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Sydney Metro – Western Sydney Airport

Technical Paper 2
Noise and vibration

Sydney Metro - Western Sydney Airport

Technical Paper 2: Noise and vibration

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Glossary and terms of abbreviation

Term	Definition
A	
ANL	Amenity noise level
AS	Australian Standard
AVTG	Assessing Vibration: a Technical Guideline
B	
BS	British Standard
C	
CEMF	Construction Environmental Management Framework
CNVMP	Construction Noise and Vibration Management Plan
CNVS	Sydney Metro Construction Noise and Vibration Standard
D	
dB	Decibel
dBA	Decibel (A-weighted)
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
DEFRA	Department for Environment, Food and Rural Affairs (United Kingdom)
DIN 4150	German Standard DIN 4150-3: Structural vibration – Effects of vibration on structures
DPIE	Department of Planning, Industry and Environment
E	
ECRL	Epping Chatswood Rail Link
EMU	Electric Multiple Unit (electric train)
EPA	Environment Protection Authority
eVDV	Estimated vibration dose value
H	
HVAC	Heating, ventilation, and air-conditioning
I	
ICNG	Interim Construction Noise Guideline
ISO	International Organization for Standardization
L	
LGAs	Local Government Areas
L_1	Statistical noise descriptor: noise level not exceeded for 1% of the measurement period. Typically used to represent the maximum noise level, excluding a few non-typical extraneous events.
L_{10}	Statistical noise descriptor: noise level not exceeded for 10% of the measurement period. Typically used to represent the upper noise level.
L_{90}	Statistical noise descriptor: noise level not exceeded for 90% of the measurement period. Typically used to represent the background noise level.
L_{eq}	Equivalent noise level: equivalent energy averaged noise level which over a defined time period would contain the same energy as the time varying signal over the same time period.
L_{max}	Maximum noise level: maximum rms noise level.

Term	Definition
M	
MF	Maintenance facility
N	
NCA	Noise catchment area
NML	Noise Management Level
NPfI	NSW Noise Policy for Industry
NSW	New South Wales
O	
ONVMP	Operational Noise and Vibration Management Plan
P	
PA	Public Address
PPV	Peak particle velocity
PNTL	Project noise trigger level
R	
RBL	Rating Background Level (as defined in the NPfI)
RING	Rail Infrastructure Noise Guideline
RIVAS	Railway Induced Vibration Abatement Solutions: a joint research and development project carried out in Europe
RMS	Roads and Maritime Services
RNP	Road Noise Policy
S	
SEARs	Secretary’s Environmental Assessment Requirements
SWL	Sound power level
T	
TBM	Tunnel boring machine
TfNSW CNVS	Transport for NSW Construction Noise and Vibration Strategy
V	
VC	Vibration Criterion
VDV	Vibration dose value

Executive Summary

Project Overview

The *Greater Sydney Region Plan* (Greater Sydney Commission, 2018a) sets the vision and strategy for Greater Sydney to become a global metropolis of three unique and connected cities; the Eastern Harbour City, the Central River City and the Western Parkland City. The Western Parkland City incorporates the future Western Sydney International (Nancy-Bird Walton) Airport (hereafter referred to as Western Sydney International) and Western Sydney Aerotropolis (hereafter referred to as the Aerotropolis).

Sydney Metro Greater West (the project) (see Figure 1-1) is identified in the *Greater Sydney Region Plan* as a key element to delivering an integrated transport system for the Western Parkland City. The project would be located within the Penrith and Liverpool Local Government Areas (LGAs) and would involve the construction and operation of a new metro railway line around 23 kilometres in length between the T1 Western Line at St Marys in the north and the Aerotropolis in the south. This would include a section of the alignment which passes through and provides access to Western Sydney International.

The project is characterised into components that are located outside Western Sydney International (off-airport) and components that are located within Western Sydney International (on-airport), to align with their different planning approval pathways required under State and Commonwealth legislation.

Key operational features of the project are shown on Figure 1-2 and would include:

- around 4.3 kilometres of twin rail tunnels (generally located side by side) between St Marys (the northern extent of the project) and Orchard Hills
- a cut-and-cover tunnel (around 350 metres long)
- around 10 kilometres of rail alignment between Orchard Hills and Western Sydney International, consisting of a combination of viaduct and surface rail alignment
- around two kilometres of surface rail alignment within Western Sydney International
- around 3.3 kilometres of twin rail tunnels (including tunnel portal) within Western Sydney International
- around three kilometres of twin rail tunnels between Western Sydney International and the Aerotropolis Core
- six new metro stations including four new metro stations outside Western Sydney International and two new metro stations within the Western Sydney International site
- grade separation of the track alignment at key locations
- modifications to the existing Sydney Trains station and rail infrastructure at St Marys
- a stabling and maintenance facility and operational control centre
- new active transport, commuter car parking facilities, public transport infrastructure, road infrastructure and landscaping as part of the station precincts.

This noise and vibration impact assessment

The Secretary's Environmental Assessment Requirements (SEARs) issued July 2020 by the NSW Department of Planning, Industry and Environment (DPIE) requires a noise and vibration impact assessment to support the Environmental Impact Statement being prepared for the project. This technical paper addresses the relevant noise and vibration impact requirements in the SEARs, and Commonwealth requirements. It provides an assessment of the (airborne and ground-borne) noise and vibration impacts generated by the construction of the project, and the operational impacts from the road, rail, stations, and ancillary facilities associated with the project. Appropriate performance outcomes and mitigation measures are identified, as required.

Construction noise impacts generated by other major projects occurring in the area are also investigated, to capture the cumulative impacts that may result from construction of the project occurring simultaneously alongside other projects.

Future noise environment

Western Sydney is a fast-growing area due to heavy economic investment. Projects either currently approved or planned, such as the Western Sydney International and the future M12 Motorway project, together with this project, will substantially change (increase) the existing noise environment.

The future noise environment will consist of noise generated from the construction of infrastructure (including transport) and private and residential development, increased operational transport infrastructure (road and rail), and eventually high levels of aircraft noise during the day, evening and night, and higher density residential areas.

The effect of an increased background noise would result in any future acoustic assessment that relies on background noise levels to set noise criteria to result in higher noise criteria than currently adopted for this assessment. The assessment of noise impacts in this assessment, while relevant, would be considered conservative in the near future. As such, when considering feasible and reasonable mitigation of noise impacts it is important to consider what the future noise environment would be like, and how this might affect the noise mitigation approach.

Potential construction impacts

Predictions indicate that airborne construction noise levels could significantly impact the closest receivers. These impacts include exceedance of noise management levels, highly noise affected receivers, and in some cases, sleep disturbance. The most affected clusters of receivers are located around the St Marys construction site and Orchard Hills tunnel portal.

Ground-borne construction noise predictions indicate that sensitive receivers, grouped above the St Marys to Orchard Hills tunnel and above the Western Sydney International to Bringelly tunnel, may experience significant exceedances of management targets. These receivers would be located within a 35 metre sideline distance of the tunnels beneath. Additionally, some (heritage, residential, and non-residential) receivers located within and adjacent to the construction footprint may be at risk of exceeding cosmetic vibration damage screening levels.

