completed outside the acoustic sheds, noting that the shed doors would not need to open and closed as spoil would be fed from the shed to the stockpiling are via conveyer. The proposed work is anticipated to have a total duration of about three years.

5.2.1.2 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction work in this study area are summarised in **Table 26**. Only residential receivers are predicted to be impacted from the work. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers.

The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dB and are separated into day, evening and night-time periods, as appropriate.

Figure 8 Site Map, Work and Sensitive Receivers

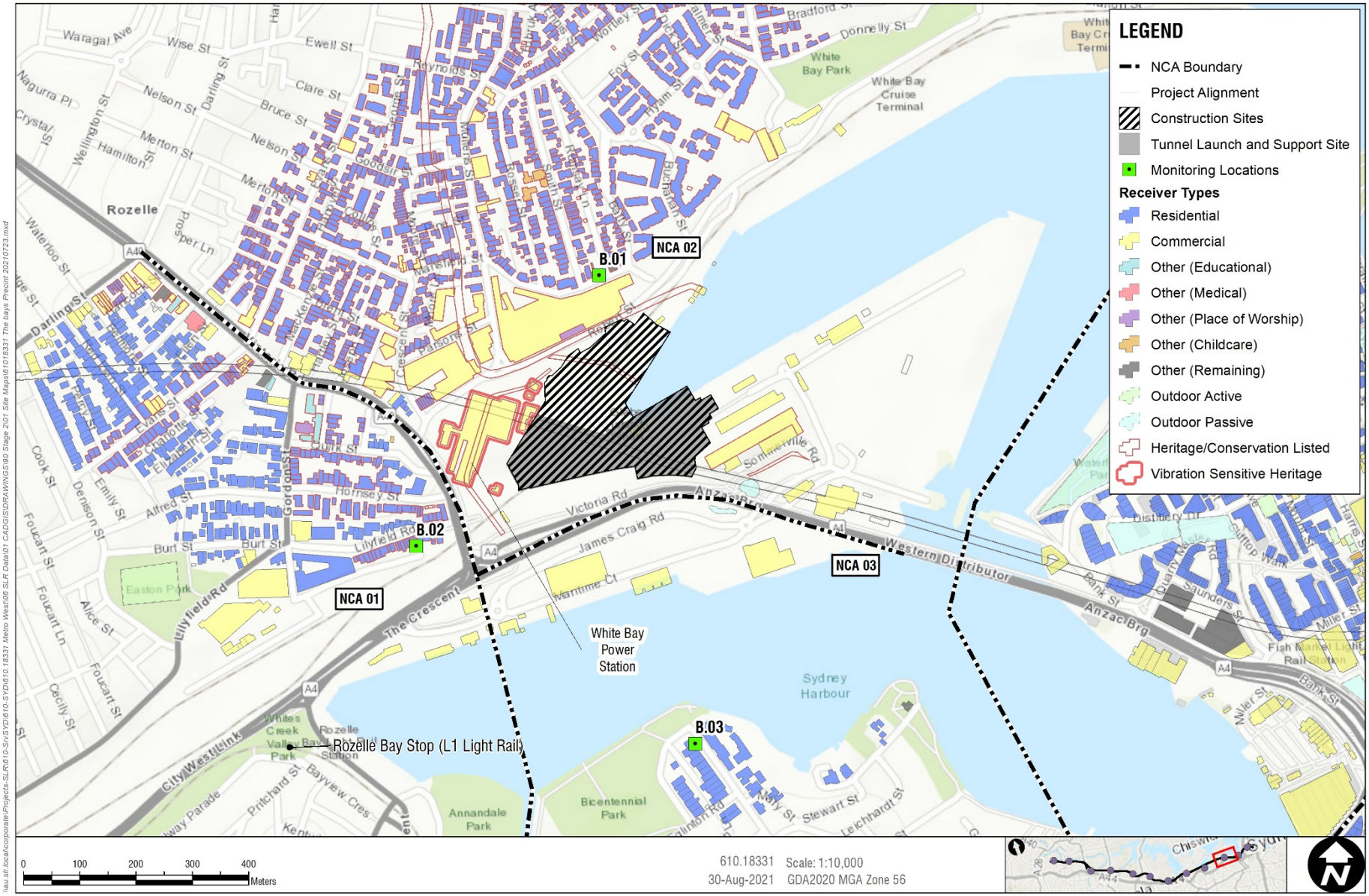


Table 25 Construction Activities and Working Hours

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces	Hours of Work[1,2]				Comments
					Std. Day	Out-of-Hours Work			
						Day OOH	Eve	Night	
Mined cavern (in shed)	Typical	Spoil removal	28	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week. The majority of work would be completed within the acoustic sheds with some loading and other less noisy work being outside the sheds.
	Peak	Mining with support	28	2	✓	✓	✓	✓	
TBM launch and support (in shed)	Typical	TBM support and spoil removal	59	1	✓	✓	✓	✓	
	Peak	TBM assembly and launch	13	2	✓	✓	✓	✓	

Note 1: Noise intensive work outside of Standard Construction Hours would only occur in acoustic sheds (constructed under existing approval).

Note 2: OOH = out of hours.

Note 3: Durations should be regarded as indicative and represent the total estimated duration of work at a typical worksite over the entire construction period.

Table 26 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Work[4]											
									Daytime OOH			Evening			Night-time			Sleep Disturbance		
						1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Mined cavern (in shed)	Typical	Spoil removal	28	1337	-	-	-	-	-	-	-	-	-	-	1	-	-	6	-	-
	Peak	Mining with support	28	1337	-	-	-	-	-	-	-	-	-	-	39	-	-	6	-	-
TBM launch and support (in shed)	Typical	TBM support and spoil removal	59	1337	-	-	-	-	-	-	-	-	-	-	1	-	-	6	-	-
	Peak	TBM assembly and launch	13	1337	-	-	-	-	-	-	-	-	-	-	31	-	-	6	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Note 2: Highly Noise Affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Daytime Scenarios

The above assessment of the worst-case daytime impacts shows the following:

- The noisiest elements of the proposed work at The Bays tunnel launch and support site are mostly underground and within the acoustic shed, which limits the potential impacts.
- Noise levels during the daytime are predicted to comply with the NMLs during all work scenarios. This results from work being in the acoustic shed and the nearest receivers being of relatively low sensitivity.

Night-time Scenarios

The highest night-time construction noise impacts are predicted during *Mined cavern* and *TBM launch and support* work. The predicted night-time noise impacts during this work are shown in:

- **Figure 9** – *Mined cavern (in shed) – Mining with support (peak)*
- **Figure 10** – *TBM launch and support (in shed) – TBM assembly and launch (peak)*
- **Figure 11** – *Mined cavern (in shed) – Spoil removal (typical).*

The highest impact work is expected to last for:

- *Mined cavern* – 28 weeks
- *TBM launch and support* – 13 weeks.

Figure 9 Predicted Night-time Airborne Noise Impacts – *Mined cavern (in shed) – Mining with support (peak)*

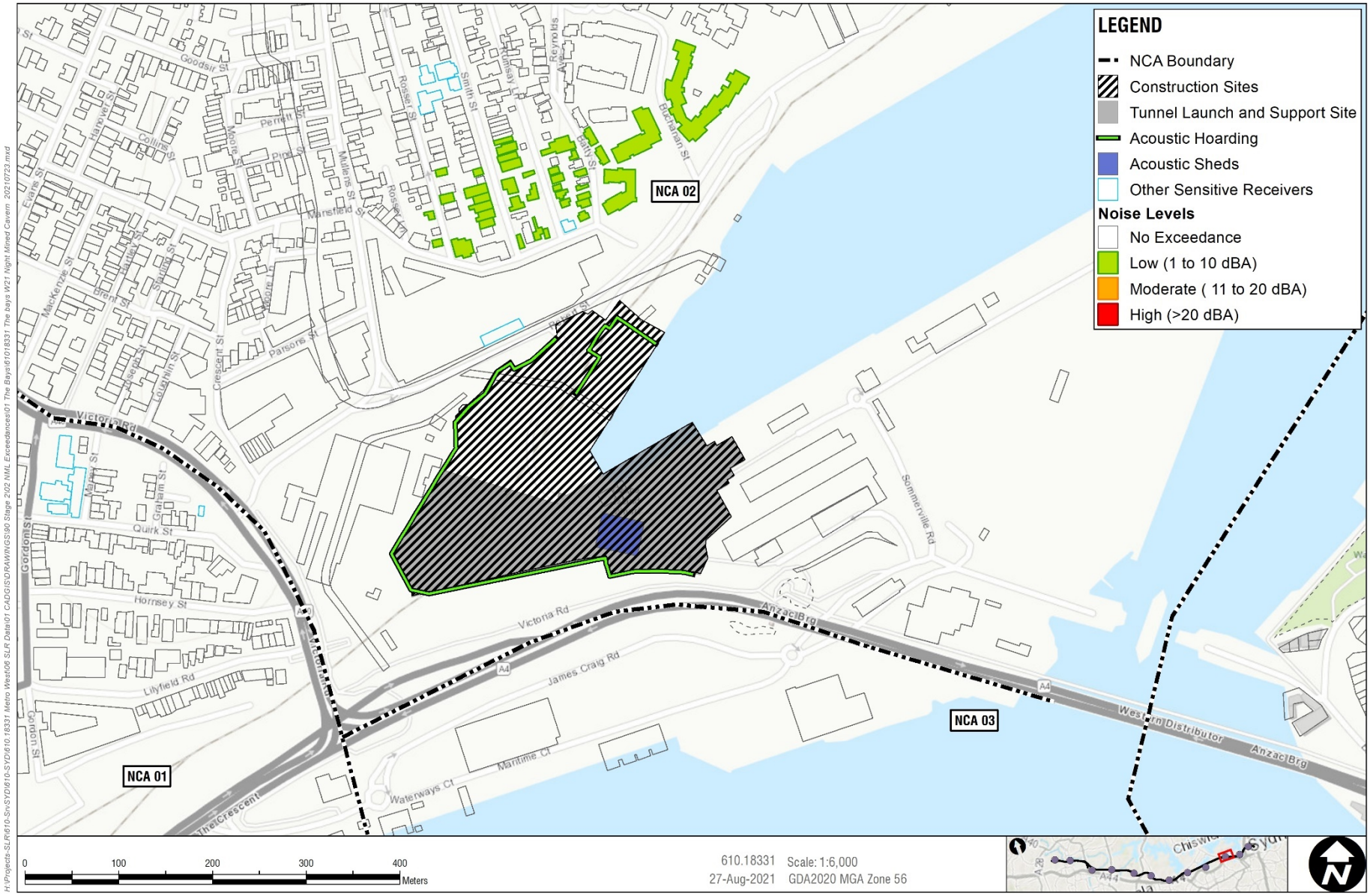


Figure 10 Predicted Night-time Airborne Noise Impacts – *TBM launch and support (in shed) – TBM assembly and launch (peak)*

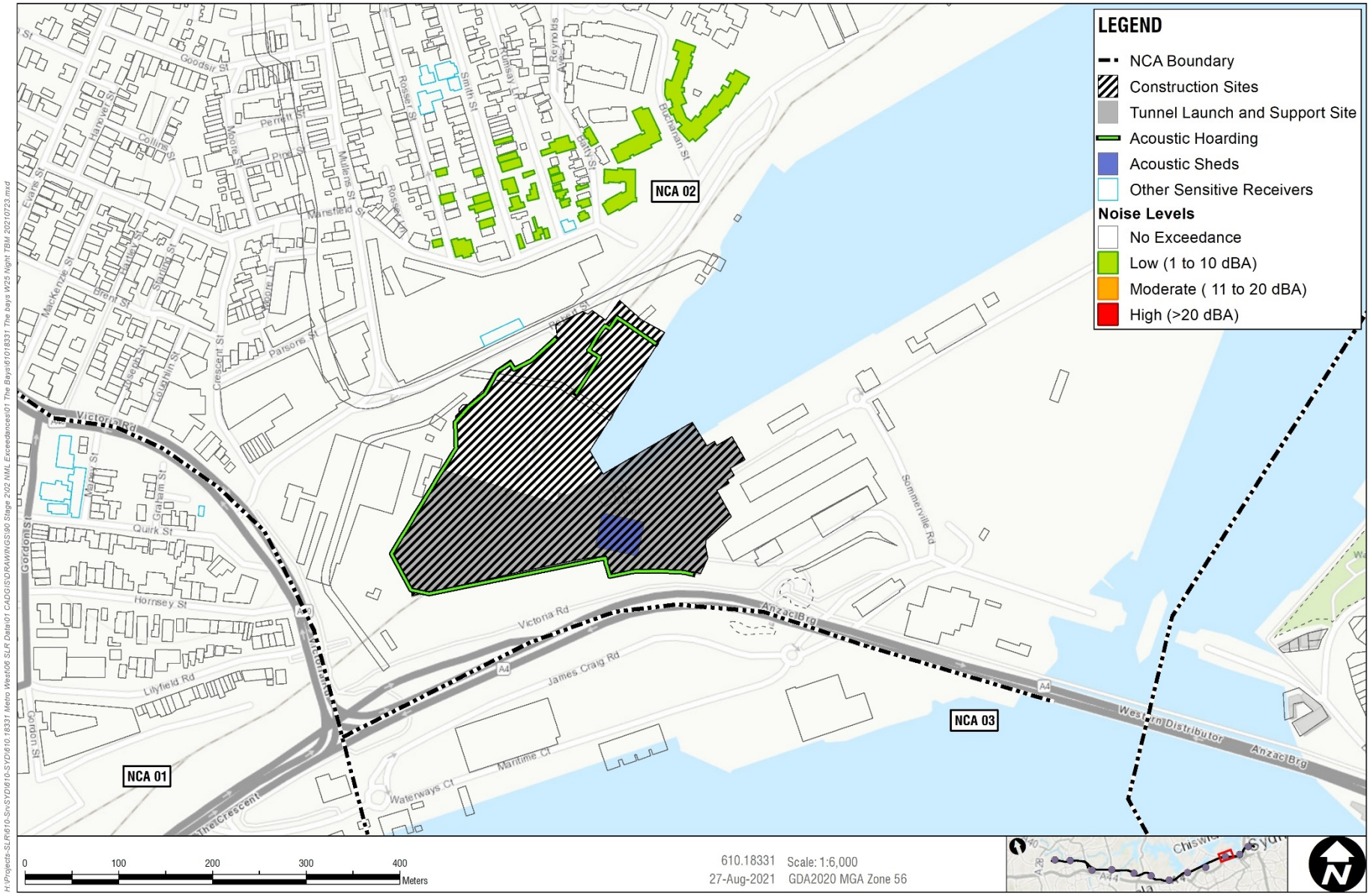
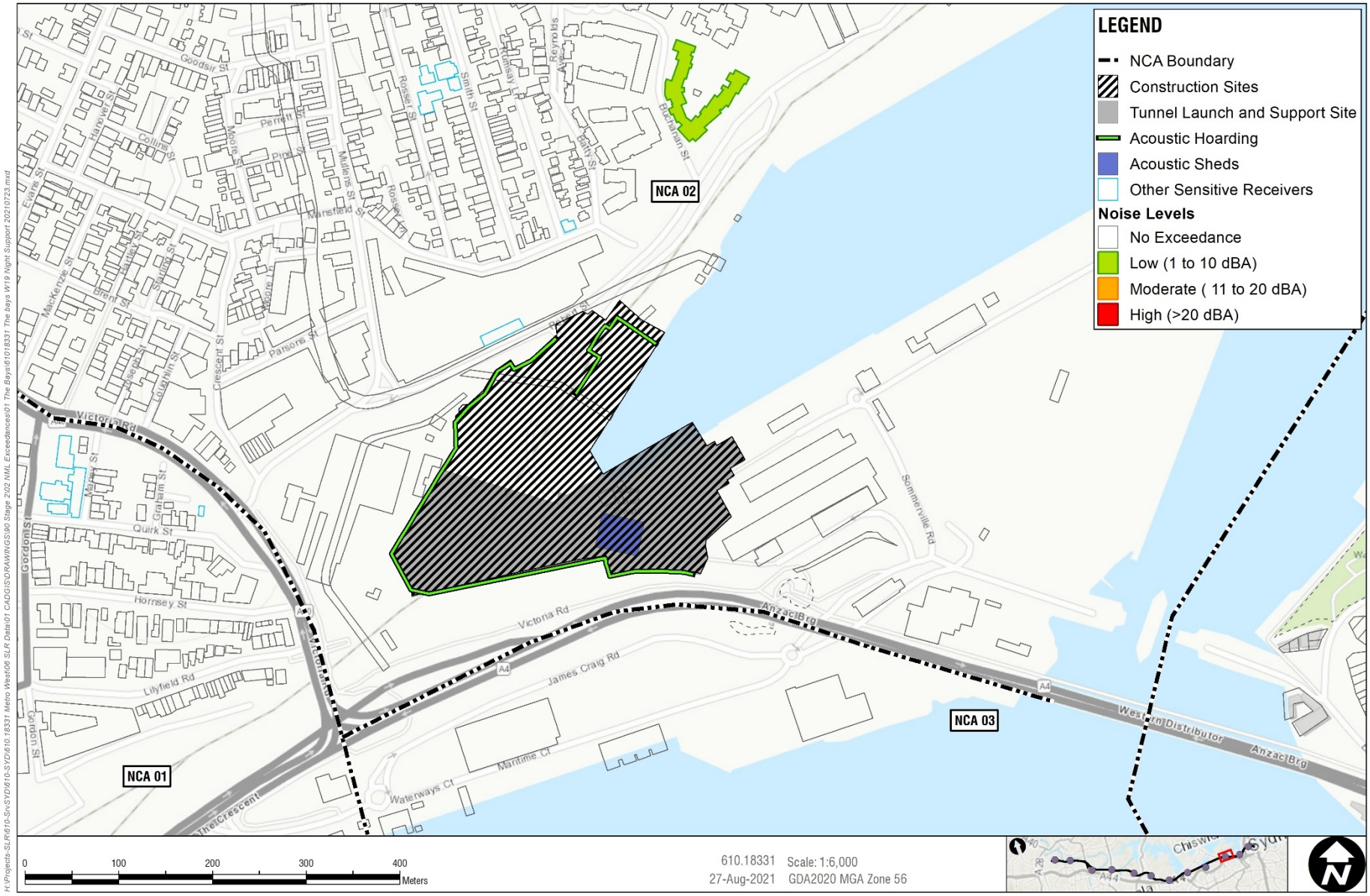


Figure 11 Predicted Night-time Airborne Noise Impacts – *Mined cavern (in shed) – Spoil removal (typical)*



The above assessment during the worst-case night-time impacts shows the following:

- The most noise intensive components of the proposed work at The Bays tunnel launch and support site are mostly underground and within the acoustic shed, which limits the potential impacts.
- The night-time noise levels during the nosiest work are predicted to result in 'low' impacts at several of the nearest residential receivers to the north of the site. This is due to their increased elevation relative to the site and increased view of the site.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive equipment.
- When noise intensive equipment is not in use during *Mined cavern – Spoil removal* and *TBM launch and support – TBM support and spoil removal*, the noise levels are predicted to comply with the management levels at most receivers. One residential receiver on Buchanan Street in Balmain is predicted to have 'low' impacts.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

Additionally, the impacts from excavation assume the work is relatively near the surface. As progress is made further underground the impacts would be expected to reduce.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction work and is summarised in **Table 26.**

'Low' sleep disturbance impacts are predicted at six residential receivers to the north during night-time work. These impacts result from heavy vehicles accessing the construction site via Port Access Road and moving around the outdoor areas.