Potential noise impacts from construction traffic on public roads has been identified along Kent Road (south of the M4 Western Motorway) and Badgerys Creek Road (north of The Northern Road).

Exceedances of noise management levels, highly noise affected receivers, potential sleep disturbance and awakening, construction traffic noise management levels, ground-borne noise management levels, and cosmetic damage and human comfort vibration screening criteria will be managed according to the *Construction Noise and Vibration Standard* (Sydney Metro, 2020) (CNVS)

Potential operational impacts

Airborne noise from the operational rail corridor is predicted to meet the noise trigger levels outlined in the NSW Rail Infrastructure Noise Guideline, without the need for any specific noise mitigation. There may be some controls required for future development.

Operational noise and vibration impacts associated with the stabling and maintenance facility located at Orchard Hills have been assessed. Noise impacts have been assessed for several scenarios under worst case meteorological impacts. Exceedances of relevant noise trigger levels are predicted at the closest receivers in Orchard Hills and may require mitigation. Sleep disturbance impacts are not predicted at any sensitive receivers as a result of the stabling and maintenance facility.

Noise from operation of ancillary facilities such as stations and service facilities has been assessed, with a minor exceedance for Orchard Hills Station identified.

Operational road noise impacts have been assessed to consider the impacts from with additional traffic flows on public roads, and new internal access roads. Minor exceedances of traffic noise criteria are predicted along multiple existing arterial and sub-arterial roads. Due to the minor nature of predicted traffic noise impacts and the current operational state of these roads, further mitigation is not considered to be reasonable or feasible.

Ground-borne noise resulting from rail operation within the tunnels can achieve the performance outcomes with standard attenuation rail fixings and high attenuation rail fixings for some small sections of rail track. Ground-borne noise for all future buildings within Western Sydney International is likely to be suitably managed with standard attenuation rail fixings.

Mitigation

Through the implementation of standard mitigation measures, as outlined in the Sydney Metro Construction Noise and Vibration Standard (CNVS), and specific mitigation measures as outlined in Chapter 7 of this technical paper, the noise and vibration performance outcomes for the project can be achieved.

1 Introduction

1.1 Project context and overview

The Greater Sydney Region Plan (Greater Sydney Commission, 2018a) sets the vision and strategy for Greater Sydney to become a global metropolis of three unique and connected cities; the Eastern Harbour City, the Central River City and the Western Parkland City. The Western Parkland City incorporates the future Western Sydney International (Nancy-Bird Walton) Airport (hereafter referred to as Western Sydney International) and Western Sydney Aerotropolis (hereafter referred to as the Aerotropolis).

Sydney Metro – Western Sydney Airport (the project) (see Figure 1 1) is identified in the Greater Sydney Region Plan as a key element to delivering an integrated transport system for the Western Parkland City. The project would be located within the Penrith and Liverpool Local Government Areas (LGAs) and would involve the construction and operation of a new metro railway line around 23 kilometres in length between the T1 Western Line at St Marys in the north and the Aerotropolis in the south. This would include a section of the alignment which passes through and provides access to Western Sydney International. The project is characterised into components that are located outside Western Sydney International (off-airport) and components that are located within Western Sydney International (on-airport), to align with their different planning approval pathways required under State and Commonwealth legislation.

1.2 Key Project features

Key operational features of the project are shown on Figure 1-2 and would include:

- around 4.3 kilometres of twin rail tunnels (generally located side by side) between St Marys (the northern extent of the project) and Orchard Hills
- a cut-and-cover tunnel around 350 metres long (including tunnel portal), transitioning to an in-cutting rail alignment south of the M4 Western Motorway at Orchard Hills
- around 10 kilometres of rail alignment between Orchard Hills and Western Sydney International, consisting of a combination of viaduct and surface rail alignment
- around two kilometres of surface rail alignment within Western Sydney International
- around 3.3 kilometres of twin rail tunnels (including tunnel portal) within Western Sydney International
- around three kilometres of twin rail tunnels between Western Sydney International and the Aerotropolis Core
- six new metro stations:
    - four off-airport stations:
        - St Marys (providing interchange with the T1 Western Line)
        - Orchard Hills
        - Luddenham Road
        - Aerotropolis Core
    - two on-airport stations:
        - Airport Business Park
        - Airport Terminal
- grade separation of the track alignment at key locations including:
    - where the alignment interfaces with existing infrastructure such as the Great Western Highway, M4 Western Motorway, Lansdowne Road, Patons Lane, the Warragamba to

Prospect Water Supply Pipelines (the pipelines), Luddenham Road, the future M12 Motorway project, Elizabeth Drive, Derwent Road and Badgerys Creek Road

  - crossings of Blaxland Creek, Cosgroves Creek, Badgerys Creek and other small waterways to provide flood immunity for the project

- modifications to the existing Sydney Trains station and rail infrastructure at St Marys (where required) to support interchange and customer transfer between the new metro station and the T1 Western Line
- a stabling and maintenance facility and operational control centre located to the south of Blaxland Creek and east of the proposed metro track
- new pedestrian, cycle, park-and-ride and kiss-and-ride facilities, public transport interchange infrastructure, road infrastructure and landscaping as part of the station precincts.

The project would also include:

- turnback track arrangements (turnbacks) at St Marys and Aerotropolis Core to allow trains to turn back and run in the opposite direction
- additional track stubs to the east of St Marys Station and south of the Aerotropolis Core Station to allow for potential future extension of the line to the north and south respectively without impacting future metro operations
- an integrated tunnel ventilation system including services facilities at Claremont Meadows and at Bringelly
- all operational systems and infrastructure such as crossovers, rail sidings, signalling, communications, overhead wiring, power supply, lighting, fencing, security and access tracks/paths
- retaining walls at required locations along the alignment
- environmental protection measures such as noise barriers (if required), on-site water detention, water quality treatment basins and other drainage works.

Off-airport project components

The off-airport components of the project would include the track alignment and associated operational systems and infrastructure north and south of Western Sydney International, four metro stations, the stabling and maintenance facility, two service facilities and a tunnel portal.

On-airport project components

The on-airport components of the project would include the track alignment and associated operational systems and infrastructure within Western Sydney International, two metro stations and a tunnel portal.

The key project features and the design development process are described in more detail in Chapter 7 (Project description – operation) of the Environmental Impact Statement.

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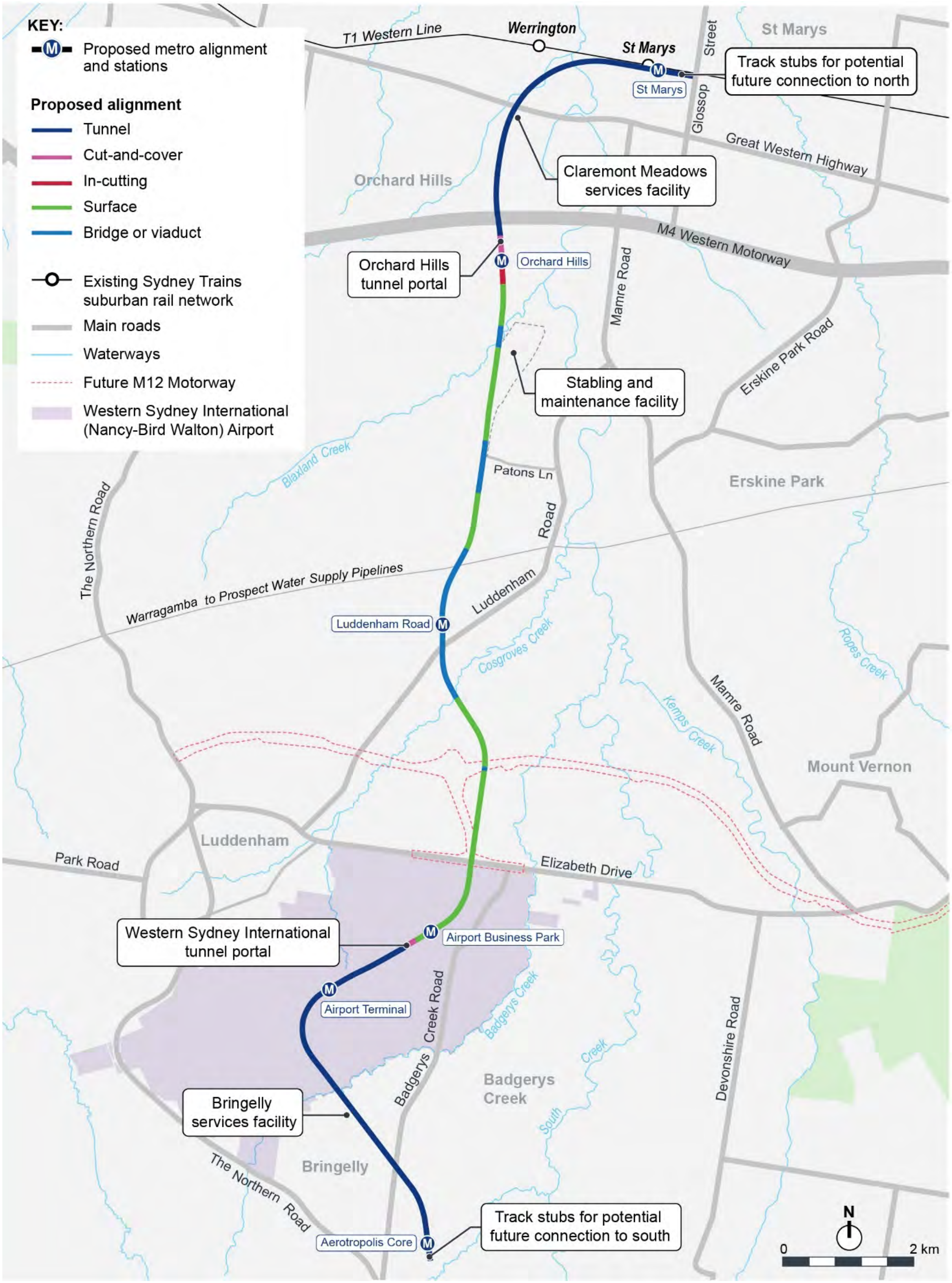


Figure 1-1 **Project overview and key features**

1.3 Project construction

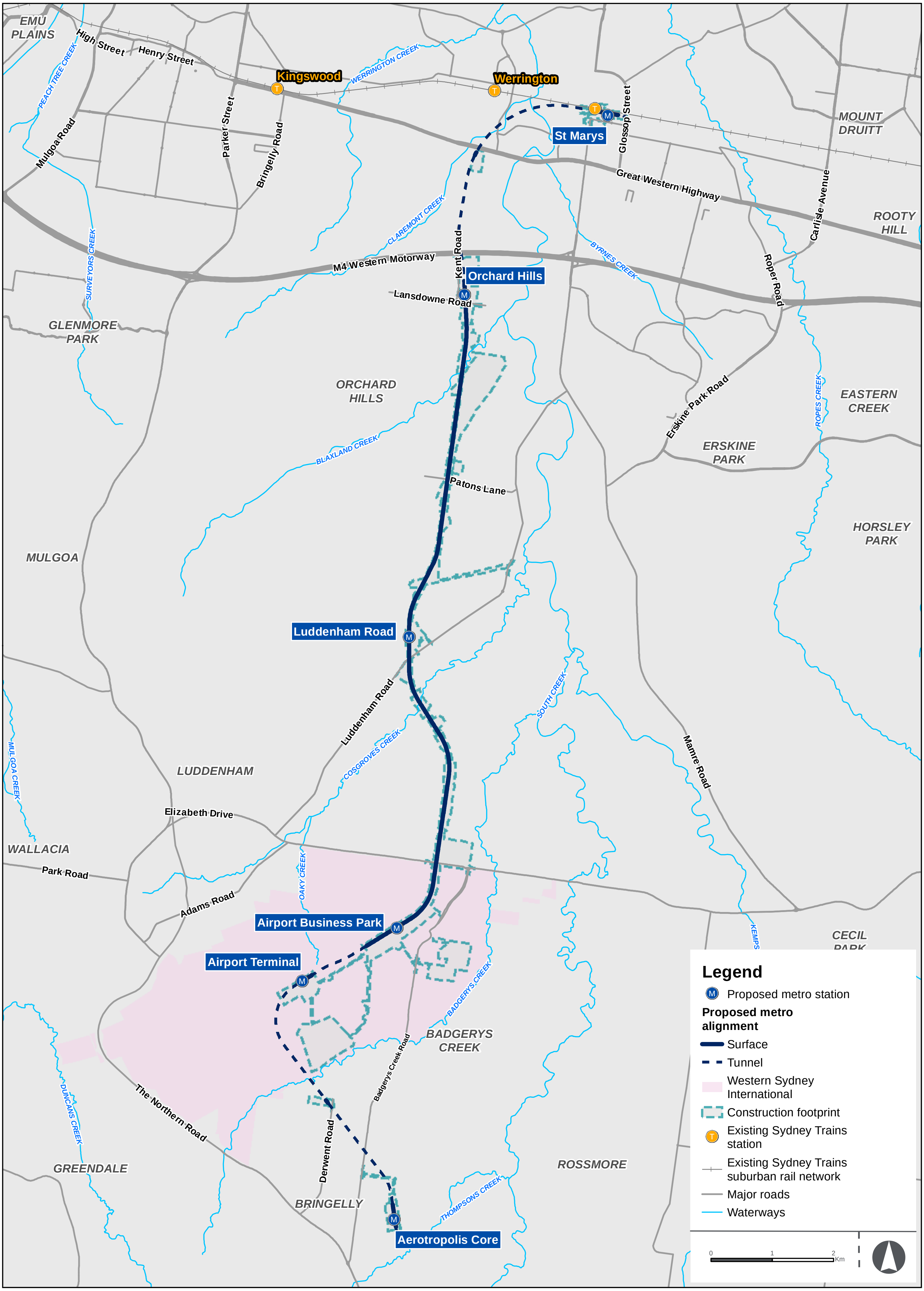
Construction of the project would involve:

- enabling works
- main construction works, including:
  - tunnelling and associated works
  - corridor and associated works
  - stations and associated works
  - ancillary facilities and associated works
  - construction of ancillary infrastructure including the stabling and maintenance facility
- rail systems fitout
- finishing works and testing and commissioning.