The number of potential night-time awakenings from heavy vehicles would be influenced by the number of vehicles and the way in which the vehicles are operated. Up to five trucks per hour are expected at this construction site during the night-time.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

No receivers are predicted to be Highly Noise Affected in this study area.

5.2.1.3 Ground-borne Noise and Vibration Impacts from Construction Sites

Ground-borne noise and vibration impacts from surface and station shaft excavation work were assessed as part of the approved *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a).

Ground-borne noise and vibration impacts at this site may occur during tunnelling work which are assessed in **Section 5.3**.

5.2.2 Pyrmont Study Area (NCA04 – NCA05)

The Pyrmont study area covers Pyrmont and Darling Harbour. Two separate construction sites are proposed:

- The Pyrmont Station western construction site, located between Paternoster Row and Pyrmont Street, immediately north of Pyrmont Bridge Road
- The Pyrmont Station eastern construction site, located between Edward Street, Union Street and Pyrmont Bridge Road.

Existing noise levels in this study area are controlled by road traffic noise on the surrounding road network. The area surrounding the construction site is mostly residential and commercial. The NCAs are shown in **Figure 12**.

5.2.2.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 27**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The main excavation work at this construction site would be completed in acoustic sheds. The proposed work is anticipated to have a total duration of about three years.

5.2.2.2 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction work in this study area are summarised in **Table 28**, **Table 29** and **Table 30** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers.

The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dB and are separated into day, evening and night-time periods, as appropriate.

Figure 12 Site Map, Work and Sensitive Receivers

Table 27 Construction Activities and Working Hours

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces	Hours of Work[1,2]				Comments
					Std. Day	Out-of-Hours Work			
						Day OOH	Eve	Night	
Enabling work	Typical	Supporting and loading	17	1	✓	✓	-	-	-
	Peak	Demolition using a rockbreaker	17	2	✓	✓	-	-	Rockbreaking work would only occur intermittently during a 17 week period between 7am – 6pm. Total duration of rockbreaking work would be about 15 days.
Piling	Typical	Supporting work	15	1	✓	✓	-	-	Piling work would only occur intermittently during a 15 week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
	Peak	Bored piling with support plant	15	4	✓	✓	-	-	
Surface construction	Typical	General work	6	1	✓	✓	-	-	Civil work and construction surface structures, including acoustic shed.
	Peak	Noise intensive work	6	2	✓	✓	-	-	
Initial excavation (in sheds)	Typical	Mucking out	2	1	✓	✓	✓	✓	Early excavation work occurring with a temporary smaller acoustic shed at the eastern construction site. This work would occur 24 hours per day, seven days per week.
	Peak	Through rock using rockbreaker	2	2	✓	✓	✓	✓	
Excavation (in sheds)	Typical	Mucking out	14	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week. Out of hours work would only occur once the acoustic sheds have been constructed.
	Peak	Through rock using rockbreaker	14	2	✓	✓	✓	✓	
Mined cavern (in sheds)	Typical	Spoil removal	53	1	✓	✓	✓	✓	
	Peak	Mining with support	53	2	✓	✓	✓	✓	

Note 1: Noise intensive work outside of Standard Construction Hours would only occur after construction of the acoustic sheds.

Note 2: OOH = out of hours.

Note 3: Durations should be regarded as indicative and represent the total estimated duration of work at a typical worksite over the entire construction period.

Table 28 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Work[4]											
									Daytime OOH			Evening			Night-time			Sleep Disturbance		
						1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	17	1155	2	31	8	2	35	24	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Demolition using a rockbreaker	17	1155	55	154	58	34	291	103	47	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	Supporting work	15	1155	2	27	3	-	32	9	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Bored piling with support plant	15	1155	10	44	20	2	70	33	6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Surface construction	Typical	General work	6	1155	2	20	2	-	33	4	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Noise intensive work	6	1155	3	36	7	2	40	25	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Initial excavation (in sheds)	Typical	Mucking out (doors closed)	2	1155	-	-	-	-	10	-	-	20	-	-	29	1	-	52	16	-
	Peak	Through rock using rockbreaker (doors closed)	2	1155	-	37	-	-	86	3	-	89	23	-	132	35	-	52	16	-
Excavation (in sheds)	Typical	Mucking out (doors closed)	14	1155	-	-	-	-	7	-	-	18	-	-	26	1	-	52	16	-
	Peak	Through rock using rockbreaker (doors closed)	14	1155	-	39	-	-	87	5	-	95	26	-	136	39	-	54	16	-
		Through rock using rockbreaker (doors open)	14	1155	11	81	18	-	118	42	5	180	54	11	232	72	20	72	27	2
Mined cavern (in sheds)	Typical	Spoil removal (doors closed)	53	1155	-	-	-	-	8	-	-	19	-	-	27	2	-	52	16	-
	Peak	Mining with support (doors closed)	53	1155	-	3	-	-	32	-	-	60	-	-	81	5	-	52	16	-
		Mining with support (doors open)	53	1155	2	35	6	-	71	14	-	95	23	3	108	37	5	63	21	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Note 2: Highly Noise Affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 29 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Work[4]											
									Daytime OOH			Evening			Night-time			Sleep Disturbance		
						1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	17	939	2	27	8	2	31	24	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Demolition using a rockbreaker	17	939	55	135	42	33	272	87	46	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	Supporting work	15	939	2	27	3	-	32	9	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Bored piling with support plant	15	939	10	34	20	2	60	33	6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Surface construction	Typical	General work	6	939	2	20	2	-	33	4	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Noise intensive work	6	939	3	31	7	2	35	25	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Initial excavation (in sheds)	Typical	Mucking out (doors closed)	2	939	-	-	-	-	10	-	-	20	-	-	28	1	-	52	16	-
	Peak	Through rock using rockbreaker (doors closed)	2	939	-	34	-	-	83	3	-	88	23	-	128	35	-	52	16	-
Excavation (in sheds)	Typical	Mucking out (doors closed)	14	939	-	-	-	-	7	-	-	18	-	-	25	1	-	52	16	-
	Peak	Through rock using rockbreaker (doors closed)	14	939	-	36	-	-	84	5	-	94	26	-	132	39	-	54	16	-
		Through rock using rockbreaker (doors open)	14	939	11	72	15	-	109	39	5	177	53	11	229	71	19	72	27	2
Mined cavern (in sheds)	Typical	Spoil removal (doors closed)	53	939	-	-	-	-	8	-	-	19	-	-	26	2	-	52	16	-
	Peak	Mining with support (doors closed)	53	939	-	3	-	-	32	-	-	60	-	-	79	5	-	52	16	-
		Mining with support (doors open)	53	939	2	31	5	-	67	13	-	93	23	3	107	35	5	63	21	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Note 2: Highly Noise Affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 30 Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity		No. Weeks[1]	Number of Receivers																				
				Commercial			Child Care			Hotel (Day)			Hotel (Night)			Outdoor Passive			Public Building			Theatre		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	17	-	-	-	1	-	-	2	-	-	n/a	n/a	n/a	-	-	-	-	-	-	1	-	-
	Peak	Demolition using a rockbreaker	17	11	9	-	-	3	-	2	3	-	n/a	n/a	n/a	1	-	-	1	1	-	4	-	1
Piling	Typical	Supporting work	15	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	-	-	-	-	-	-	-	-	-
	Peak	Bored piling with support plant	15	4	-	-	2	-	-	3	-	-	n/a	n/a	n/a	-	-	-	-	-	-	1	-	-
Surface construction	Typical	General work	6	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	-	-	-	-	-	-	-	-	-
	Peak	Noise intensive work	6	1	-	-	1	-	-	2	-	-	n/a	n/a	n/a	-	-	-	-	-	-	1	-	-
Initial excavation (in sheds)	Typical	Mucking out (doors closed)	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Peak	Through rock using rockbreaker (doors closed)	2	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-
Excavation (in sheds)	Typical	Mucking out (doors closed)	14	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Peak	Through rock using rockbreaker (doors closed)	14	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-
		Through rock using rockbreaker (doors open)	14	4	1	-	2	1	-	1	1	-	2	1	1	-	-	-	1	-	-	1	-	-
Mined cavern (in sheds)	Typical	Spoil removal (doors closed)	53	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Peak	Mining with support (doors closed)	53	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
		Mining with support (doors open)	53	2	-	-	-	1	-	2	-	-	1	2	-	-	-	-	-	-	-	-	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Enabling work* when rockbreakers are used before construction of the acoustic sheds. The predicted daytime impacts during this work are shown in:

- **Figure 13** – *Enabling work – Demolition using a rockbreaker (peak)*
- **Figure 14** – *Enabling work – Supporting and loading (typical).*

Once the acoustic sheds are constructed, worst-case impacts are predicted during *Excavation – Through rock using a rockbreaker* and are shown in:

- **Figure 15** – *Excavation (in sheds) – Through rock using a rockbreaker (doors closed) (peak)*.

The highest impact work is expected to last for:

- *Enabling work – Demolition using a rockbreaker* – 15 days actual rockbreaker use
- *Excavation – Through rock using rockbreaker* – 14 weeks.

Figure 13 Predicted Daytime Airborne Noise Impacts – *Enabling work – Demolition using a rockbreaker (peak)*

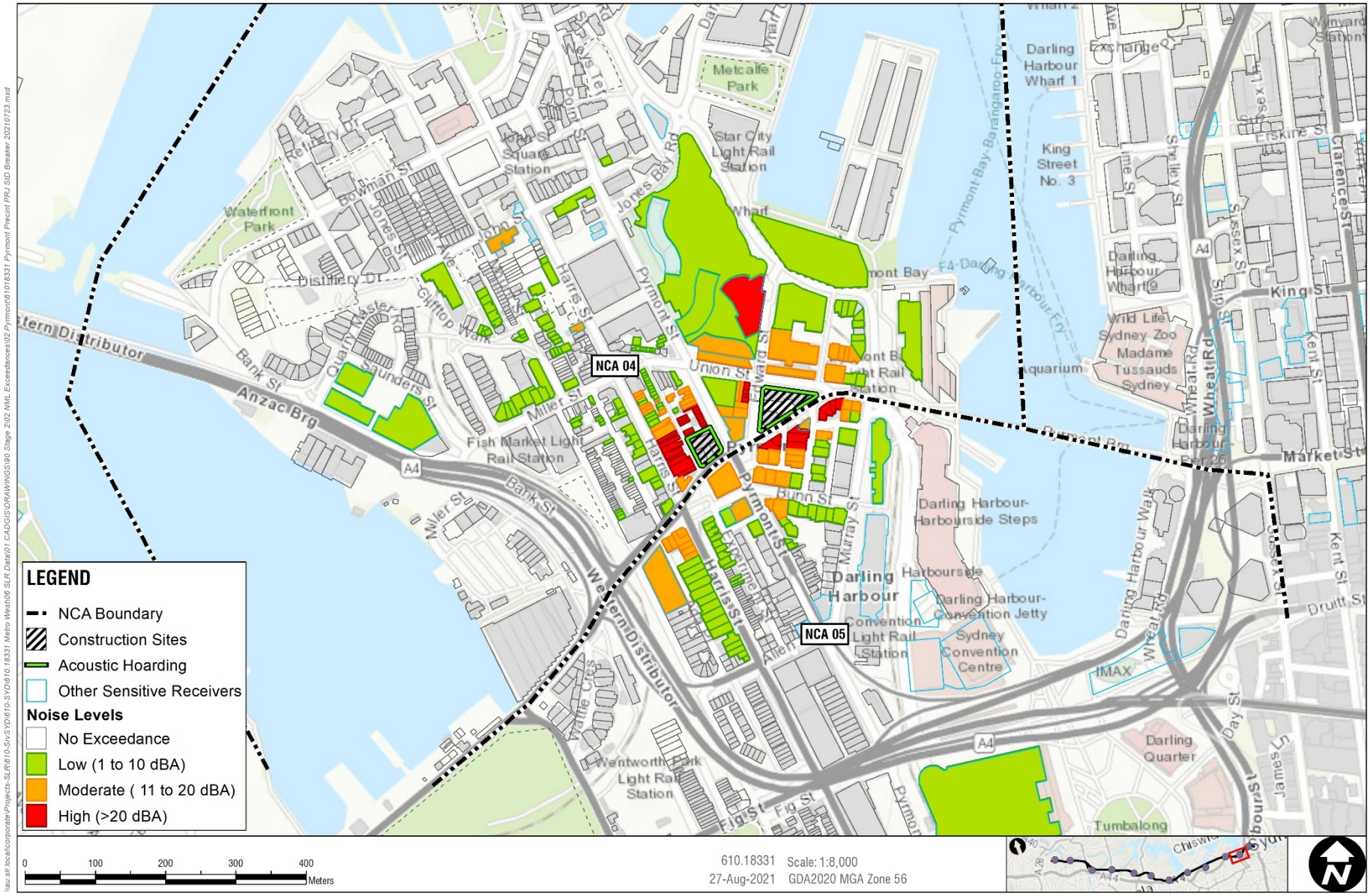


Figure 14 Predicted Daytime Airborne Noise Impacts – *Enabling work – Supporting and loading (typical)*

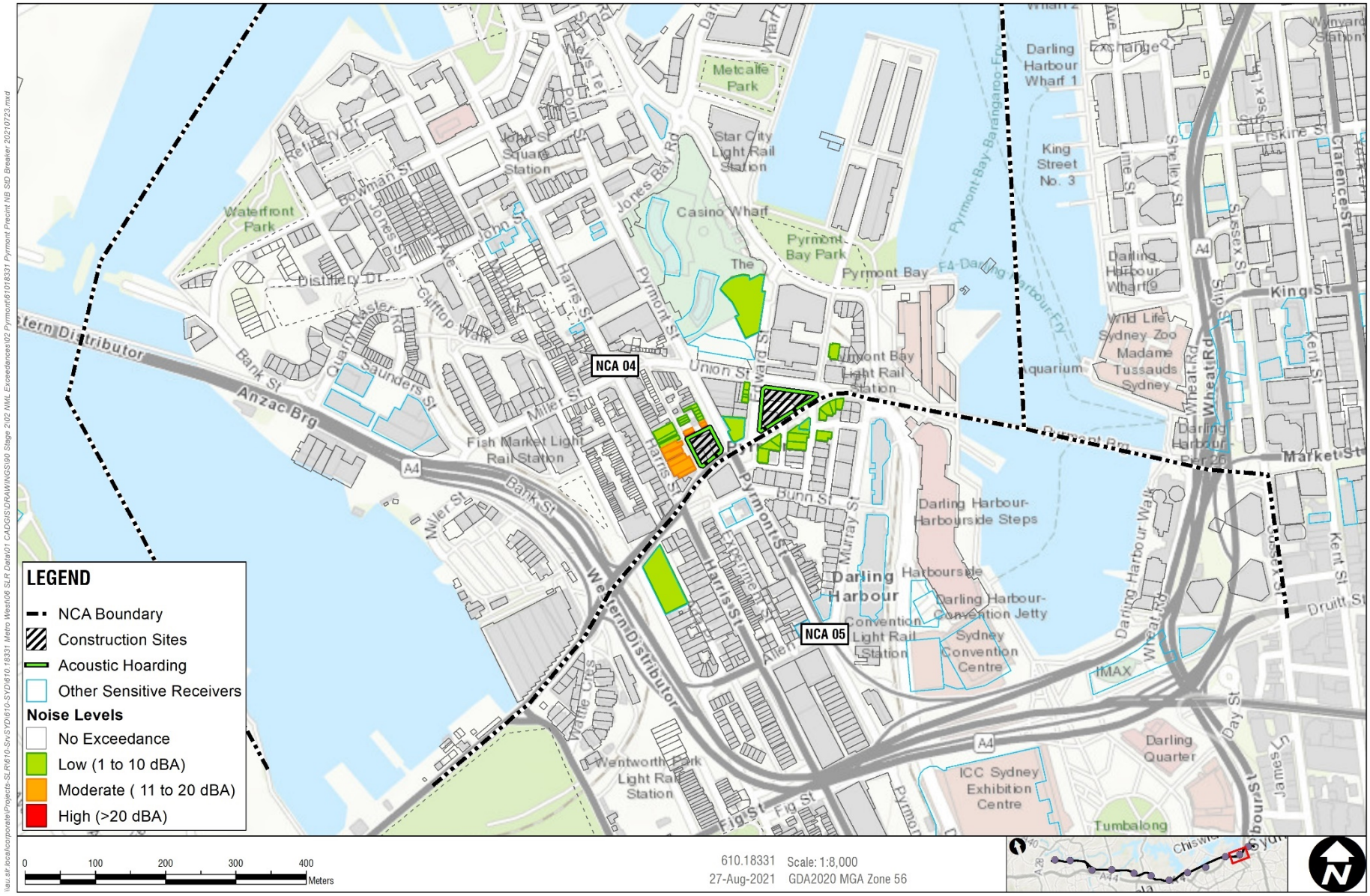
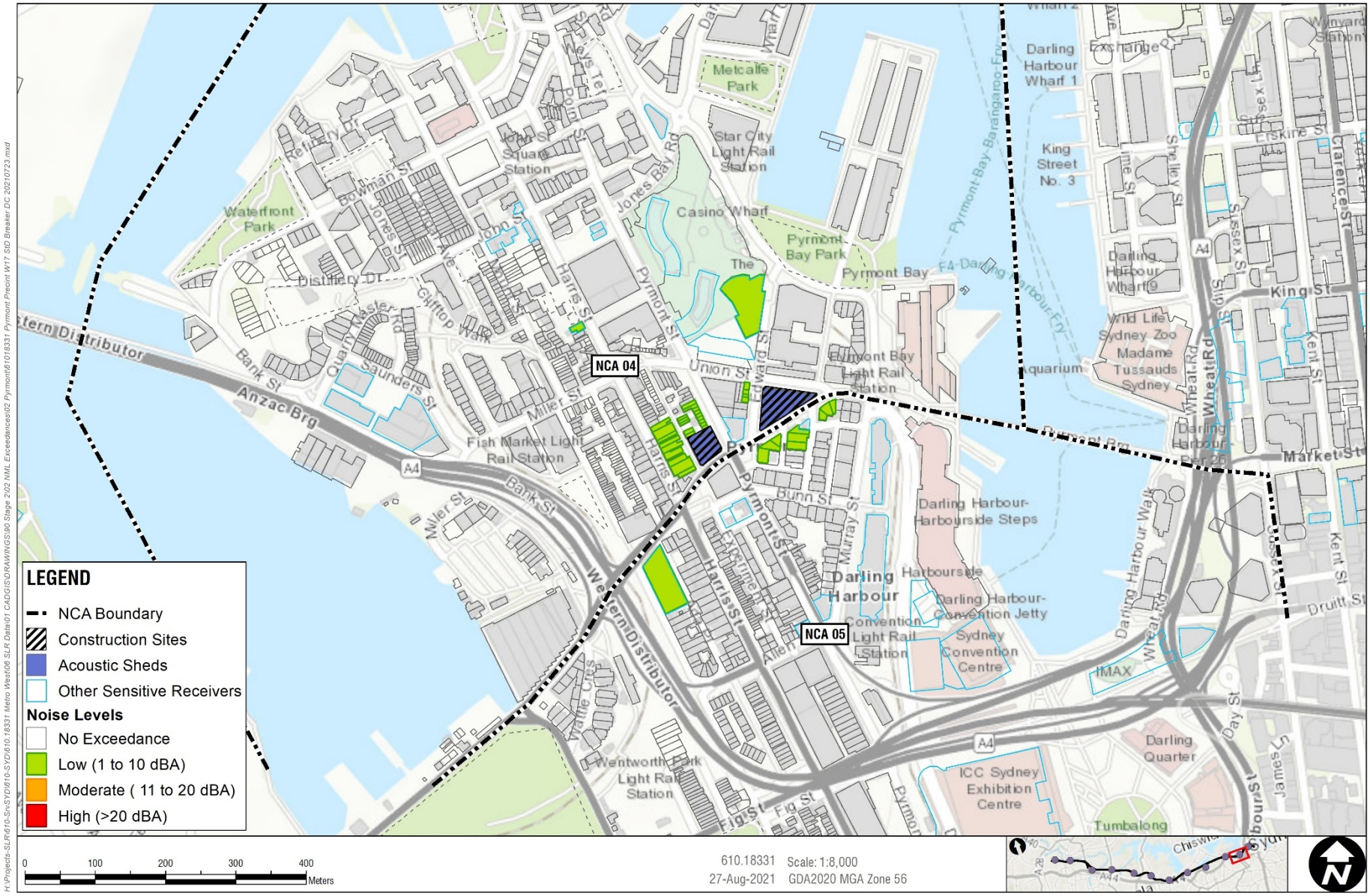