These activities are described in more detail in Chapter 8 (Project description – construction) of the Environmental Impact Statement.

The construction footprint for the project is shown on Figure 1-2.

Construction of the project is expected to commence in 2021, subject to planning approval, and take around five years to complete. An overview of the construction program is provided in Chapter 8 (Project description – construction) of the Environmental Impact Statement.



Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Construction footprint overview

Figure 1-2

1.4 Purpose of this Technical Paper

This technical paper, Technical Paper 2: (Noise and Vibration), is one of a number of technical documents that forms part of the Environmental Impact Statement. The purpose of the technical paper is to provide a noise and vibration assessment which aims to address the requirements outlined in Section 1.4.1 and Section 1.4.2. An overview of the structure of this technical paper is provided in Section 1.5.

This technical paper specifically includes the following:

- noise monitoring and site surveys results
- construction noise and vibration assessment (including ground-borne noise)
- construction road traffic noise assessment.
- operational rail airborne noise assessment
- operational rail ground-borne noise and vibration assessment
- operational noise assessment for the stabling and maintenance facility
- operational noise assessment for the metro stations
- operational road traffic noise assessment for the new and upgraded roads associated with the new metro stations

1.4.1 Assessment Requirements

The Secretary's Environmental Assessment Requirements (SEARs) relating to noise and vibration, and where these requirements are addressed in this technical paper, are outlined in Table 1-1.

The key issues and desired acoustic performance outcomes in relation to noise and vibration for the project are:

- construction noise and vibration (including airborne noise, ground-borne noise and blasting) is effectively managed to minimise adverse impacts on acoustic amenity
- increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community
- construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage.

Table 1-1 SEARs relevant to this assessment

SEARs requirements	Where addressed in this document
7. Noise and vibration	
1. Construction noise and vibration, including: a) commitments made in Section 8.3.3 of the Scoping Report; b) in accordance with relevant NSW noise and vibration guidelines; c) the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage)	Construction noise and vibration requirements are addressed in Chapter 4 of this technical paper (airborne noise, ground-borne noise and vibration, and construction traffic noise).
2. Demonstration that **blast impacts** can comply with the current guidelines, if blasting is required.	Blasting is not proposed to be undertaken, and therefore has not been addressed.

SEARs requirements	Where addressed in this document
3. **Operation noise and vibration**, including: a) commitments made in Section 8.3.3 of the Scoping Report b) in accordance with relevant NSW noise and vibration guidelines	Operational noise and vibration requirements are addressed in Chapter 5 of this technical paper (rail noise and vibration, road noise, and ancillary facility noise).

1.4.2 Commonwealth agency assessment requirements

The Minister for the Environment has advised that the on-airport aspects of the project would be assessed based on the provision of preliminary documentation. Further information was requested to guide the assessment of the on-airport components of the project. This information is included in Appendix J (EPBC Act Draft Environmental Impact Assessment of on-airport proposed action (EPBC 2019/8541)) of the Environmental Impact Statement and also addressed in this technical paper.

1.5 Structure of report

This technical paper is broadly structured in two parts, covering construction impacts and operational noise and vibration impacts.

Within each impact assessment section, specific items related to either construction or operation are addressed with a brief summary, an outline of the relevant noise assessment guidelines, noise management levels (NML) and criteria, the assessment methodology and the assessment of impacts and identified mitigation measures to manage these impacts.

Relevant noise mapping and detailed tabulated results are provided as appendices.

The structure of the technical paper is as follows:

- Chapter 1 – Introduction – introduces the project
- Chapter 2 – Legislative and policy context – describes the legislative and policy context for the assessment and relevant guidelines
- Chapter 3 – Existing environment – describes the existing noise environment of the area and identifies sensitive receivers
- Chapter 4 – Assessment of construction impacts – describes the guidelines, methodology and assessment and predicted noise and vibration impacts generated by the construction of the project
- Chapter 5 – Assessment of operational impacts – describes the guidelines, methodology and assessment and predicted noise and vibration impacts generated by the operation of the project
- Chapter 6 – Cumulative impact – describes the potential cumulative impacts as a result of construction of the project and other significant construction projects in the locality
- Chapter 7 – Identified mitigation measures – describes the mitigation measures and performance outcomes relevant to the project
- Chapter 8 – Conclusion – overview of the key findings of the technical paper.