Figure 15 Predicted Daytime Airborne Noise Impacts – *Excavation (in sheds) – Through rock using a rockbreaker (doors closed) (peak)*



The above assessment during the worst-case daytime impacts shows the following:

- The proposed work at Pyrmont Station construction site would involve noise intensive surface work which would be completed before construction of the acoustic sheds. This work would only be completed during the daytime. Underground 24/7 excavation work would occur after construction of the acoustic sheds.
- Receivers are located close to the construction sites and impacts are predicted to be 'high' during noisy outdoor surface work when noise intensive equipment such as rockbreakers are being used. The total duration of outdoor rockbreaker use is expected to be about 15 days. When work is underground and inside acoustic sheds the daytime impacts are predicted to substantially reduce, with 'low' impacts predicted at the nearest receivers when rockbreaking is being completed with the acoustic shed doors closed.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to impacted during some of the noisier activities, particularly when work is completed outdoors before the construction of the acoustic sheds. 'High' or 'moderate' worst-case impacts are predicted at:
  - 'High' at the Sydney Lyric Theatre when rockbreakers are being used outdoors (the total duration of outdoor rockbreaker use is expected to be about 15 days)
  - 'Moderate' at Bliss Early Learning, KU Maybanke Preschool, SDN Pyrmont Children's Education and Care Centre, The Sebel Hotel, the Peg Leg Inn, The Darling Hotel, Pyrmont Fire Station and some of the surrounding commercial buildings, during noisy outdoor activities or when acoustic shed doors are open.
  - Work that does not require noise intensive equipment is predicted to result in noise levels that comply with the management levels or result in 'low' exceedances at a small number of receivers.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

Additionally, the impacts from excavation assume the work is relatively near the surface. As progress is made further underground the impacts would be expected to reduce.

Night-time Scenarios

Noise intensive work during the night-time at this construction site would only be completed inside the acoustic sheds. The highest night-time construction noise impacts are predicted during *Excavation in sheds* when rockbreakers are in use. The predicted night-time noise impacts during this work are shown in:

- **Figure 16** – *Excavation (in sheds) – Through rock using rockbreaker (doors open) (peak)*
- **Figure 17** – *Excavation (in sheds) – Through rock using rockbreaker (doors closed) (peak)*
- **Figure 18** – *Excavation (in sheds) – Mucking out (doors closed) (typical)*, which has no requirement for noise intensive equipment.

The highest impact work is expected to last for:

- *Excavation (in sheds)* – 14 weeks.

Figure 16 Predicted Night-time Airborne Noise Impacts – *Excavation (in sheds) – Through rock using rockbreaker (doors open) (peak)*

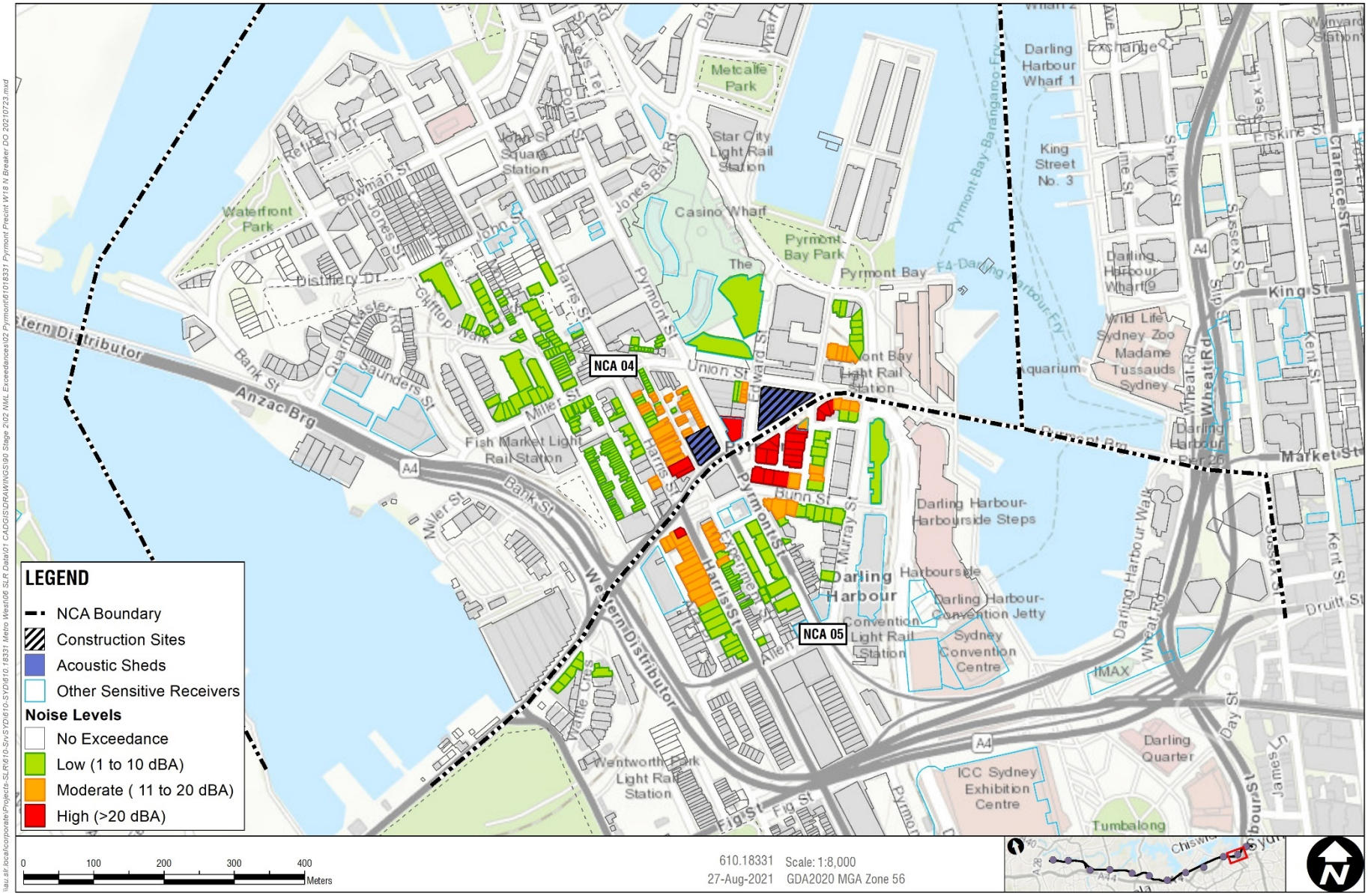


Figure 17 Predicted Night-time Airborne Noise Impacts – *Excavation (in sheds) – Through rock using rockbreaker (doors closed) (peak)*

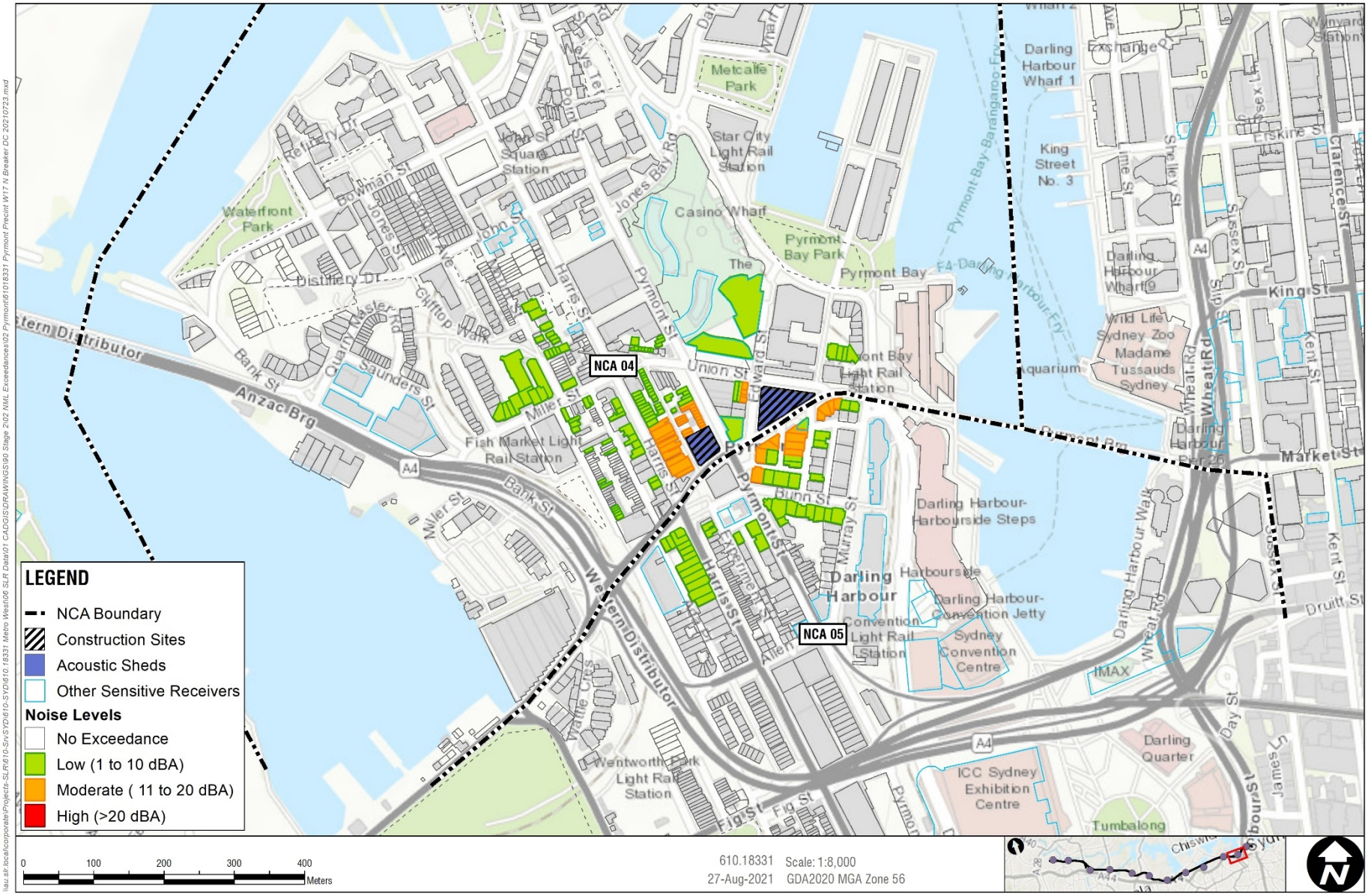
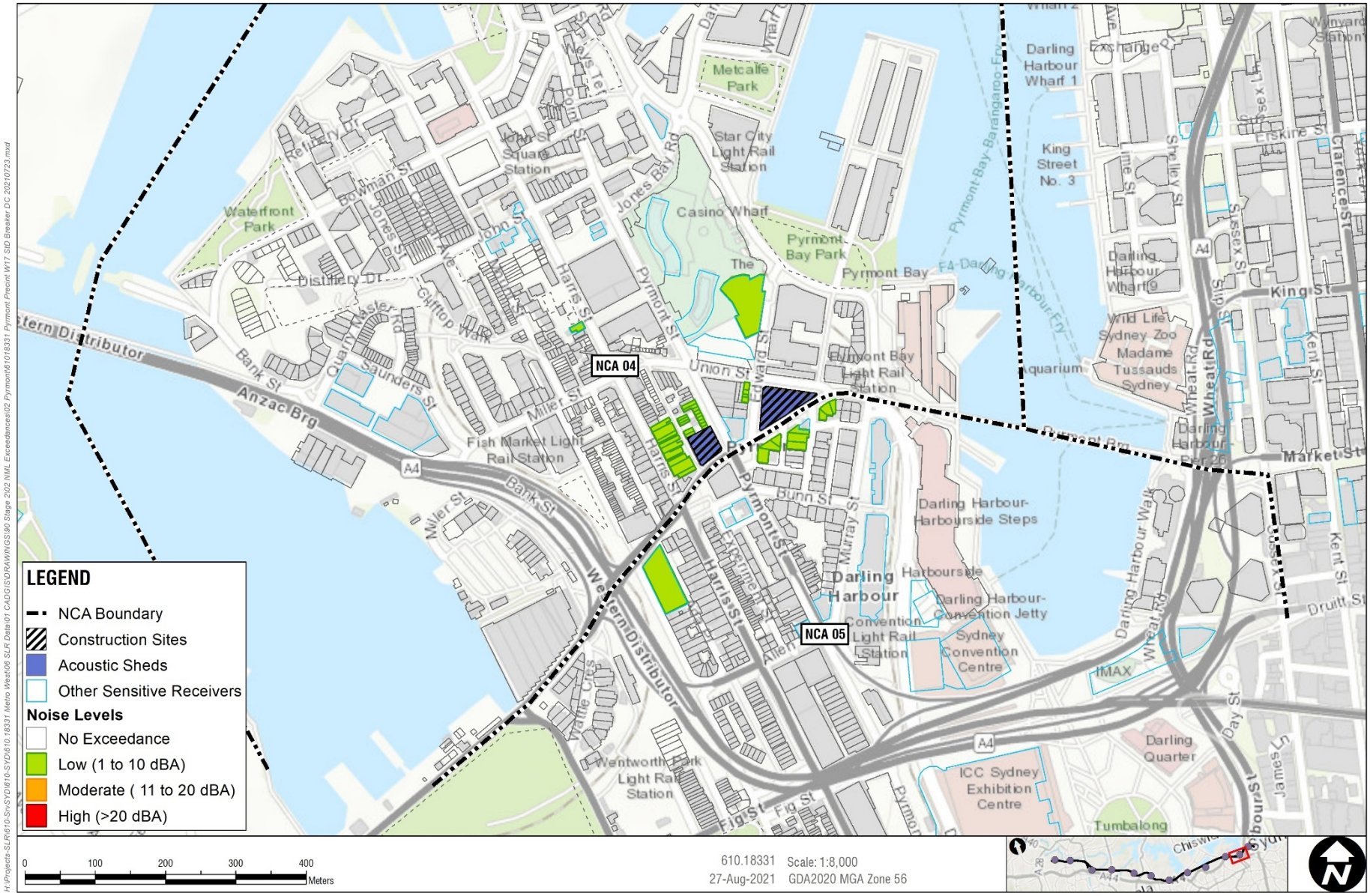


Figure 18 Predicted Night-time Airborne Noise Impacts – *Excavation (in sheds) – Mucking out (doors closed) (typical)*



The above assessment during the worst-case night-time impacts shows the following:

- The proposed night-time work at Pyrmont Station construction site would only occur after construction of the acoustic sheds.
- 'Moderate' impacts are predicted at the nearest receivers during the noisiest work which would occur during *Excavation – Through rock using rockbreaker* when the acoustic shed doors are closed. These impacts are predicted to increase to 'high' at a small number of receivers when the doors are open.
- When noise intensive equipment is not in use during *Excavation – Mucking out* and *Mined cavern – supporting work*, the impacts are substantially lower, with 'low' impacts generally predicted at the nearest receivers and compliance with the NMLs at receivers further away.
- The nearest 'other sensitive' receivers are predicted to impacted during some of the noisier work activities. 'High' or 'moderate' worst-case impacts are predicted at:
  - The Sebel Hotel and the Peg Leg Inn, during noisy activities when acoustic shed doors are open
  - When acoustic shed doors are closed noise levels are predicted to comply with the management levels or result in 'low' exceedances at a small number of receivers.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

Additionally, the impacts from excavation assume the work is relatively near the surface. As progress is made further underground the impacts would be expected to reduce.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction work and is summarised in **Table 28**.

'Moderate' sleep disturbance impacts are predicted at the adjacent residential receivers during noisy *Excavation* and *Mined cavern* night-time work, with 'low' impacts at receivers which are more distant. These impacts result from heavy vehicles accessing the construction site. Sleep disturbance impacts are predicted to increase if acoustic shed doors are opened during excavation work.

The number of potential night-time awakenings from heavy vehicles would be influenced by the number of vehicles and the way in which the vehicles are operated. The majority of vehicle movements at Pyrmont would likely be restricted to between 7am and 10pm due to proximity of night-time sensitive receivers. Infrequent heavy vehicles may, however, be required during the night-time at Pyrmont to support concrete delivery during cavern lining pours required to be carried out 24/7 for safety reasons. Up to five trucks would be expected at this construction site during the night-time.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be Highly Noise Affected are summarised in **Table 31** and shown in **Figure 19**.

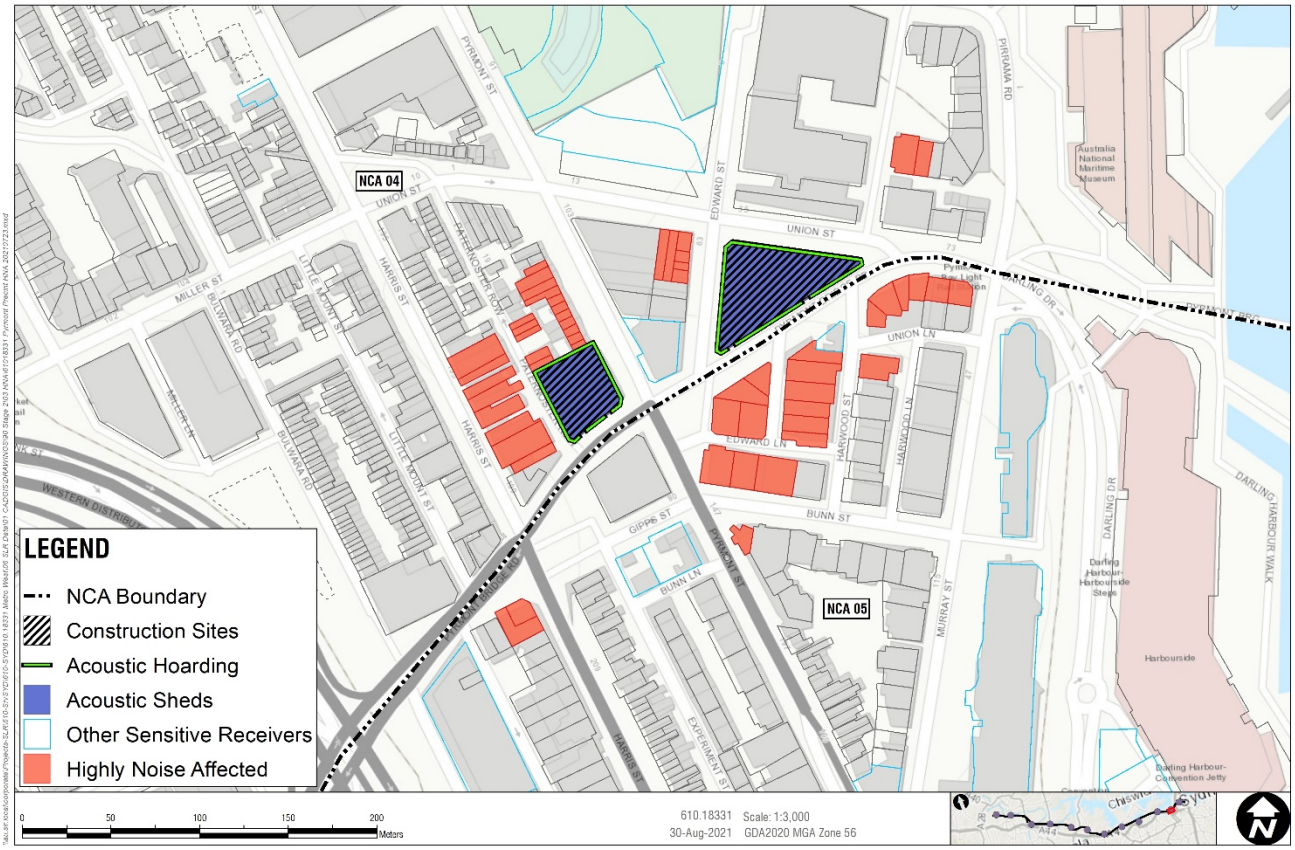
Table 31 Predicted Number of Highly Noise Affected Residential Receivers by Work and NCA

Scenario	Activity		NCA04			NCA05		
			Day	Eve	Night	Day	Eve	Night
Enabling work	Typical	Supporting and loading	2	n/a	n/a	-	n/a	n/a
	Peak	Demolition using a rockbreaker with supporting plant	32	n/a	n/a	23	n/a	n/a
Piling	Typical	Supporting work	2	n/a	n/a	-	n/a	n/a
	Peak	Bored piling with support plant	9	n/a	n/a	1	n/a	n/a
Surface construction	Typical	General work	2	n/a	n/a	-	n/a	n/a
	Peak	Noise intensive work	3	n/a	n/a	-	n/a	n/a
Initial excavation (in sheds)	Typical	Mucking out	-	-	-	-	-	-
	Peak	Through rock using rockbreaker	-	-	-	-	-	-
Excavation (in sheds)	Typical	Mucking out (doors closed)	-	-	-	-	-	-
	Peak	Excavation through rock using rockbreaker (doors closed)	-	-	-	-	-	-
		Excavation through rock using rockbreaker (doors open)	2	2	2	9	9	9
Mined cavern (in sheds)	Typical	Supporting work (doors closed)	-	-	-	-	-	-
	Peak	Mining with Support (doors closed)	-	-	-	-	-	-
		Mining with Support (doors open)	-	-	-	2	2	2

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

The assessment shows that the nearest receivers to the site are predicted to be Highly Noise Affected during daytime work before the acoustic sheds are constructed. Work in the shed is predicted to result in Highly Noise Affected impacts at receivers nearest to the site boundary only when shed doors are open.

Figure 19 Highly Noise Affected Residential Receivers (During Any Work)



5.2.2.3 Ground-borne Noise Impacts from Construction Sites

The predicted ground-borne noise impacts from station shaft excavation work inside the acoustic sheds are summarised in **Table 32**. The results are shown in **Figure 20** and **Figure 21** for the daytime and night-time, respectively. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation work is close.

Table 32 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime[2]			Out-of-Hours Work					
						Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
NCA04	Residential	560	12	8	5	11	8	10	9	12	13
	Commercial	112	1	-	-	-	-	-	-	-	-
	Other Sensitive	48	1	-	-	1	-	-	-	1	-
NCA05	Residential	396	4	-	-	7	2	-	9	4	-
	Commercial	32	-	-	-	-	-	-	-	-	-
	Other Sensitive	23	1	-	-	1	-	-	-	1	-

Note 1: Based on worst-case predicted noise levels.

Note 2: Daytime ground-borne noise NMLs taken from preceding Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Figure 20 Predicted Ground-borne Noise Impacts – Daytime

Figure 21 Predicted Ground-borne Noise Impacts – Night-time

The above assessment during the worst-case impacts shows the following:

- Receivers are close to the western construction site and vibration intensive work is predicted to result in 'high' ground-borne noise impacts at adjacent receivers. 'Moderate' or 'low' exceedances are predicted at receivers further away from the western site and at the nearest receivers to the eastern construction site.
- While daytime exceedances are predicted, it is noted that neither the ICNG nor CNVS specify daytime NMLs for ground-borne noise. The assessment has used daytime ground-borne noise NMLs from preceding Sydney Metro planning applications for consistency.
- More receivers are predicted to be impacted by ground-borne noise during the evening and night-time periods due to the lower residential ground-borne NML in these periods.
- 'Moderate' to 'low' ground-borne noise impacts are predicted at The Sebel Hotel and Peg Leg Inn.

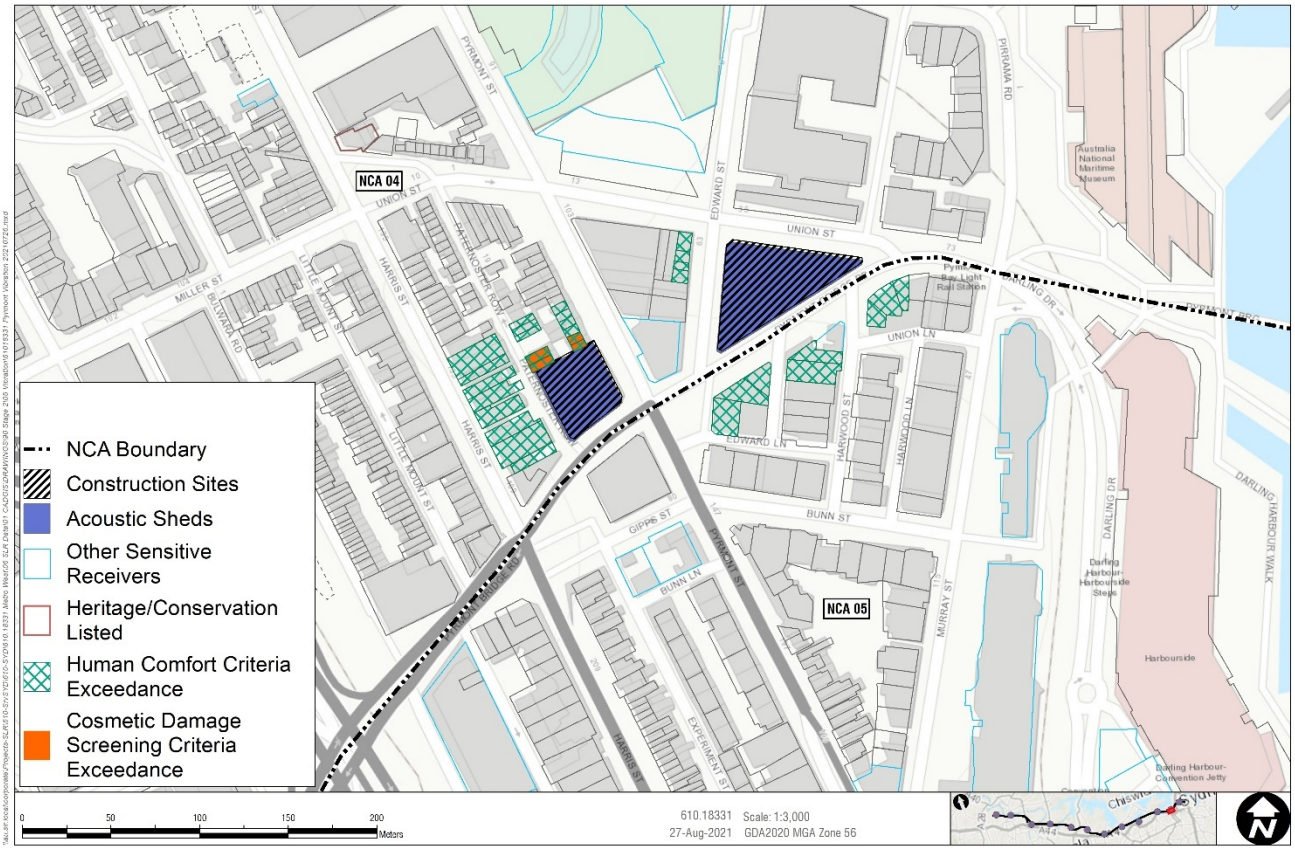
Vibration intensive shaft excavation work inside the acoustic shed is expected to last for around 16 weeks.

The predictions assume the work is relatively near surface level. As progress is made further underground the impacts would be expected to reduce.

5.2.2.4 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive work are shown in **Figure 22**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when work is close.

Figure 22 Predicted Vibration Impacts



The above assessment during the worst-case impacts shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at up to four residential buildings to the north of the western construction site. These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the sites and is in close proximity to the affected buildings. In reality, smaller equipment or alternative methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.
- The human comfort criteria are also predicted to be exceeded at several surrounding buildings at both sites, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.
- Worst-case vibration intensive activities may occur over around 17 weeks during demolition and around 14 weeks during excavation. The predictions represent work at its closest point to each receiver. Impacts would be reduced when work is more distant or further underground.

- It is noted that a data centre is located at 13A-29 Union Street, Pyrmont, which is around 20 m from both construction site boundaries. A review of the relevant guidance regarding vibration impacts on computer equipment indicates less stringent criteria than what has been used in this assessment for potential human comfort impacts on this receiver.

5.2.3 Hunter Street (Sydney CBD) Study Area (NCA06 – NCA07)

The Hunter Street (Sydney CBD) study area is located in Sydney CBD near Pitt Street. Two separate construction sites are proposed:

- The Hunter Street Station (Sydney CBD) eastern construction site, bounded by O'Connell Street, Hunter Street and Bligh Street. The construction site is currently the existing Sydney Metro City and Southwest tunnelling support site at 33 Bligh Street, which would be handed over around January 2023. This site currently has an acoustic shed, utility connections and site office buildings fronting Bligh Street, which would be retained for this proposal.
- The Hunter Street Station (Sydney CBD) western construction site, located on the south-east corner of Hunter Street and George Street. The CBD has higher existing background noise levels and no acoustic shed is proposed at this site. This is consistent with excavation work completed at the existing construction sites within Sydney CBD as part of Sydney Metro City & Southwest.

Existing noise levels in this study area are controlled by road traffic noise and general urban hum associated with the CBD. As with any CBD, existing noise levels and are relatively high during all periods. The area surrounding the construction site is mainly commercial and the nearest receivers are directly adjacent to the boundary of the site. The NCAs are shown in **Figure 8**.

5.2.3.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 33**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The mined cavern work at the eastern construction site would be completed in an acoustic shed. The eastern site is also proposed to be used for tunnel boring machine retrieval.

The proposed work is anticipated to have a total duration of about three years.

5.2.3.2 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction work in this study area are summarised in **Table 34**, **Table 35** and **Table 36** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers.

The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dB and are separated into day, evening and night-time periods, as appropriate.

Figure 23 Site Map, Work and Sensitive Receivers

Table 33 Construction Activities and Working Hours

Scenario	Activity		Total Indicative Duration (Weeks)[2]	Maximum Number of Working Faces	Hours of Work[1]				Comments
					Std. Day	Out-of-Hours Work			
						Day OOH	Eve	Night	
Enabling work	Typical	Supporting and loading	55	1	✓	✓	-	-	-
	Peak	Demolition using a rockbreaker	55	2	✓	✓	-	-	Rockbreaking work would only occur intermittently during a 55 week period between 7am – 6pm. Total duration of rockbreaking work would be about 50 days.
Piling	Typical	Supporting work	16	1	✓	✓	-	-	Piling work would only occur intermittently during a 16 week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
	Peak	Bored piling with support plant	16	4	✓	✓	-	-	
Surface construction	Typical	General work	6	1	✓	✓	-	-	Civil work and construction surface structures.
	Peak	Noise intensive work	6	2	✓	✓	-	-	
Excavation	Typical	Mucking out	39	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week.
	Peak	Through rock using rockbreaker	39	2	✓	✓	✓	✓	Excavation through rock using rockbreaker. This work would occur 24 hours per day, seven days per week.
Mined cavern	Typical	Spoil removal	116	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week.
	Peak	Mining with support	116	2	✓	✓	✓	✓	The work would be completed at the eastern construction site within an acoustic shed.
TBM retrieval	Typical	Deliveries and on/off loading	4	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week, at the eastern construction site.
	Peak	TBM disassembly	4	2	✓	✓	✓	✓	

Note 1: OOH = out of hours.

Note 2: Durations should be regarded as indicative and represent the total estimated duration of work at a typical worksite over the entire construction period.

Table 34 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Work[4]											
									Daytime OOH			Evening			Night-time			Sleep Disturbance		
						1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	55	624	-	4	7	-	4	7	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Demolition using a rockbreaker	55	624	-	50	33	10	54	33	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	Supporting work	16	624	-	6	4	-	6	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Bored piling with support plant	16	624	-	17	9	-	17	9	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Surface construction	Typical	General work	6	624	-	9	-	-	9	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Noise intensive work	6	624	-	16	8	-	16	8	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	Mucking out	39	624	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	Peak	Through rock using rockbreaker	39	624	-	29	19	6	30	19	6	6	4	-	6	5	3	1	-	-
Mined cavern	Typical	Spoil removal (doors closed)	116	624	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	Peak	Mining with support (doors closed)	116	624	-	2	-	-	2	-	-	-	-	-	1	-	-	-	-	-
		Mining with support (doors open)	116	624	-	3	-	-	3	-	-	-	-	-	1	-	-	-	-	-
TBM retrieval	Typical	Deliveries and on/off loading	4	624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak	TBM disassembly	4	624	-	4	-	-	4	-	-	1	-	-	2	-	-	-	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Note 2: Highly Noise Affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 35 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Work[4]											
									Daytime OOH			Evening			Night-time			Sleep Disturbance		
						1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	55	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Demolition using a rockbreaker	55	54	-	2	-	-	6	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	Supporting work	16	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Bored piling with support plant	16	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Surface construction	Typical	General work	6	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Noise intensive work	6	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	Mucking out	39	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak	Through rock using rockbreaker	39	54	-	-	-	-	1	-	-	1	-	-	2	1	-	1	-	-
Mined cavern	Typical	Spoil removal (doors closed)	116	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak	Mining with support (doors closed)	116	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mining with support (doors open)	116	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TBM retrieval	Typical	Deliveries and on/off loading	4	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak	TBM disassembly	4	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Note 2: Highly Noise Affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 36 Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity		No. Weeks[1]	Number of Receivers																								
				Commercial			Court			Educational			Hotel (Day)			Hotel (Night)			Outdoor Passive			Place of Worship			Theatre		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	55	2	6	-	-	-	-	-	-	-	-	1	-	n/a	n/a	n/a	-	-	-	-	-	-	2	-	-
	Peak	Demolition using a rockbreaker	55	41	27	8	1	-	-	2	-	-	3	4	1	n/a	n/a	n/a	1	-	-	-	1	-	-	1	1
Piling	Typical	Supporting work	16	5	3	-	-	-	-	-	-	-	-	1	-	n/a	n/a	n/a	-	-	-	-	-	-	1	-	-
	Peak	Bored piling with support plant	16	13	8	-	-	-	-	-	-	-	3	1	-	n/a	n/a	n/a	-	-	-	-	-	-	1	-	-
Surface construction	Typical	General work	6	8	-	-	-	-	-	-	-	-	1	-	-	n/a	n/a	n/a	-	-	-	-	-	-	-	-	-
	Peak	Noise intensive work	6	12	7	-	-	-	-	-	-	-	2	1	-	n/a	n/a	n/a	-	-	-	-	-	-	2	-	-
Excavation	Typical	Mucking out	39	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Peak	Through rock using rockbreaker	39	24	15	6	1	-	-	-	-	-	3	3	-	2	3	3	-	-	-	-	-	-	1	1	-
Mined cavern	Typical	Spoil removal (doors closed)	116	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Peak	Mining with support (doors closed)	116	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
		Mining with support (doors open)	116	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
TBM retrieval	Typical	Deliveries and on/off loading	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak	TBM disassembly	4	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration, and depends on the rate of progress.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Enabling work* when rockbreakers are used. The predicted daytime impacts during this work are shown in:

- **Figure 24** – *Enabling work – Demolition using a rockbreaker (peak)*
- **Figure 25** – *Enabling work – Supporting and loading (typical)*.

The highest impact work is expected to last for:

- *Enabling work – Demolition using a rockbreaker* – 50 days actual rockbreaker use
- *Excavation – Through rock using rockbreaker* – 39 weeks.