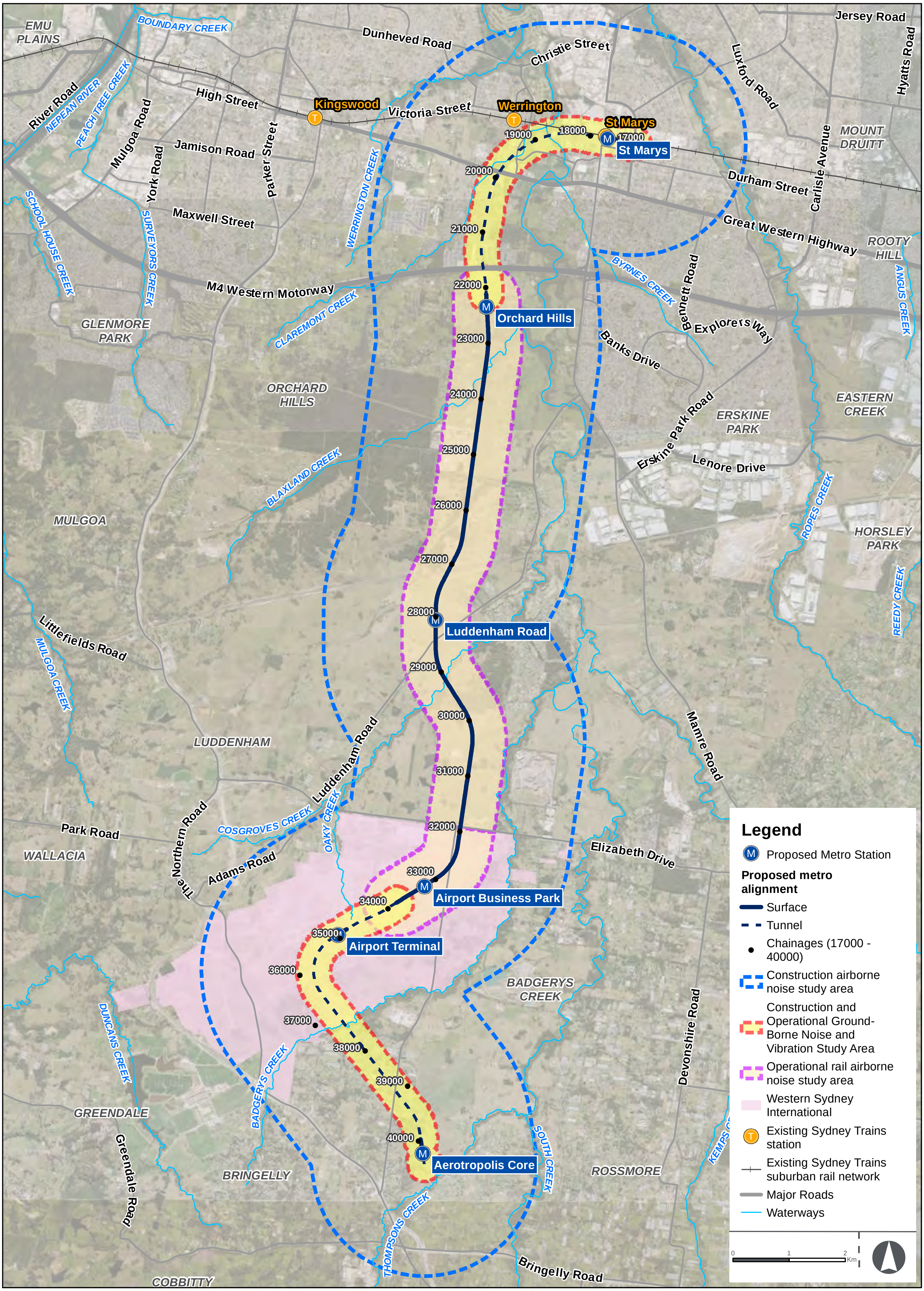
1.6 Study area

The project is located within the Penrith and Liverpool Local Government Areas (LGAs), between the T1 Western Line in the north and the Western Sydney Aerotropolis (Aerotropolis) in the south, via Western Sydney International. The project’s context and location are shown in Figure 1-1.

The study areas for this technical paper are defined by the assessment of each noise or vibration generating component of the project (e.g. construction noise, operational rail noise).

The study areas for each assessment are shown in Figure 1-3 and are outlined below in respect to the radius from the project alignment:

- construction assessment:
  - airborne noise 2,000 metres
  - ground-borne noise and vibration 300 metres
- operation assessment:
  - airborne noise 600 metres
  - ground-borne noise and vibration 300 metres.



Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Assessment Study Area

Figure 1-3

2 Legislative and policy context

The relevant legislation, policies and assessment guidelines for the noise and vibration assessment considered in the preparation of this technical paper and are listed in Table 2-1 and Table 2-2.

A full description of the legislation, policies and assessment guidelines and their relevance to the noise and vibration assessment are provided in the respective assessment chapters (refer to Chapters 4 and 5).

2.1 Off-airport assessment guidelines, standards, and policy

Table 2-1 provides a summary of the relevant off-airport guidelines, standards, and policy for the noise and vibration assessment.

Table 2-1 Off-airport assessment guidelines

Acoustic Aspect	Description	Assessment Guidelines
Airborne noise	Construction noise	Interim Construction Noise Guideline (DECCW, 2009) Sydney Metro Construction Noise and Vibration Standard (Sydney Metro, 2020)
	Construction traffic noise	*NSW Road Noise Policy* (DECCW, 2011) Sydney Metro Construction Noise and Vibration Standard (Sydney Metro, 2020)
	Sleep disturbance from construction noise (for work lasting more than 2 consecutive nights)	Interim Construction Noise Guideline (DECCW, 2009) *Noise Policy for Industry* (EPA, 2017) *NSW Road Noise Policy* (DECCW, 2011) Sydney Metro Construction Noise and Vibration Standard (Sydney Metro, 2020)
	Operational rail noise	Rail Infrastructure Noise Guideline (EPA, 2013)
	Operational road traffic noise	*NSW Road Noise Policy* (DECCW, 2011)
	Stations, ancillary facilities, and fixed plant operational noise	*Noise Policy for Industry* (EPA, 2017)
	Existing ambient and background noise levels	*Noise Policy for Industry* (EPA, 2017) Australian Standard AS 1055: Description and measurement of environmental noise
Ground-borne noise	Construction noise transmitted through the ground into a structure	Interim Construction Noise Guideline (DECCW, 2009)
	Operational rail noise transmitted through the ground into a structure	ISO 14837-1 2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance Assessing Vibration a technical guideline (DECC, 2006) Rail Infrastructure Noise Guideline (EPA, 2013)
Vibration	Construction vibration amenity impacts	Assessing Vibration a technical guideline (DECC, 2006)
	Construction vibration effect on structures (structural or cosmetic damage)	German Standard DIN 4150-3: Structural Vibration - effects of vibration on structures

Acoustic Aspect	Description	Assessment Guidelines
	Operational rail vibration	ISO 14837-1 2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance Assessing Vibration, a technical guideline (DECC, 2006) US FTA Manual (FTA, 2018)
Management	Mitigation and management of construction noise and vibration issues	Interim Construction Noise Guideline (DECCW, 2009). Sydney Metro Construction Noise and Vibration Standard (Sydney Metro, 2020) Noise Mitigation Guideline (RMS, 2015) Rail Infrastructure Noise Guideline (EPA, 2013) *Noise Policy for Industry* (EPA, 2017)

2.2 On-airport legislative and policy context

Table 2-2 provides a summary of the relevant on-airport legislation for the assessment of airborne noise impacts.

No specific on-airport legislation or guidelines are available for the assessment of ground-borne noise or vibration.

Table 2-2 On-airport legislation and assessment guidelines

Acoustic Aspect	Description	Legislation and assessment guidelines
Airborne noise	Noise from construction, road traffic, rail traffic, and airport operations	*Airports Act (1996)* Airports (Environment Protection) Regulations (1997)
Ground-borne noise	-	No specific assessment guidance available, refer to off-airport guidelines
Vibration	-	No specific assessment guidance available, refer to off-airport guidelines

3 Existing environment

The prevailing background (existing) noise levels in the study area were determined through a combination of unattended and operator attended noise monitoring in accordance with the Australian Standard 1055:1997 – Acoustics – Description and Measurement of Environmental Noise (AS 1055) and the NSW *Noise Policy for Industry* (EPA,2017) (NPfI).

3.1 Existing noise environment (off-airport)

The existing noise environment surrounding the project can be grouped into two separate noise environments, north and south of the M4 Western Motorway.

The noise environment north of M4 Western Motorway is typical of a suburban landscape. The background noise environment is characterised by road traffic noise as well as pockets of industry and commerce focused around St Marys. Evening background noise levels typically consist of noise generated by the natural environment and human activity.

The noise environment south of M4 Western Motorway is characteristic of a semi-rural landscape. The background noise environment is most influenced by natural sounds, with most of the area having little road traffic noise, and generally characterised by moderately low background noise levels. Traffic along sub-arterial roads such as Luddenham Road and Elizabeth Drive, and arterial roads such as The Northern Road, are the main noise sources within this area.

3.1.1 Sensitive receivers

The project has the potential to adversely impact nearby properties that are considered sensitive to noise and vibration.

The off-airport sensitive receivers broadly consist of those located in the residential areas of St Marys and Claremont Meadows, north of the M4 Western Motorway, and receivers located in the semi-rural areas of Orchard Hills, Luddenham, Badgerys Creek and Bringelly, south of the M4 Western Motorway.

Receivers potentially sensitive to both noise and vibration have been categorised based on their use, as defined in the NPfI (i.e. residential, non-residential, commercial and industrial), and have been identified in the surrounding area.

Individual sensitive receiver locations are identified in Appendix A.1.

3.1.2 Noise Catchment Areas (NCA)

Noise Catchment Areas (NCAs) are groups of sensitive receivers that are likely to experience similar impacts from the project. Predicted impacts for each NCA are considered to represent typical noise and vibration impacts at each individual receiver within that NCA. Table 3-1 describes the location of the NCAs adopted for the project which are also presented in Figure 3-1.

The NCAs are delineated by landmark features, such as roads, to encompass groupings of houses with similar background noise environments. These NCAs contain sensitive receivers approximately two kilometres around the project.

Table 3-1 Noise Catchment Areas (NCAs)

NCA	Indicative number of receiver buildings assessed in NCA	Description
NCA01	765	Medium density single and multi-storey residential dwellings north of the project at St Marys. Ambient noise conditions are dominated by road and rail traffic noise from Glossop Street and Forrester Road, and the existing Sydney Trains suburban rail network. Includes commercial and industrial receivers along Kurrajong Road and Glossop Street.
NCA02	41	Predominantly industrial and commercial receivers located to the northwest of St Marys Station and the project.

NCA	Indicative number of receiver buildings assessed in NCA	Description
NCA03	1385	Predominantly medium density single and multi-storey residential dwellings, with commercial receivers located along Queen Street. Ambient noise conditions are dominated by traffic along the existing heavy rail line through St Marys Station, and traffic along Queen Street.
NCA04	26	Medium density residential dwellings are grouped around Werrington Station to the north of the project, with Wollemi College and Cobham Detention to the west.
NCA05	1051	Predominantly medium density single and multi-storey residential dwellings. Ambient noise conditions are dominated by traffic along Mamre Road.
NCA06	1315	Predominantly medium density residential dwellings to the east of Gipps Street and south of Caddens Road. Ambient noise conditions are dominated by traffic along M4 Western Motorway and Gipps Street.
NCA07	999	Predominantly medium density single-storey residential dwellings, located to the east of the project. Ambient noise conditions are dominated by traffic along Mamre Road.
NCA08	229	Predominantly low density single storey residential dwellings. East of the project is mostly open land with scattered receivers along Samuel Marsden Road and Lansdowne Road. Ambient noise conditions are dominated by traffic along the M4 Western Motorway.
NCA09	68	Open farmland and a grouping of low density single storey residential dwellings within 1200 metres east of the project along Luddenham Road.
NCA10	378	Open farmland with low density single storey and multi-storey residential dwellings within the Twin Creeks area east of the project, and scattered residential dwellings along Luddenham Road.
NCA11	68	Predominantly Western Sydney International (on-airport) land. Low density residential dwellings along Lawson Road and Martin Road to the east of the project. Medium density residential dwellings at Luddenham to the west of the project.
NCA12	396	Predominantly scattered low density single-storey residential dwellings, located either side of the project. Ambient noise conditions are dominated by traffic along The Northern Road.

Residential noise sensitive receivers

The greatest density of residential receivers are located in St Marys and Claremont Meadows, at the northern end of the project, in medium-density residential dwellings. South of the M4 Western Motorway, residential receivers are typically semi-rural residential dwellings.

Residential dwellings located near the project are predominantly single-storey. The highest density grouping of residential receivers located near the project has been identified in St Marys along Philip Street.

Non-residential noise sensitive receivers

Non-residential noise sensitive receivers located within in the study area are primarily education, active recreation, and passive recreation receivers, with child care centres and a few places of worship. Non-residential noise sensitive receivers are mostly located north of the M4 Western Motorway, with a few active and passive recreation receivers located to the south.

Commercial and industrial noise sensitive receivers

Commercial and industrial buildings are not considered as noise sensitive receivers for operational rail or road traffic noise. However, for construction noise and vibration, commercial and industrial receivers are classified as being noise sensitive and have been assessed. Commercial and industrial areas are predominantly located in St Marys along Queen Street and to the west of Glossop Street and Forrester Road.

Vibration sensitive receivers

At sufficient levels, vibration can lead to cosmetic (and possibly structural) building damage as well as cause disturbance to occupants. Vibration can also affect sensitive structures, which could include heritage listed buildings. Table 3-2 outlines sensitive heritage structures identified which may be potentially impacted by the project. Table 3-2 does not include receivers proposed for demolition. The residential, non-residential, commercial and industrial receivers identified as noise sensitive receivers, may also be impacted by vibration generating equipment during construction of the project, or by ground-borne noise and vibration generated by operation of the rail.

Table 3-2 Identified heritage receivers

Heritage Receiver	Construction site	Listing	Significance	Approximate distance to construction footprint
St Marys Railway Station Group	St Marys	SHR 01249 RailCorp s170 SHI 4801036 Penrith LEP 2010 I282	State	Located within the construction footprint
Queen Street, St Marys, Post-War Commercial Building	St Marys	Potential heritage item	Local	Located immediately adjacent the construction footprint
St Marys Munitions Workers Housing	St Marys	Potential heritage item	Local	10 metres
Four Winds - Dwelling	Claremont Meadows services facility	Penrith LEP 2010	Local	270 metres
Brick House	Claremont Meadows services facility	Penrith LEP 2010	Local	300 metres
Warragamba to Prospect Water Supply Pipelines	Off-airport corridor	WaterNSW s170 Register	State	Located within the construction footprint
McGarvie-Smith Farm	Off-airport corridor	Penrith LEP 2010 I857	Local	0-300 metres