Figure 24 Predicted Daytime Airborne Noise Impacts – *Enabling work – Demolition using a rockbreaker (peak)*

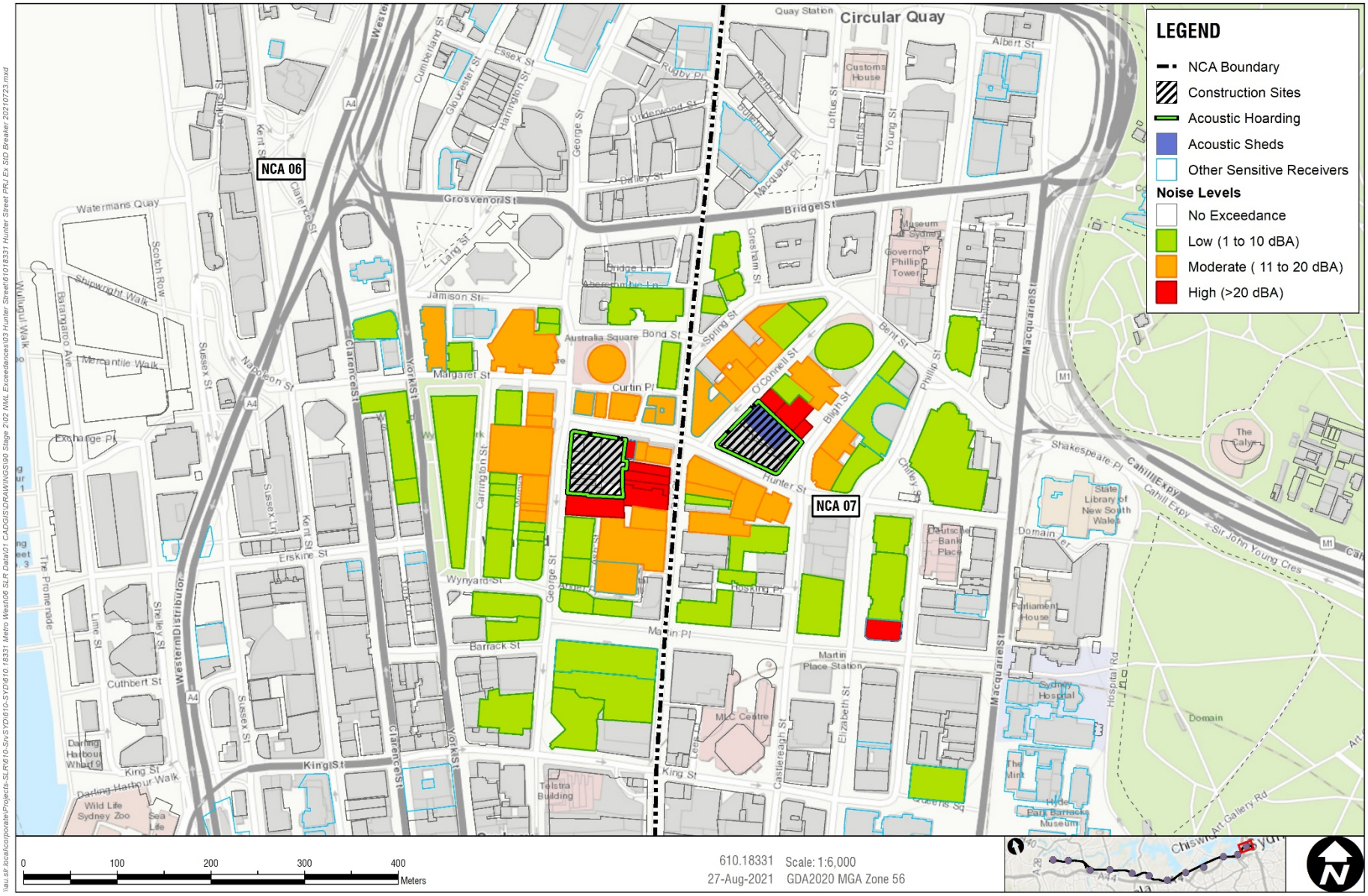
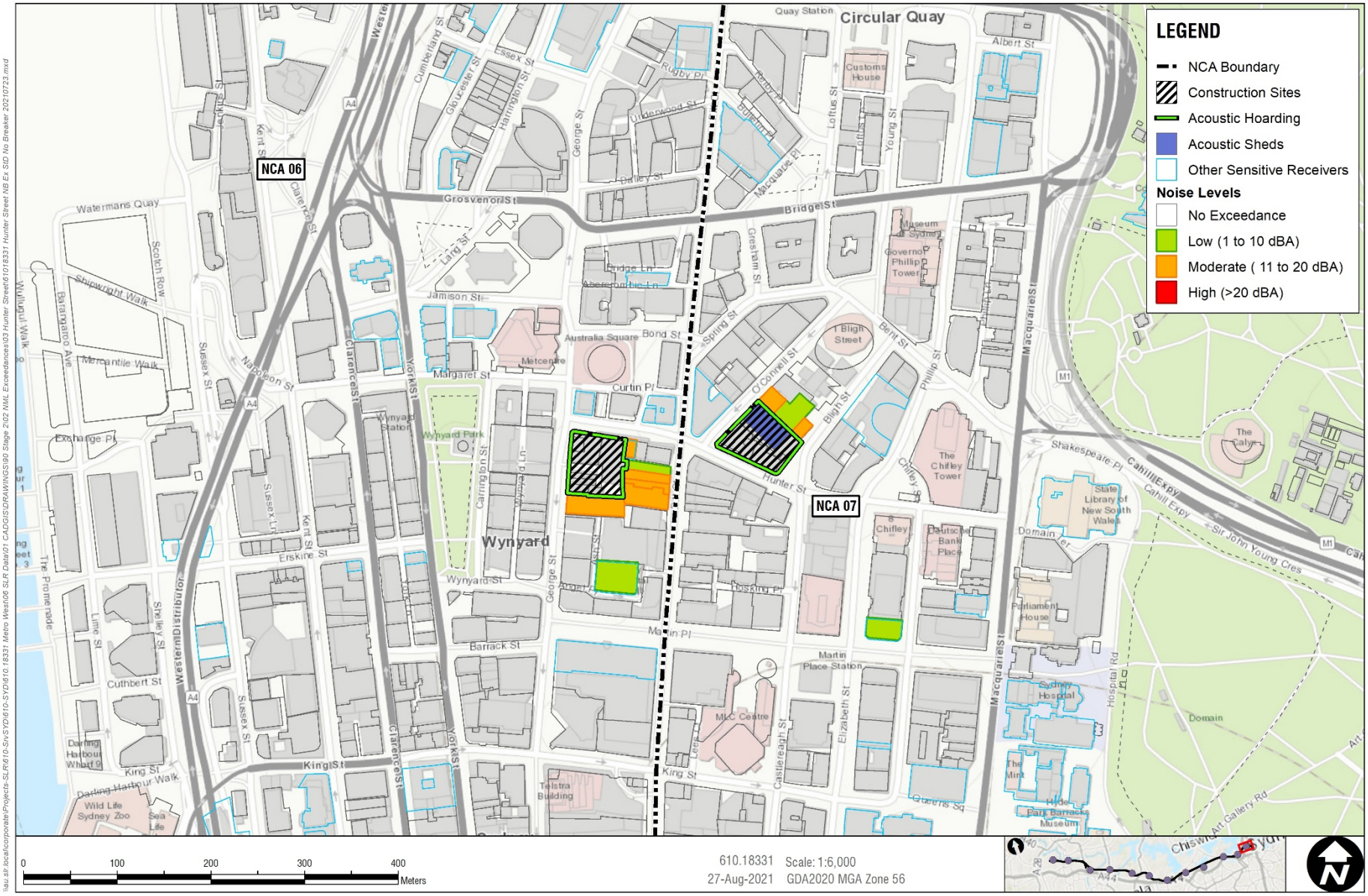


Figure 25 Predicted Daytime Airborne Noise Impacts – *Enabling work – Supporting and loading (typical)*



The above assessment during the worst-case daytime impacts shows the following:

- The proposed work at the Hunter Street Station (Sydney CBD) construction sites would involve noise intensive surface and excavation work which would be completed without acoustic sheds, consistent with the approach for Sydney Metro City & Southwest construction sites within Sydney CBD. Mined cavern excavation work would occur inside an acoustic shed at the eastern construction site. Noise mitigation measures would be in place at both construction sites (see **Section 6**).
- Residential receivers are distant from the sites and the noise levels are mostly predicted to comply the management levels. Commercial receivers are, however, located close to the construction sites and impacts are predicted to be 'high' during noisy work when noise intensive equipment such as rockbreakers are being used. Rockbreakers would be used intermittently during demolition and excavation activities, which have a duration of about 55 and 39 weeks, respectively. When noise intensive equipment is not in use during 'typical' work, impacts are predicted to substantially reduce, with 'moderate' and 'low' impacts predicted at the nearest receivers.
- The nearest 'other sensitive' receivers are predicted to impacted during some of the noisier work activities. 'High' or 'moderate' worst-case impacts are predicted at:
  - 'High' at the Comfort Hotel Sydney and at 7 News Sydney, due to its relatively low NML, when rockbreakers are being used during demolition (the total duration of outdoor rockbreaker use during demolition is expected to be about 50 days)
  - 'Moderate' at A by Adina Hotel Sydney, The Grand Hotel, the Tank Stream Hotel, Radisson Blu Plaza Hotel Sydney, City Recital Hall, Scots Presbyterian Church Sydney during noisy outdoor activities.
  - Work inside the acoustic shed is predicted to result in noise levels that comply with the management levels or result in 'low' exceedances at a small number of receivers.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

Additionally, the impacts from excavation assume the work is relatively near the surface. As progress is made further underground the impacts would be expected to reduce.

Night-time Scenarios

The highest night-time construction noise impacts are predicted during *Excavation* when rockbreakers are in use. The predicted night-time noise impacts during this work are shown in:

- **Figure 26** – *Excavation – Through rock using rockbreaker (peak)*
- **Figure 27** – *Excavation – Mucking out (typical)*, which has no requirement for noise intensive equipment.

The highest impact work is expected to last for:

- *Excavation* – 39 weeks.

Figure 26 Predicted Night-time Airborne Noise Impacts – *Excavation – Through rock using rockbreaker (peak)*

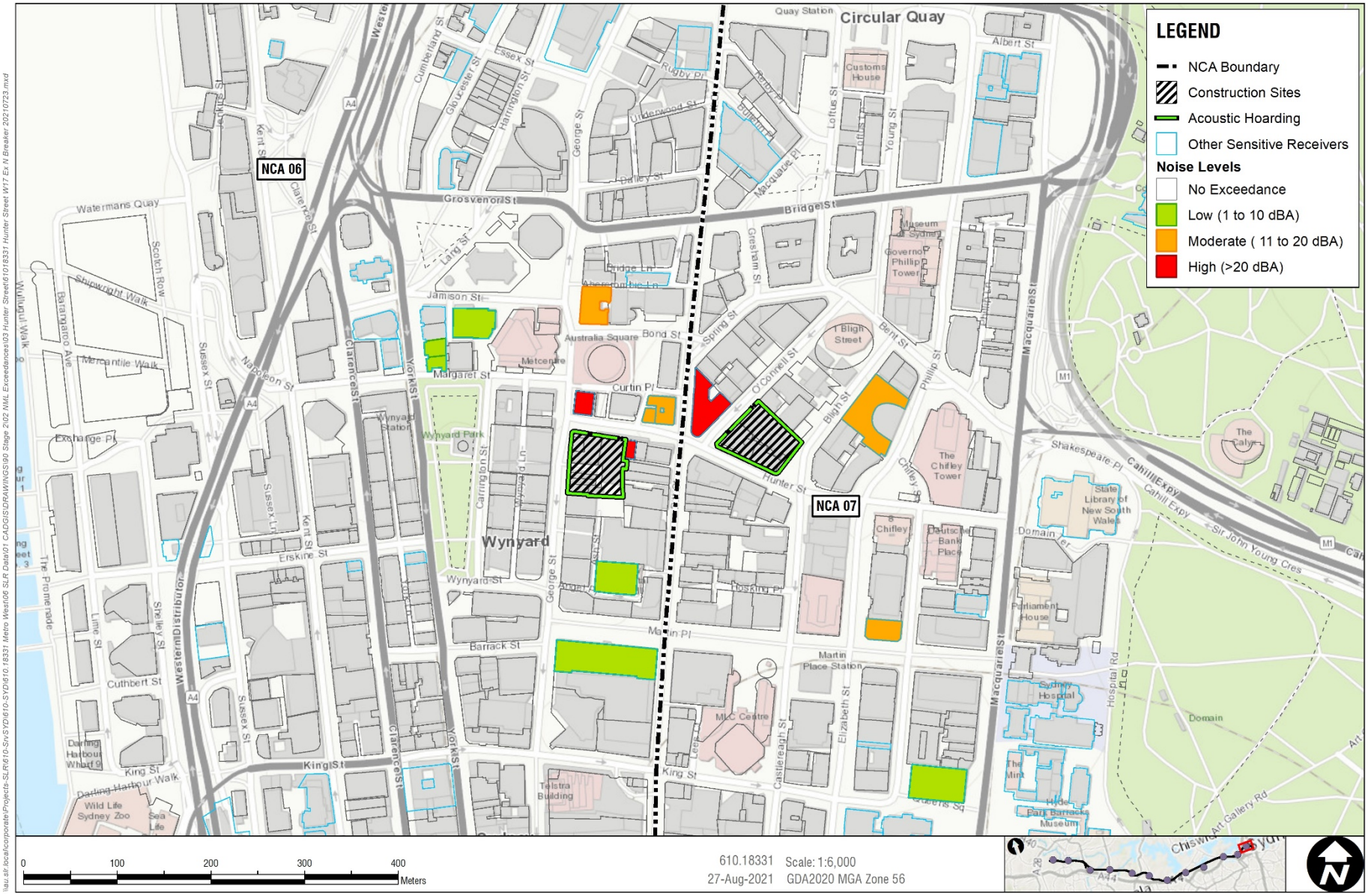


Figure 27 Predicted Night-time Airborne Noise Impacts – *Excavation – Mucking out (typical)*

The above assessment during the worst-case night-time impacts shows the following:

- The proposed night-time *Mined cavern* work at Hunter Street Station (Sydney CBD) construction sites would be completed inside an acoustic shed at the eastern construction site. *Excavation* would be completed without sheds.
- 'High' or 'moderate' impacts are predicted at a small number of the nearest receivers when noise intensive equipment such as rockbreakers are being use as part of *Excavation*. When noise intensive equipment is not in use during 'typical' work, the impacts are substantially reduced with noise levels predicted to comply with the management levels at most receivers.
- Work inside the acoustic shed is predicted to result in noise levels that comply with the management levels or result in 'low' exceedances at a small number of receivers.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted during some of the noisier work activities, particularly when noise intensive equipment, such as rockbreakers, are being used outdoors.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

Additionally, the impacts from excavation assume the work is relatively near the surface. As progress is made further underground the impacts would be expected to reduce.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction work and is summarised in **Table 34**.

'Low' sleep disturbance impacts are predicted at one residential receiver to the north during the night-time. This impact is due to the use of noise intensive equipment such as rockbreakers.

The number of potential night-time awakenings would depend on several factors, including the type of equipment being used, the duration of the noisy work, and the distance of the work to nearest residential receivers.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

No receivers are predicted to be highly noise affected in this study area.

5.2.3.3 Ground-borne Noise Impacts from Construction Sites

Shaft excavation at the Hunter Street Station (Sydney CBD) construction sites would be completed without acoustic sheds meaning airborne noise levels at the nearest receivers would likely be higher than the corresponding internal ground-borne noise levels. Where airborne noise levels are higher than ground-borne noise levels it is not necessary to evaluate potential ground-borne noise impacts.

Some receivers next to the construction sites may have internal spaces which do not have windows or facades facing the construction site, or may have acoustically isolated internal rooms which could result in ground-borne noise levels during vibration intensive work being audible in these spaces.

On this basis, ground-borne noise levels have been assessed at this site and the potential worst-case impacts are summarised in **Table 37.** The results are shown in **Figure 28** and **Figure 29** for the daytime and night-time, respectively. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation work is close.

Table 37 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime[2]			Out-of-Hours Work					
						Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
NCA06	Residential	42	-	-	-	-	-	-	-	-	-
	Commercial	312	2	-	5	-	-	-	-	-	-
	Other Sensitive	42	-	-	1	-	-	1	1	-	1
NCA07	Residential	13	-	-	-	-	-	-	-	-	-
	Commercial	197	6	1	2	-	-	-	-	-	-
	Other Sensitive	30	1	-	-	1	-	-	-	1	-

Note 1: Based on worst-case predicted noise levels.

Note 2: Daytime ground-borne noise NMLs taken from preceding Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Figure 28 Predicted Ground-borne Noise Impacts – Daytime

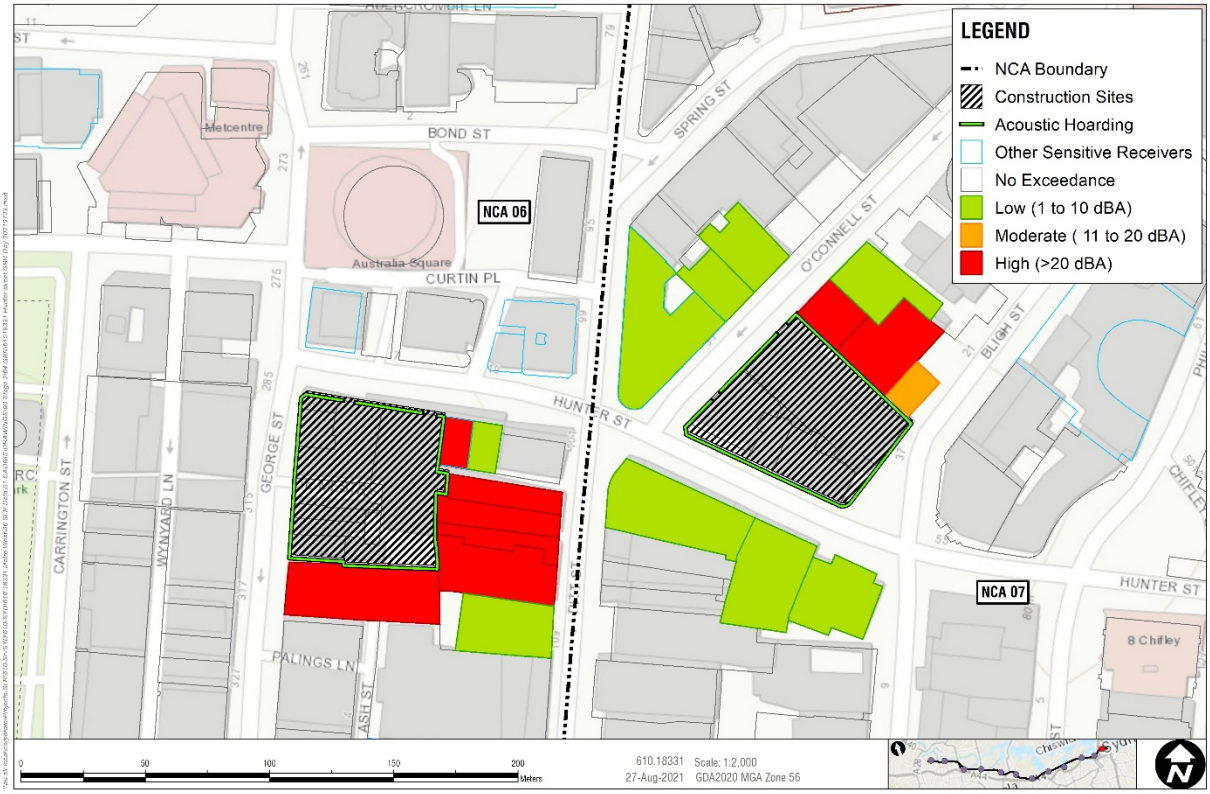
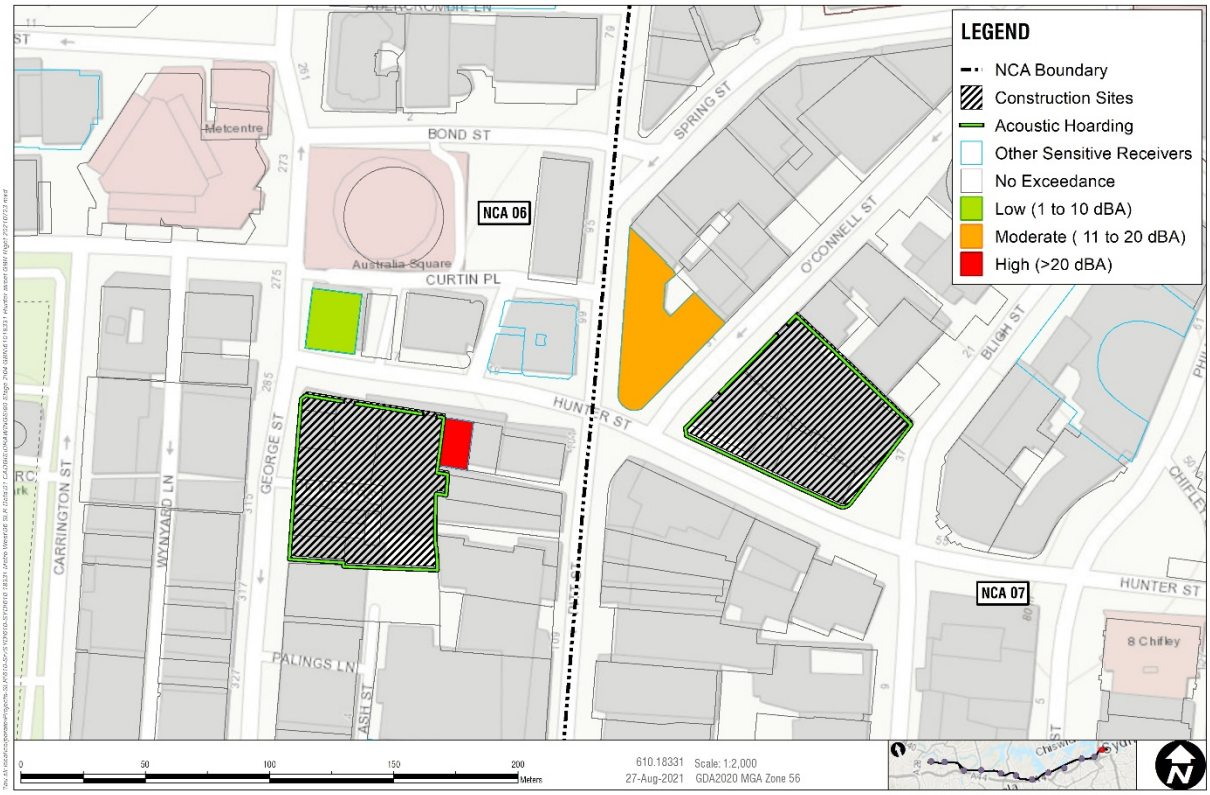