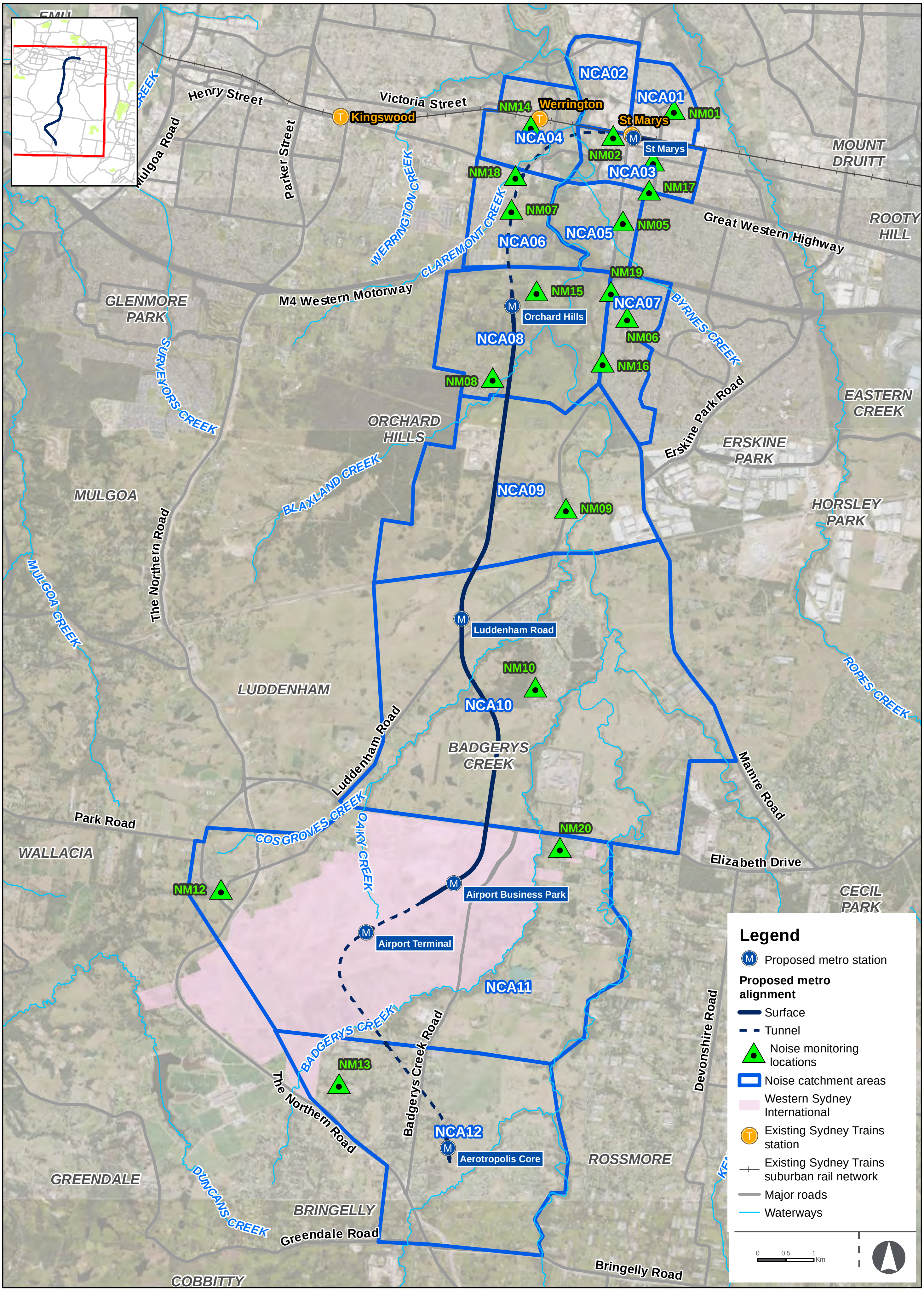
3.1.3 Background noise monitoring locations

Eighteen noise monitoring locations were used to characterise the existing noise environment in the areas surrounding the project and sensitive receivers potentially impacted by the project. Noise monitoring was undertaken at locations where site access was granted by the resident/occupant. The noise monitoring locations selected for the assessment were considered to be representative of the existing background noise environment in each NCA. The weather conditions at the time of monitoring were recorded by Bureau of Meteorology weather stations located at Penrith (Station ID: 67113) and Badgerys Creek (Station ID: 67108). The locations of the attended and unattended monitoring are presented in Table 3-3 and shown in Figure 3-1. Instrumentation and quality control of the deployed monitoring equipment is provided in Appendix A.2.

Table 3-3 Noise monitoring locations

Noise monitoring location	NCA	Start date	End date	Address
NM01	NCA01	27-02-20	09-03-20	12 Cedar Crescent, North St Marys
NM02	NCA03	18-02-20	25-02-20	47 Kalang Avenue, St Marys
NM03	NCA03	27-02-20	09-03-20	26 Champness Crescent, St Marys
NM04[1]	NCA10	-	-	-
NM05	NCA05	17-02-20	25-02-20	28 Mitchell Street, St Marys
NM06	NCA07	27-02-20	09-03-20	84 Shadlow Crescent, St Clair
NM07	NCA06	17-02-20	25-02-20	4 Powie Close, Claremont Meadows
NM08	NCA08	17-02-20	25-02-20	7 Bordeaux Place, Orchard Hills
NM09	NCA09	17-02-20	25-02-20	246 Luddenham Road, Orchard Hills
NM10	NCA10	17-02-20	25-02-20	27 Halmstad Boulevard, Luddenham
NM11[1]	NCA11	-	-	-
NM12	NCA11	17-02-20	25-02-20	5 Jamison Street, Luddenham
NM13	NCA12	27-02-20	09-03-20	80 Mersey Road, Bringelly
NM14	NCA04	27-02-20	09-03-20	33 Walker Street, Werrington
NM15	NCA08	17-02-20	25-02-20	68-74 Samuel Marsden Road, Orchard Hills
NM16	NCA07	17-02-20	25-02-20	68 Solander Drive, St Clair
NM17	NCA03	27-02-20	09-03-20	293 Great Western Highway, St Marys
NM18	NCA06	27-02-20	09-03-20	11 Dolphin Close, Claremont Meadows
NM19	NCA07	17-02-20	25-02-20	47 Kunipipi Street, St Clair
NM20	NCA11	27-02-20	09-03-20	25 Lawson Road, Badgerys Creek

(1) Noise monitoring not undertaken due to site access constraints



Sydney Metro – Western Sydney Airport

Noise catchment areas and noise monitoring locations

Figure 3-1

Indicative only, subject to design development

3.1.4 Unattended noise survey results

Unattended noise monitoring was carried out by M2A between 17th February 2020 and 9th March 2020.

The measured Rating Background Levels (RBLs) and ambient noise levels are summarised in Table 3-4 and a detailed daily plot of data is presented in Appendix A.3.