Figure 29 Predicted Ground-borne Noise Impacts – Night-time



The above assessment during the worst-case impacts shows the following:

- Receivers are close to both construction sites and vibration intensive work is predicted to result in 'high' ground-borne noise impacts at a small number of receivers. 'Moderate' or 'low' exceedances are predicted at receivers further away.
- While exceedances are predicted during the daytime, it is noted that neither the ICNG nor CNVS specify daytime NMLs for ground-borne noise. The assessment has used daytime ground-borne noise NMLs from preceding Sydney Metro planning applications for consistency.
- During the night-time period, only the three closest hotels are predicted to be impacted by ground-borne noise.

Vibration intensive shaft excavation work is expected to last for around 39 weeks.

The predictions assume the work is relatively near surface level. As progress is made further underground the impacts would be expected to reduce.

5.2.3.4 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive work are shown in **Figure 30**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when work is close.

Figure 30 Predicted Vibration Impacts

The assessment during the worst-case impacts above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the adjacent buildings at both sites. This includes the heritage listed building retained within the western construction site footprint. These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the sites and is in close proximity to the affected buildings. In reality, smaller equipment or alternative methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.
- The human comfort criteria are also predicted to be exceeded at the nearest buildings, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.
- Worst-case vibration intensive activities may occur over around 55 weeks during demolition and around 39 weeks during excavation. The predictions represent work at its closest point to each receiver. Impacts would be reduced when work is more distant or further underground.

5.3 Tunnelling from The Bays to Sydney CBD

The following sections present an assessment of the predicted ground-borne noise and vibration impacts from the proposed tunnelling work, which includes:

- Tunnel boring machines excavating rock and constructing the main tunnel exterior structure
- Roadheaders and rockbreakers excavating stations, station shafts, crossover caverns, cross passages, turnback cavern, stub tunnels and adits.

5.3.1 Ground-borne Noise Impacts

The ground-borne noise assessment is based on the worst-case predicted internal ground-borne noise levels for sensitive receivers above the proposed tunnelling work. The predictions represent noise levels when the work is below each receiver.

A summary of the predicted ground-borne noise levels in each NCA is shown in **Table 38**. The results are also presented in a scatter graph in **Figure 31** and in **Appendix E** which shows the highest predicted NML exceedance for each receiver building.

Table 38 Overview of Tunnelling Ground-borne NML Exceedances – All Receiver Types

Study area	NCA	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime[2]			Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
The Bays	NCA01	491	-	-	-	-	-	-	-	-	-
	NCA02	842	-	-	-	-	-	-	-	-	-
	NCA03	47	-	-	-	-	-	-	-	-	-
Pyrmont	NCA04	728	53	5	-	67	28	-	88	47	4
	NCA05	461	-	-	-	7	-	-	13	-	-
Hunter Street	NCA06	399	4	6	-	1	3	-	2	1	3
	NCA07	250	1	1	-	-	1	-	1	-	1

Note 1: Based on worst-case predicted noise levels in each NCA.

Note 2: Daytime ground-borne noise NMLs taken from preceding Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

The above assessment during the worst-case impacts shows that:

- The ground-borne noise impacts during tunnelling work are predicted to comply with the daytime NMLs at most receivers. A small number of the nearest receivers at the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites are predicted to have 'moderate' or 'low' impacts.
- During the night-time, the impacts are more wide-spread due to a lower NML. The impacts are predicted to be 'high' in the Pyrmont and Hunter Street (Sydney CBD) study areas where the tunnel depth is shallowest.
- The impacted receivers are mostly residential properties in the Pyrmont study area. In the Hunter Street (Sydney CBD) study area the impacts are mostly at commercial receivers.

The ground-borne noise predictions are based on the nearest receivers within each building at ground floor. The impacts would reduce for sensitive receivers which are further away from the work or for receivers on high floors in multistorey buildings.

The tunnel boring machines are expected to progress at a rate of around 20 to 30 metres per day. This means the worst-case ground-borne noise impacts from tunnelling at a receiver would likely only last for a few days for each tunnel boring machine as the tunnelling work passes beneath.

As the work progresses and moves away, a receiver's exposure to ground-borne noise would reduce as illustrated in **Figure 32**, which shows indicative internal ground-borne noise levels from tunnel boring machine tunnelling as work progresses past a particular location.

Figure 31 Tunnelling Ground-borne Noise Predictions

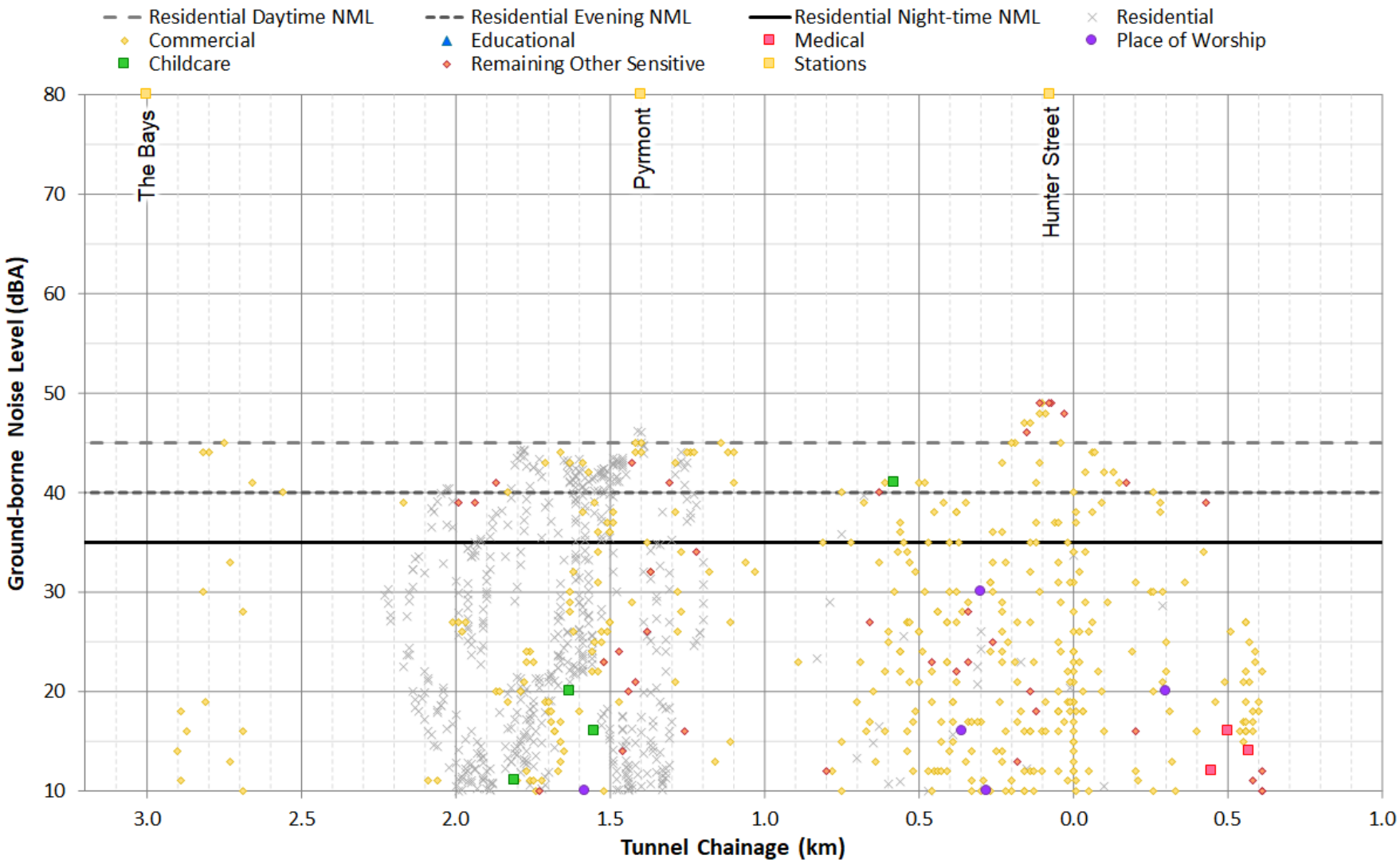
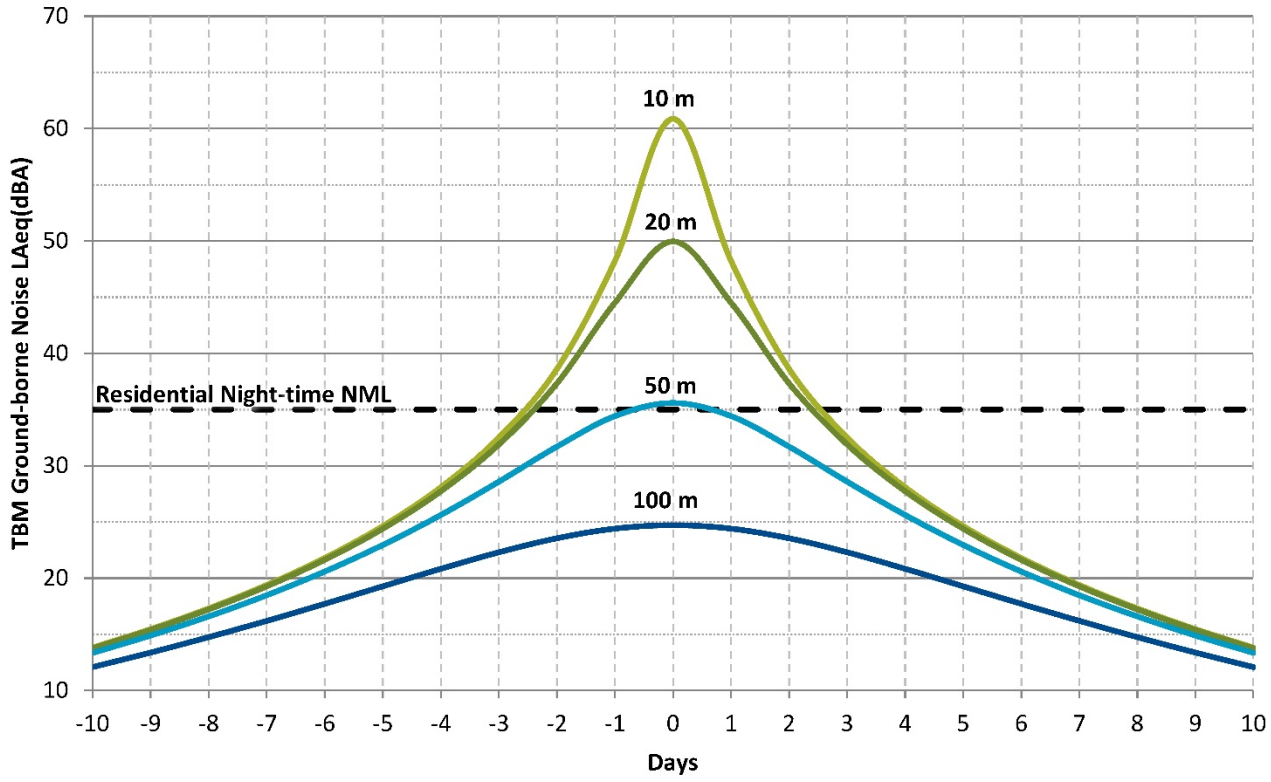


Figure 32 Example Tunnel Boring Machine Ground Borne Noise Levels (Progress = 20m/day)



The above figure shows that where a residential receiver has a 20 metres slant distance from the nearest tunnel (i.e. the three dimensional distance which takes into account the tunnel depth and the horizontal offset), internal ground-borne noise levels are likely to exceed the 35 dB night-time ground-borne NML for around five days. Where residential receivers have a slant distance of greater than around 50 metres, exceedances of the night-time NML are not considered likely.

5.3.2 Vibration Impacts

The ground-borne vibration assessment is based on the worst-case predicted ground-borne vibration level for sensitive receivers above the proposed tunnelling work. The predictions represent vibration levels when the work is below each receiver.

A summary of the predicted ground-borne vibration levels in each NCA is shown in **Table 39**. The locations of all tunnelling vibration exceedances are shown in **Appendix F**.

Table 39 Overview of Vibration Criteria Exceedances – All Receiver Types

Study area	NCA	Number of Receivers				
		Total	With Vibration Criteria Exceedance[1]			
			Cosmetic Damage	Human Comfort		Sensitive Equipment
			Day / Night	Day	Night	Day / Night
The Bays	NCA01	491	-	-	-	-
	NCA02	842	-	-	-	-
	NCA03	47	-	-	-	-
Pyrmont	NCA04	728	-	25	43	-
	NCA05	461	-	-	-	-
Hunter Street	NCA06	399	-	7	3	-
	NCA07	250	-	1	1	3

Note 1: Based on worst-case predicted vibration levels.

The above assessment during the worst-case impacts shows the following:

- Vibration levels during tunnelling are predicted to comply with the cosmetic damage criteria.
- Potential exceedances of the human comfort criteria are likely in the Pyrmont and Hunter Street (Sydney CBD) study areas, meaning perceptible levels of vibration may occur when tunnelling work is below these areas. These impacts are typically at receivers which surround the construction sites, as this is where the tunnel depth is shallowest.
- Three buildings at the Sydney Hospital are predicted to potentially have exceedances of the sensitive equipment criteria. These buildings have been identified based on an initial screening assumption that they contain vibration sensitive equipment with VC-C criteria.
- No vibration impacts at the former White Bay Power Station are predicted as vibration intensive work during cavern mining would be around 300 metres away.

The above predictions assume the tunnel boring machine is in use for 50 per cent of the assessment period. If this is reduced to 20 per cent, the number of human comfort criteria exceedances would substantially decrease. The rate of tunnelling would depend on several factors and may vary throughout the alignment.

5.3.3 Work Trains

Consistent with the tunnelling methodology used on previous Sydney Metro projects, work trains would likely be used to supply materials, such as precast tunnel lining segments, and workers to the workface.

Work trains are anticipated to operate on bespoke underground wheeled vehicles, with an alternative of a temporary narrow gauge rail with resilient mounts and/or rubber wheels. The speed of these trains is typically limited to 10 km/h for safety reasons. The work trains would be used on a 24/7 basis.

Given the slow speeds, the potential ground-borne noise and vibration impacts from work trains are expected to be minimal.

5.4 Utilities Adjustments

An assessment of the potential noise levels from utility work is provided in **Table 40**. Utility work would include trenching during the installation of a power supply route in the area surrounding the Pyrmont Station construction sites. The Pyrmont power supply route is expected to be along Harris Street and Pyrmont Bridge Road.

Noise levels have been predicted at various offset distances from typical items of equipment to determine the potential indicative impacts.

Table 40 Potential Noise Levels from Utility Work

Equipment	Predicted Noise Level at Distance ($L_{Aeq(15minute)}$ dBA)				
	10 metres	15 metres	30 metres	50 metres	70 metres
Asphalt milling machine	83	79	73	69	66
Concrete saw[1]	84	80	74	70	67
Excavator	81	77	71	67	64
Excavator (breaker)[1]	90	86	80	76	73
Hand tools	69	65	59	55	52
Paver	77	73	67	63	60
Roller	78	74	68	64	61
Vacuum Excavation Truck	72	68	62	58	55

Note 1: Assumed to be working for 7.5 minutes in worst-case 15-minute period.

The above table shows that relatively high noise levels are likely where noise intensive equipment is required near to adjacent receivers. On typical streets surrounding the proposed work areas, the closest receivers are around 10 metres from the road. In this situation, worst-case noise levels in the region of 80 to 90 dBA are possible during noisy phases of the work.

Night-time NMLs in the vicinity of most sites are in the region of 40 to 50 dBA (see **Table 6**), meaning worst-case exceedances at residential receivers of greater than 30 dB above the NML are possible if noise intensive equipment is used during the night-time. Utility work would be temporary and the duration of impacts at would be limited.

5.5 Construction Road Traffic Noise Impacts

Construction related traffic has the potential to temporarily increase road traffic noise levels at receivers which are adjacent to construction haulage routes.

The forecast construction traffic volumes in the study area have been used to determine where potentially noticeable increases in road traffic noise (i.e. a greater than 2.0 dB increase above the existing noise level) is likely. The assessment is summarised in **Figure 33**, **Figure 34** and **Figure 35** which show the worst-case potential increase from any period.

Figure 33 The Bays – Predicted Change in Road Traffic Noise Levels

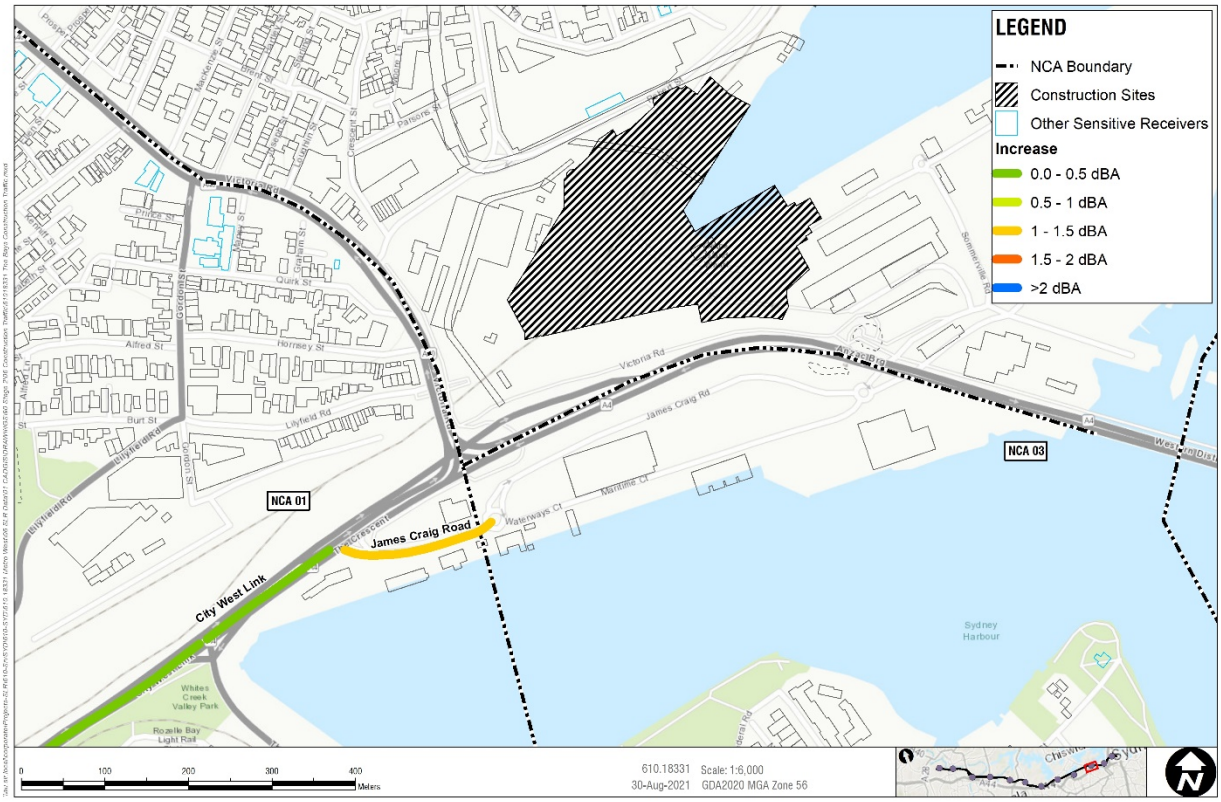


Figure 34 Pyrmont – Predicted Change in Road Traffic Noise Levels

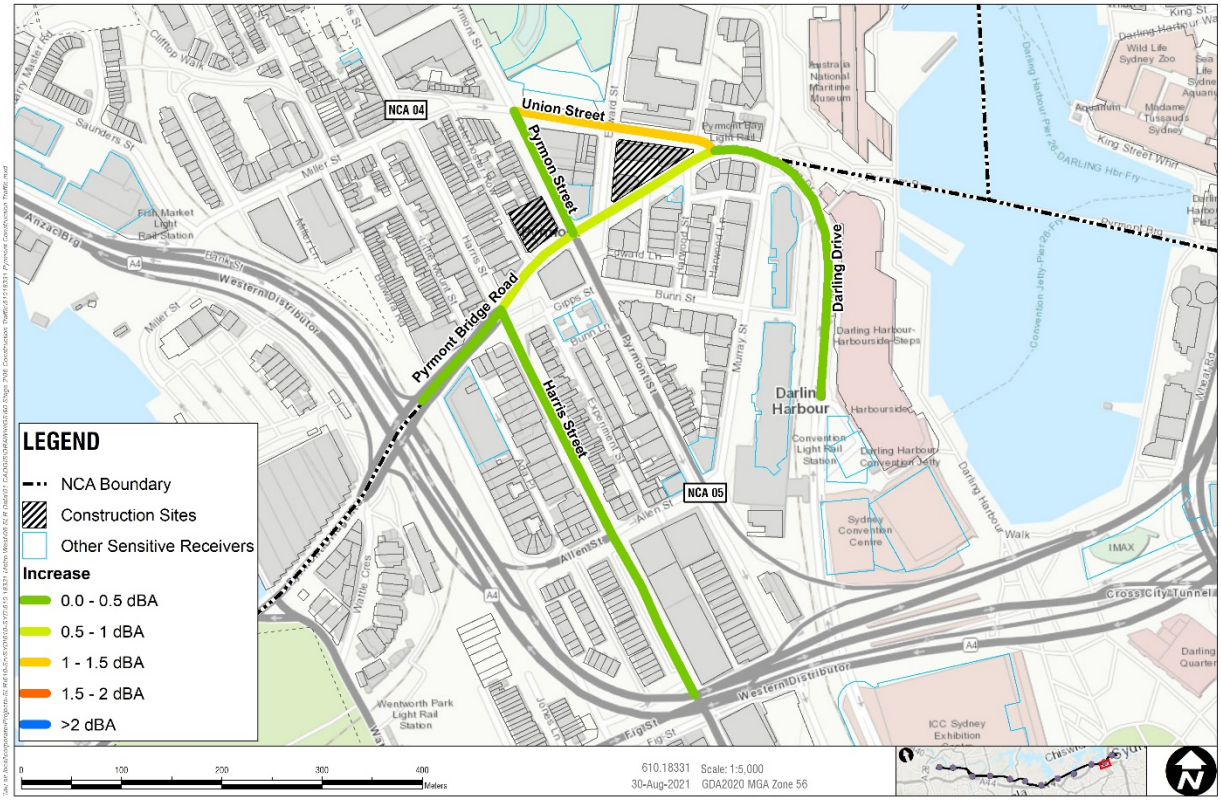
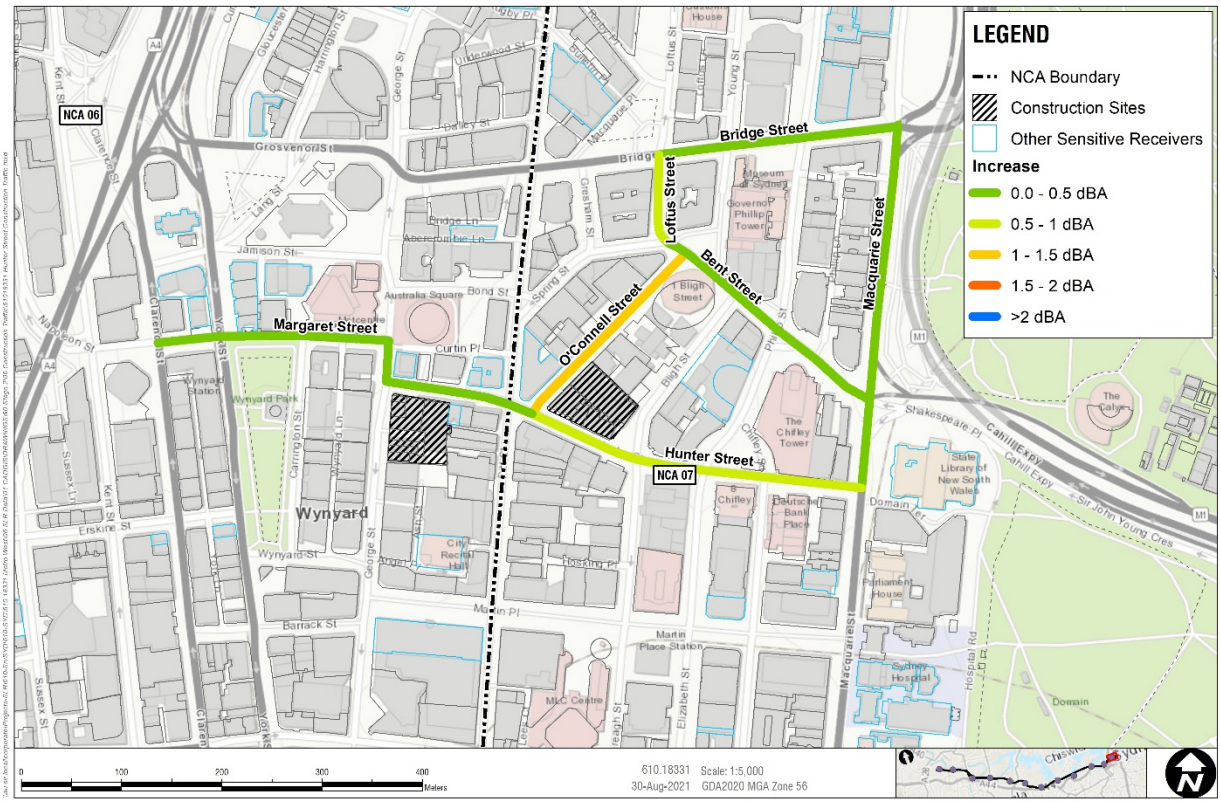


Figure 35 Hunter Street – Predicted Change in Road Traffic Noise Levels



The above assessment shows that construction traffic is unlikely to result in a noticeable increase in noise levels on the proposed construction haulage routes. This is due to the high existing volumes of traffic that use these routes compared to the relatively small volume of proposed construction vehicles.

The assessment assumes free flowing traffic on the haulage routes. Additional road traffic noise impacts may occur when construction heavy vehicles accelerate and decelerate at the entrances/exits of the construction sites. The requirement for vehicles to accelerate and decelerate would depend on the size/type of heavy vehicle, their loaded weight and the local traffic conditions at the time, all of which are currently unknown. The following is noted with respect to the potential for increased noise impacts:

- The potential increase would likely be limited to around 150 metres either side of the construction site access points (based on a typical acceleration rate for a cat 3 semi-trailer heavy vehicle to 60 km/h)
- The areas most likely to be affected are on Pyrmont Bridge Road and Hunter Street, opposite the construction sites
- Heavy vehicles would be required to accelerate and decelerate more on roads with notable gradients. This would affect both existing heavy vehicles and construction related heavy vehicles
- The increased noise levels may result in increased annoyance at the closest receivers. Pyrmont has the closest residential receivers, however, construction heavy vehicles are generally not proposed to access these sites during the night-time (infrequent deliveries of concrete by truck would be required to support station lining pours for safety reasons) which would minimise the potential for annoyance.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.6 Cumulative Impacts

Cumulative impacts are impacts that result from the successive, incremental, or combined effects of an activity or project when added to other past, current, planned, or reasonably anticipated future impacts (Department of Planning and Environment, 2017). Work covered by this proposal has the possibility of interacting with a number of other projects along the planned corridor or at proposed construction sites. Key projects to be considered are described below.

Concurrent cumulative construction noise and vibration impacts can occur where multiple work activities are being completed near to a particular receiver at the same time. Additionally, if more than one project occurs in the same area consecutively, there may be a prolonged effect from the extended duration of construction impacts. This effect is termed 'construction fatigue'.

5.6.1 Sydney Metro West (Stage 1 of the planning approval process) Existing Approval

The Sydney Metro West Concept and major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval for Sydney Metro West) were approved on 11 March 2021. As part of this work, The Bays tunnel launch and support site would initially be occupied by the Contractor undertaking construction work (tunnelling westbound) under the existing approval.

This part of the site would be vacated by the tunnelling contractor (for the tunnelling westbound) at about the end of the first quarter 2023. The Contractor for this proposal would undertake enabling work, crossover excavations and prepare for the tunnel boring machine launch from the end of the first quarter 2023. The site would, therefore, be in use for an extended period, from the second quarter, 2023 to about the end of the fourth quarter, 2025.

In addition, proposed tunnelling and support work at The Bays tunnel launch and support site would occur concurrently with the approved tunnelling work westwards from The Bays to Sydney Olympic Park, for a period of approximately six months. There is potential for concurrent cumulative noise impacts during this overlap period as the noise impacts from The Bays to Sydney Olympic Park work (see *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD*) and from work as part of this proposal are both predicted to be 'low' at the nearest residential receivers.

Where concurrent construction work is being completed near to a particular area, the worst-case noise levels could theoretically increase by around 3 dB (i.e. a logarithmic adding of two sources of noise at the same level). The likelihood of worst-case noise levels being generated by two different work activities at the same time is, however, considered low and rather than increase construction noise levels, the impact of concurrent work would generally be limited to a potential increase in the duration, and annoyance, of noise impacts on the affected receivers.

The tunnelling west from this site as part of the existing approval would be carried out between mid-2022 and mid-2024. The tunnelling east as part of this proposal would be carried out between early 2024 and early 2025. No concurrent ground-borne noise or vibration impacts are expected as the tunnelling would be in opposite directions and would generally not affect the same receivers.

The use of the proposed site by multiple overlapping projects may result in consecutive impacts (i.e. 'construction fatigue') at the surrounding receivers due to construction work being in the area for an extended period.

Mitigation measures aimed at short-term construction work may be less effective where receivers are affected by longer duration impacts from several projects, especially where extensive night-time work is required. Where receivers are affected by 'construction fatigue', it may be necessary to consider specific mitigation and management measures to minimise the impacts.

5.6.2 Sydney Metro West – Rail infrastructure, stations, precincts and operations (Stage 3 of the planning approval process)

Stage 3 of the planning approval process for Sydney Metro West includes tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line. The Scoping Report for *Sydney Metro West – Rail infrastructure, stations, precincts and operations* (Sydney Metro, 2021) was lodged on 21 June 2021. Construction would commence from about the fourth quarter 2024 to about the third quarter 2028, with finishing, testing and commissioning activities to be carried out between third quarter 2028 and fourth quarter 2029.

The construction impacts from Stage 3 of the planning approval process for Sydney Metro West are currently unknown. The potential impacts from Stage 3 work at The Bays tunnel launch and support site are, however, likely to be comparable to impacts described in **Section 5.6.1** for Stage 1. Both concurrent and consecutive cumulative impacts may occur. This would be confirmed in the Environmental Impact Statement for Sydney Metro West Rail infrastructure, stations, precincts and operations.

5.6.3 Sydney Metro City & Southwest

Sydney Metro City & Southwest will deliver 30 kilometres of new metro rail between Chatswood and Bankstown, including new twin tunnels under Sydney Harbour, and the upgrade and conversion of all 11 stations between Sydenham and Bankstown to metro railway standard. The Chatswood to Sydenham component of Sydney Metro City & Southwest was granted planning approval in January 2017, and the Sydenham to Bankstown upgrade was approved in December 2018.

The Sydenham to Bankstown component of this project was not considered in this cumulative impact assessment as this stage of the project did not meet the spatial relevance criterion. Components of the Chatswood to Sydenham alignment relevant to this assessment include the tunnel rail systems fit out and station construction and fit out work which would overlap with shaft excavation work at the Hunter Street Station (Sydney CBD) eastern construction site during the first quarter, 2023.

The existing Sydney Metro City and Southwest tunnelling support site at 33 Bligh Street would be handed over from the City and Southwest contractor to the Sydney Metro West contractor around January 2023 and would become part of the Hunter Street Station (Sydney CBD) eastern construction site. The site would, therefore, be in use for an extended period, from January 2023 to about the end of the fourth quarter, 2025.

The use of the proposed site by overlapping projects may result in consecutive impacts (i.e 'construction fatigue') at the surrounding receivers due to construction work being in the area for an extended period.

5.6.4 WestConnex M4-M5 Link

The WestConnex M4-M5 Link will comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project will also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (the Iron Cove Link).

All construction work on the mainline tunnels for the M4-M5 Link will be completed by the end of 2022. Therefore, it is anticipated that the proposal would only produce cumulative impacts with the Rozelle interchange and Iron Cove Link stage of the WestConnex M4-M5 Link which will continue until the third quarter of 2023. Work to be undertaken during this time include site rehabilitation and landscaping, demobilisation, and testing and commissioning.

The overlapping work between the second quarter of 2023 and the third quarter of 2023 is unlikely to result in concurrent noise impacts. The Conditions of Approval for WestConnex M4-M5 Link identified areas of receivers that are likely to be impacted by long-term, high impact work (in Condition E87). These areas are to the west of Victoria Road and cover receivers which are not predicted to impacted by this proposal (see **Section 5.2.1**).

The presence of construction work in the wider area by several overlapping projects may, however, result in consecutive impacts (i.e. 'construction fatigue') at the surrounding receivers.

5.6.5 Other Projects

A review of the Department of Planning, Industry and Environment Major Project Register, Government agency websites, relevant local government websites and state media releases identified a list of 13 other projects and proposals that have the potential to generate further cumulative impacts with this proposal (see Appendix G of the Environmental Impact statement). The projects that have the potential to generate cumulative noise and vibration impacts are detailed in **Table 41**.

Table 41 Nearby Major Developments

Project	Details
Western Harbour Tunnel and Warringah Freeway Upgrade	The Western Harbour Tunnel and Warringah Freeway Upgrade project form part of the Western Harbour Tunnel and Beaches Link Program and comprise a new motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network. The project includes construction activities at White Bay. The construction program is 2020 to 2026.
Glebe island concrete batching plant	This project involves the construction and operation of a new aggregate handling and concrete batching facility, with the capacity to produce up to one million cubic metres of concrete per annum. The construction program is 2021 to 2022.
Glebe island multi user facility	This proposal includes the construction and operation of a ship off-loading, storage and dispatch facility for bulk construction materials such as sand, aggregates and other dry bulk construction materials. The proposal site is located within land owned by the Port Authority on the eastern side of Glebe Island. The construction program is 2020 to 2021.
New Sydney Fish Market	The project involves building a new Sydney Fish Market which will be set within an improved public domain including the creation of a waterfront promenade. The site is located at the head of Blackwattle Bay between Pyrmont Peninsula and Glebe Peninsula. The construction program is 2020 to 2024.
Cockle Bay Wharf Mixed Use Development	The SSDA was approved on 13 May 2019 for the Concept Proposal and Stage 1 work which include demolition work. The current proposal includes construction of a land bridge across part of the Western Distributor and construction of a 43-storey mixed-use development. The project is currently in the planning stages.
50-52 Phillip Street New Hotel	The proposal involves the construction of a new 47 storey hotel building in Sydney's CBD. The construction program is 2023 to 2026.

Project	Details
One Sydney Harbour	One Sydney Harbour is a skyscraper complex under construction in Sydney which includes 808 apartments in three towers. The project is part of the major urban renewal precinct of Barangaroo. The construction program is 2019 to 2025.
Sydney Metro - Martin Place Over Station Development	The project includes two over station development commercial towers above the northern and southern entrances of the yet to be constructed Martin Place Metro Station. The Concept Proposal is intended to be delivered as a single, integrated project along with the delivery of rail, station, concourse infrastructure and public domain work associated with the Martin Place Metro Station. The construction of the different elements is likely to be staged so as not to interrupt the Metro construction program. The construction program is 2017 to 2024.
65-77 Market Street, Sydney	The proposal involves retention and alteration of the existing retail/commercial building and the construction of a 22-storey residential tower above (total height of 32 storeys). The construction program is 2020 to 2023.
317 and 319-321 George Street	This proposal is for the redevelopment including the retention and restoration of the existing heritage listed facade and the construction and use of a new building for commercial offices and retail premises. The new 14 storey commercial office building would include two lower levels of retail and 12 levels of commercial offices. The construction program is currently unknown.
194-204 Pitt Street	The Concept development application sought approval for a Concept building envelope for the redevelopment of the City Tattersall's Club, comprising a podium and tower containing indicative residential, retail, hotel and club land uses. The construction program is currently unknown.
301 and 305 Kent Street Concept Hotel Development	The Concept proposal sought consent for the establishment of a building envelope, use of the site at 301 and 305 Kent Street as a hotel with ancillary uses, pedestrian and vehicular access arrangements, and the provision of on-site bicycle and car parking. The construction program is currently unknown.
180 George Street	180 George Street will encompass the Salesforce Tower with a collection of new urban laneways hosting retail, dining and a major public square on George Street. The construction program is currently unknown.

Concurrent construction noise impacts may occur if construction of these projects is carried out at the same time as this proposal. There is also potential for consecutive impacts if certain receivers are affected by construction noise from two or more projects occurring in succession near the same area.

The potential cumulative impacts (both concurrent and consecutive) from this proposal and other projects should be investigated further as the project progresses when detailed construction planning is developed. Specific management and mitigation measures designed to address potential impacts should be developed and used to minimise the impacts as far as practicable, in consultation with the affected community, as outlined in **Section 6**.

6 Mitigation and Management Measures

This section provides a summary of the mitigation and management measures that would be implemented to minimise, avoid or mitigate the noise and vibration impacts of the proposal. The ICNG acknowledges that due to the nature of construction work it is inevitable that there will be impacts where construction is near to sensitive receivers.

These would be supplemented by mitigation measures detailed in Chapter 23 (Synthesis of the Environmental Impact Statement) of the Environmental Impact Statement with respect to cumulative impacts.

6.1 Construction Environmental Management Framework

The *Sydney Metro Construction Environmental Management Framework* (CEMF) was developed and successfully implemented as part of the Sydney Metro Northwest and Sydney Metro City & Southwest projects. This framework has been reviewed and amended to be applicable to the major civil construction work for Sydney Metro West. The *Sydney Metro Construction Environmental Management Framework* is provided in Appendix C to this Environmental Impact Statement.

The CEMF details environmental, management systems and processes for major civil construction work between The Bays and Sydney CBD. Specifically, it details the requirements in relation to the content of the construction environmental management plan, sub-plans and other supporting documentation for each specific environmental aspect.

The CEMF would require the principal contractors to prepare a Construction Noise and Vibration Management Plan (CNVMP) for their scope of work in line with the requirements of the ICNG (see **Section 3**) and the Sydney Metro CNVS (see **Section 6.2**).

The CNVMP would be prepared before any work begin and would define how the predicted impacts would be mitigated and managed. The CNVMP would include:

- Identification of nearby sensitive receivers
- Description of work, construction equipment and hours the work would be completed in
- Criteria for the project and relevant licence and approval conditions
- Requirements for noise and vibration monitoring
- Details of how community consultation would be completed
- Procedures for handling complaints
- Details on how respite would be applied where ongoing high impacts are seen at certain receivers.

The CNVMP would also consider cumulative concurrent construction impacts and the likelihood for ‘construction fatigue’ from consecutive projects in the areas which have substantial night-time work.

6.2 Sydney Metro Construction Noise and Vibration Standard

The *Construction Noise and Vibration Standard* (CNVS) establishes a consistent strategy for the assessment, mitigation and monitoring of noise and vibration generated by construction activities across Sydney Metro. It defines a minimum standard for managing noise and vibration impacts that considers currently best practice guidelines and other regulatory requirements, and adopts strategic objectives to understand and manage potential noise and vibration impacts.

The Sydney Metro CNVS is provided as Appendix E to the Environmental Impact Statement.

6.2.1 Standard Mitigation Measures

The CNVS contains a number of 'standard mitigation measures'. These measures are summarised in **Appendix G** and would be applied to the work at all construction sites to minimse the impacts from the work as far as practicable and where feasible and reasonable.

The standard measures include items such as requiring construction contractors to complete site inductions to make workers aware of any noise and vibration specifics, completing regular monitoring to check noise and vibration levels are as expected, and checking that noise emission levels for construction equipment remains within allowed CNVS and manufacturers specifications.

6.2.2 Additional Noise Mitigation Measures

Where impacts remain after the use of 'standard mitigation measures', the Sydney Metro CNVS requires 'additional mitigation measures' to be applied, where feasible and reasonable. The 'additional mitigation measures' are described in **Table 42**.

Table 42 Additional Management Measures

Measure	Description	Abbreviation[1]
Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts over an extended period of time. Alternative accommodation will be determined on a case-by-case basis.	AA
Monitoring	Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals, noise or vibration monitoring may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver have been identified). Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to inform the relevant personnel when the noise or vibration goal has been exceeded so that additional management measures may be implemented.	M
Individual briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project.	IB

Measure	Description	Abbreviation[1]
Letter box drops	For each Sydney Metro project, a newsletter is produced and distributed to the local community via letterbox drop and the project mailing list. These newsletters provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage and inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on the community. Content and newsletter length is determined on a project-by-project basis. Most projects distribute notifications on a monthly basis. Each newsletter is graphically designed within a branded template	LB
Project specific respite offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact.	RO
Phone calls and emails	Phone calls and/or emails detailing relevant information would be made to identified/affected stakeholders within 7 days of proposed work. Phone calls and/or emails provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.	PC
Specific notifications	Specific notifications would be letterbox dropped or hand distributed to identified stakeholders no later than 7 days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications, or to advertise unscheduled works	SN

The CNVS defines how and when 'additional mitigation measures' are applied to airborne noise impacts, ground-borne noise impacts and potential human comfort vibration impacts. The approach for each is shown in **Table 43**, **Table 44** and **Table 45**, respectively.

The airborne noise mitigation requirements in the CNVS are defined by the predicted exceedance of the NML. Ground-borne noise and vibration mitigation requirements are defined by the predicted exceedance of the management or maximum levels.

Table 43 Additional Mitigation Measures – Airborne Construction Noise

Time Period		Mitigation Measure			
		Predicted $L_{Aeq(15minute)}$ Noise Level above NML			
		0 to 10 dB	10 to 20 dB	20 to 30 dB	>30 dB
Standard	Mon-Fri (7am - 6pm)	-	LB	LB, M, SN	LB, M, SN
	Sat (8am - 1pm)				
	Sun/Pub Hol. (Nil)				
OOHW Period 1	Mon-Fri (6pm - 10pm)	LB	LB, M	LB, M, SN, RO	LB, M, SN, RO, IB, PC, RO
	Sat (1pm - 10pm)				
	Sun/Pub Hol. (8am - 6pm)				
OOHW Period 2	Mon-Fri (10pm - 7am)	LB	LB, M, SN, RO	LB, M, SN, RO, IB, PC, RO, AA	LB, M, SN, RO, IB, PC, RO, AA
	Sat (10pm - 8am)				
	Sun/Pub Hol. (6pm - 7am)				

Note: The following abbreviations are used: Alternative accommodation (AA), Monitoring (M), Individual briefings (IB), Letter box drops (LB), Project specific respite offer (RO), Phone calls (PC), Specific notifications (SN). See **Table 42** for descriptions of the measures.

Table 44 Additional Mitigation Measures – Ground-borne Noise

Time Period		Mitigation Measure		
		Predicted $L_{Aeq(15minute)}$ Noise Level above NML		
		0 to 10 dB	10 to 20 dBA	>20 dBA
Standard	Mon-Fri (7am - 6pm)	No NML for GBN during standard hours		
	Sat (8am - 1pm)			
	Sun/Pub Hol. (Nil)			
OOHW Period 1	Mon-Fri (6pm - 10pm)	LB	LB, M, SN	LB, M, SN, IB, PC, RO
	Sat (1pm - 10pm)			
	Sun/Pub Hol. (8am - 6pm)			
OOHW Period 2	Mon-Fri (10pm - 7am)	LB, M, SN	LB, M, SN, IB, PC, RO, AA	LB, M, SN, IB, PC, RO, AA
	Sat (10pm - 8am)			
	Sun/Pub Hol. (6pm - 7am)			

Note: See **Table 42** for descriptions of the measures.

Table 45 Additional Mitigation Measures – Human Comfort Vibration

Time Period		Mitigation Measure
		Predicted Vibration Levels Exceed Maximum Levels
Standard	Mon-Fri (7am - 6pm)	LB, M, RO
	Sat (8am - 1pm)	
	Sun/Pub Hol. (Nil)	
OOHW Period 1 (Evening)	Mon-Fri (6pm - 10pm)	LB, M, IB, PC, RO, SN
	Sat (1pm - 10pm)	
	Sun/Pub Hol. (8am - 6pm)	
OOHW Period 2 (Night)	Mon-Fri (10pm - 7am)	LB, M, IB, PC, RO, SN, AA
	Sat (10pm - 8am)	
	Sun/Pub Hol. (6pm - 7am)	

Note: See **Table 42** for descriptions of the measures.

The specific 'additional noise mitigation' requirements would be determined at a later stage in Detailed and General Construction Noise and Vibration Impact Statements when detailed construction data is available.

6.2.3 Construction Noise and Vibration Impact Statements

The contractor engaged to construct the proposal would complete site specific Detailed Construction Noise and Vibration Impact Statements (DNVIS) and General Construction Noise and Vibration Impact Statements (GNVIS) in accordance with the Sydney Metro CNVS for all work outside Standard Construction Hours likely to exceed the relevant NMLs, activities likely to result in Highly Noise Affected receivers and/or activities likely to generate vibration levels at receivers which exceed the relevant criteria.

- **DNVIS** – these are detailed quantitative assessments undertaken by contractors when they have a better understanding of the exact equipment list and construction methodology to be used in carrying out their work. They are typically focused on specific activities or locations and consider work carried out inside and outside of Standard Construction Hours. Work described in a DNVIS cannot proceed until it is approved by an Acoustic Advisor appointed under an SSI approval or other delegate approved by Sydney Metro.
- **GNVIS** – these are secondary assessments that have the same purpose as a DNVIS except that the assessment process is simplified. Work described in a GNVIS cannot proceed until the GNVIS is approved by Sydney Metro.

The DNVIS and/or GNVIS assessments would be completed prior to the work starting and would assess the potential impacts at nearby receivers and determine appropriate measures to minimise the impacts as far as practicable.

The mitigation and management measures would be determined based on the magnitude and duration of the predicted impacts and would be consistent with the 'standard' and 'additional mitigation measures' defined in the Sydney Metro CNVS, or any relevant conditions of approval.

6.3 Project Specific Construction Mitigation Measures

The revised environmental mitigation measures included in the *Sydney Metro West Westmead to The Bays and Sydney CBD – Submissions Report* (Sydney Metro, 2020b) that would be applicable to the proposal are presented in **Table 46**.

These would be supplemented by mitigation measures detailed in Chapter 23 (Synthesis of the Environmental Impact Statement) of the Environmental Impact Statement with respect to cumulative impacts.

The Sydney Metro Overarching Community Communications Strategy (OCCS) (Appendix B of the Environmental Impact Statement) provides a framework for communication and engagement during construction on Sydney Metro projects and will be applicable to the proposal. The OCCS requires Community Communication Strategies to be developed that include a process for managing potential environmental issues during construction and outlining tailored mitigation measures to address the site specific needs of the community, stakeholders and businesses that would incorporate mitigation measures from the planning approval process.

Such measures relating to noise and vibration would include early engagement with neighbouring stakeholders and a process to respond to complaints. The OCCS and Community Communication Strategies are supported by a Construction Complaints Management System that outlines the framework for managing complaints, enquiries and escalation processes throughout the construction of the proposal. Together these documents and processes would ensure feedback from stakeholders would be taken into account in the implementation of noise and vibration mitigation measures.

Table 46 Summary of Potential Specific Construction Noise and Vibration Mitigation Measures

ID	Impact	Mitigation measure	Applicable Location(s)
NV01	Community preference for noise mitigation and management	Where justified by the application of the *Sydney Metro Construction Noise and Vibration Standard*, further engagement and consultation would be carried out in accordance with the Sydney Metro Overarching Community Consultation Strategy with: • The affected communities to understand their preferences for mitigation and management measures. • 'Other sensitive' receivers such as schools, medical facilities, places of worship or theatres to understand periods in which they are more sensitive to impacts. Based on this consultation, appropriate mitigation and management options would be considered and implemented where feasible and reasonable to minimise the impacts.	All
NV02	Alternative construction methodologies	Alternative construction methodologies and measures that minimise noise and vibration levels during noise intensive work would be investigated and implemented where feasible and reasonable. This would include consideration of: • The use of hydraulic concrete shears in lieu of hammers/rock breakers • Sequencing work to shield noise sensitive receivers by retaining building wall elements • Locating demolition load out areas away from the nearby noise sensitive receivers • Providing respite periods to minimise impacts from prolonged periods of noise intensive work • Minimising structural-borne noise to adjacent buildings including separating the structural connection prior to demolition through saw-cutting and propping, using hand held splitters and pulverisers or hand demolition • Installing sound barrier screening to scaffolding facing noise sensitive neighbours • Using portable noise barriers around particularly noisy equipment, such as concrete saws • Modifying demolition work sequencing / hours to minimise impacts during peak pedestrian times and / or adjoining neighbour outdoor activity periods. These measures could provide between 5 to 10 dB noise benefit, depending on the alternative approach(es) used.	All
NV03	Construction noise – respite periods	Appropriate respite would be provided to affected receivers in accordance with the *Sydney Metro Construction Noise and Vibration Standard*. This would include consideration of impacts from utility and power supply work when determining appropriate respite periods for affected receivers. When determining appropriate respite, the need to efficiently undertake construction would be balanced against the communities' preferred noise and vibration management approach.	All
NV04	Construction noise – out of hours work	The use of noise intensive equipment at construction sites with 'moderate' and 'high' out-of-hours noise management level exceedances would be scheduled for standard construction hours, where feasible and reasonable. Where this is not feasible and reasonable, the work would be undertaken as early as possible in each work shift.	All
NV05	Night-time noise impacts	Where appropriate, air brake silencers would be used on heavy vehicles that access construction sites multiple times per night or over multiple nights.	All
NV06	Sleep disturbance impacts from heavy vehicles	Perimeter site hoarding would be designed with consideration of on-site heavy vehicle movements with the aim of minimising sleep disturbance impacts.	All

ID	Impact	Mitigation measure	Applicable Location(s)
NV07	Noise emissions from equipment	Long term construction site support equipment and machinery would be low noise emitting and suitable for use in residential areas, where feasible and reasonable. Examples include: • Low noise water pumps for use in water treatment facilities • Low noise generators and compressors • Low noise air conditioner units for use of amenities buildings.	All
NV08	Acoustic sheds	Where acoustic sheds are installed, the internal lining and construction materials would be determined during later design stages to ensure appropriate attenuation is provided. The design of sheds would likely include the following considerations: • All significant noise producing equipment that would be used during the night-time would be inside the shed, where feasible and reasonable • Noise generating ventilation systems such as compressors, scrubbers, etc, would also be inside the shed and external air intake/discharge ports would be appropriately acoustically treated • Acoustic shed doors would be kept closed during the night-time period, where feasible and reasonable. Where night-time vehicle access is required, the doors would be designed and constructed to minimise noise breakout. Acoustic sheds are expected to provide around 15 to 20 dB noise benefit.	All
NV09	Ground-borne noise	Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. This may require implementation of less ground-borne noise and less vibration intensive alternative construction methodologies.	All
NV10	Ground-borne noise – cross passages	The proximity of cross passages to nearby receivers and the corresponding construction ground-borne noise and vibration impacts during the excavation work would be considered when determining locations. Relocation of cross passages to be further away from sensitive receivers to mitigate potential construction impacts would be considered, where feasible and reasonable.	Metro rail tunnels
NV11	Ground-borne noise – underground rockbreaking	Activity specific Detailed and/or General Construction Noise and Vibration Impact Statements (in accordance with the requirements of the *Construction Noise and Vibration Standard*) would be developed for rockbreaking in the tunnel and at cross passages, specifically addressing the activity where it is required between 10pm-7am.	Metro rail tunnels
NV12	Construction traffic noise	Further assessment of construction traffic would be completed during detailed design, including consideration of the potential for exceedances of the *NSW Road Noise Policy* base criteria (where greater than 2.0 dB increases are predicted). The potential impacts would be managed using the following approaches, where feasible and reasonable: • On-site spoil storage capacity would be maximised to reduce the need for truck movements during sensitive times • Vehicle movements would be redirected away from sensitive receiver areas and scheduled during less sensitive times • The speed of vehicles would be limited and the use of engine compression brakes would be avoided • Heavy vehicles would not be permitted to idle near sensitive receivers.	All
NV13	Construction vibration	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure (in consultation with a structural engineer) and vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.	All

ID	Impact	Mitigation measure	Applicable Location(s)
NV14	Building condition surveys – construction vibration	Condition surveys of buildings and structures near to the tunnel and excavations would be undertaken prior to the commencement of excavation at each site, where appropriate. For heritage buildings and structures the surveys would consider the heritage values of the structure in consultation with a heritage specialist.	All
NV15	Cumulative construction noise impacts	The likelihood of cumulative construction noise impacts would be reviewed during detailed design when detailed construction schedules are available. Co-ordination would occur between potentially interacting projects to minimise concurrent or consecutive work in the same areas, where possible. Specific mitigation strategies would be developed to manage impacts. Depending on the nature of the impact, this could involve adjustments to construction program or activities of Sydney Metro West or of other construction projects.	All

The above measures are expected to control the potential impacts from the proposal as far as practicable. Residual impacts are, however, expected to remain, particularly when noise or vibration intensive activities are being completed near to sensitive receivers. Residual impacts would be evaluated further during later design stages and would be mitigated using the processes defined in the CNVS.

7 Conclusion

Noise and vibration impacts from work at the proposed construction sites in the three study areas have been assessed, together with impacts from tunnelling, construction road traffic and utility work. The potential cumulative impacts from concurrent and consecutive work of the proposal and other major interfacing projects have also been identified.

Consistent with other major infrastructure projects in suburban/urban areas, noise impacts during construction are inevitable, particularly where work requires the use of noise intensive equipment near to sensitive receivers.

The assessment identifies that mitigation measures are required to be considered to minimise the potential noise and vibration impacts. Several mitigation strategies have been recommended with reference to the *Interim Construction Noise Guideline* and the *Sydney Metro Construction Noise and Vibration Standard*, as required by the *Sydney Metro Construction Environmental Management Framework*.

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