Table 3-4 Summary of unattended noise monitoring results

Location	Rating Background Level (RBL) dBA[1]			Ambient noise level dBA[1] $L_{eq\ 15\ minute}$		
	Day	Evening	Night	Day	Evening	Night
NM01	38	(41) 38[3]	(40) 38[3]	53	53	50
NM02	37	(40) 37[3]	36	55	59	51
NM03	38	32	31	50	41	46
NM04	-	-	-	-	-	-
NM05	40	(44) 40[3]	(44) 40[3]	54	51	50
NM06	42	(44) 42[3]	38	59	57	52
NM07	37	37	36	48	49	45
NM08	31	(32) 31[3]	30	52	48	40
NM09	40	39	34	61	57	54
NM10	(30) 35[2]	30	30	47	42	37
NM11	-	-	-	-	-	-
NM12	(34) 35[2]	32	(24) 30[2]	58	60	48
NM13	38	35	34	58	52	51
NM14	35	32	31	48	47	43
NM15	44	(47) 44[3]	40	55	53	50
NM16	47	42	(28) 30[2]	59	56	54
NM17	54	50	36	63	62	59
NM18	42	(43) 42[3]	39	55	53	52
NM19	53	48	36	62	59	57
NM20	39	37	(28) 30[2]	49	47	42

(1) Time periods defined as – Day: 7am to 6pm Monday to Saturday, 8am to 6pm Sunday; Evening, 6pm to 10pm; Night 10pm to 7am Monday to Saturday, 10pm to 8am Sunday

(2) Where background levels are below the minimum assumed rating background noise levels outlined in the NPfI, they have been adjusted to 35dBA during the day period, and 30 dBA during the evening and night periods in accordance with the NPfI

(3) Where evening or night background noise levels exceed that of the previous period, they have been set at the background noise level of the previous period, in line with the NPfI, to reflect community's expectation for greater noise control during more sensitive periods

3.1.5 Operator attended noise survey

M2A carried out operator attended noise surveys to characterise the noise environment and identify the contributors to the acoustic environment. The results of the attended noise surveys and observations are detailed in Table 3-5.

Table 3-5 Summary of attended noise measurement results

Location	Date	Time	dBA $L_{eq(15min)}$	dBA $L_{90(15min)}$	Observations
NM01	27/02/2020	14:00	47	36	The background noise environment was dominated by natural noise, with traffic along Glossop Street barely audible.
NM02	18/02/2020	10:00	52	40	The background noise environment was dominated by natural noise. Train passbys along the T1 Western Line were audible on site.
NM03	27/02/2020	10:30	46	36	The background noise environment was dominated by natural noise, with traffic along Glossop Street barely audible.
NM04	-	-	-	-	-
NM05	17/02/2020	15:30	46	42	The ambient noise environment was dominated by consistent road traffic noise (heavy and light vehicles) along Mamre Road. Natural sounds were audible.
NM06	27/02/2020	15:45	62	47	The background noise environment was dominated by natural noise including cicadas. After school traffic noise along Shadlow Crescent and Banks drive was noted during the measurement.
NM07	17/02/2020	16:15	50	44	The background noise environment was dominated by traffic along Gipps Street.
NM08	27/02/2020	14:30	43	37	Background dominated by natural noise.
NM09	17/02/2020	11:45	58	42	The ambient noise environment was dominated by road traffic noise along Luddenham Road. Natural sounds were audible.
NM10	17/02/2020	11:15	37	27	The ambient noise environment was generally characterised by natural sounds such as birds, insects, or wind through trees. Occasional car passbys on Halmstad Boulevarde were audible but uncommon.
NM11	-	-	-	-	-
NM12	17/02/2020	10:30	43	37	The ambient noise environment was generally characterised by natural sounds (e.g. birds and insects), as well as distant traffic along The Northern Road. The ambient noise environment was occasionally punctuated by events such as car or truck passbys along Adam Road, the occasional dog bark, and plane flyovers.
NM13	27/02/2020	10:30	57	38	The background noise environment was dominated by natural noise including cicadas. Semi-frequent truck passbys along Mersey Street, and fixed wing aircraft flyovers noted during measurements.
NM14	27/02/2020	14:15	48	41	The background noise environment was dominated by natural noise including cicadas. Traffic along Werrington Road and occasional passbys along the train line were noted during measurements.
NM15	17/02/2020	14:00	54	41	The ambient noise environment was dominated by road traffic noise (heavy and light vehicles) along the M4 Western Motorway. Natural sounds were noted in the near-field.

Location	Date	Time	dBA $L_{eq(15min)}$	dBA $L_{90(15min)}$	Observations
NM16	17/02/2020	12:00	65	53	The ambient noise environment was dominated by consistent road traffic noise (heavy and light vehicles) along Mamre Road. Natural sounds were audible.
NM17	27/02/2020	11:45	64	56	The background noise environment was dominated by road traffic along the Great Western Highway. Free flow traffic was observed to fluctuate between 60 – 70 dBA. Stationary traffic was observed as 55 dBA.
NM18	27/02/2020	11:15	48	44	The background noise environment was dominated by natural sounds, with road traffic noise from Great Western Highway and Gipps Road audible.
NM19	17/02/2020	13:30	66	59	The ambient noise environment was dominated by consistent road traffic noise (heavy and light vehicles) along Mamre Road. Natural sounds were audible.
NM20	27/02/2020	13:15	48	43	The background noise environment was dominated by natural sounds and road traffic along Elizabeth Drive. Natural sounds were audible.

3.1.6 Existing noise mitigation

The only noise mitigation that has been identified along the project corridor is a north-south running noise wall on the western side of Gipps Street, between the Great Western Highway and the M4 Western Motorway.

The noise wall is of a concrete construction with clear acrylic panels along the top, and its current purpose is for the mitigation of road traffic noise. This noise wall is 3-4 metres tall and has been considered in the acoustic assessment for this Environmental Impact Statement.

3.1.7 Future planned noise sensitive land uses

The project corridor would run through areas of semi-rural land that may encounter future noise sensitive development near the corridor during construction and operation of the project. The approach adopted for assessing noise impacts generated by the project on potential future land use developments is presented below.

1) Undertake the assessment to all existing and known (approved development) noise sensitive receiver locations.
2) Review the current Local Environmental Plans (LEP) for Penrith and Liverpool council areas to determine where future noise sensitive development may take place (i.e. areas that are currently zoned as Residential, or similar).
3) For areas that are not developed and are not zoned for future noise sensitive development, future noise sensitive development or rezoning would only occur where it can be demonstrated that Clause 87 of the *State Environmental Planning Policy (Infrastructure) 2007* (Infrastructure SEPP) can be met. Guidelines such as Development near Rail Corridors and Busy Roads – Interim Guideline could be used to inform such assessment. Alignment with the requirements set out in other relevant planning policies for the area such as the Western Sydney Aerotropolis Plan and the Penrith to Eastern Creek Growth Investigation Area would also be required (see below for an outline of each).

This approach applies to operational noise impacts from the project. Construction noise impacts would need to be considered as part of the Construction Noise and Vibration Management Plan. Preparation of the plan, which would occur as per the CNVS, would include confirming the identified noise sensitive receivers and as such any new noise sensitive receivers that are developed between the completion of the EIS and commencement of (or during) construction would need to be considered.

Figure 3-2 highlights the current land use zoning along the length of the project, which is based upon a review of the current LEPs. A summary of locations where future noise sensitive development could possibly occur without any rezoning are presented in Table 3-6. Locations where future noise sensitive development is currently contemplated has been considered further in this assessment.

Table 3-6 Areas where future noise sensitive development is contemplated

Land area	Future noise sensitive development contemplated?
R2 Low Density Residential zone, located to the west of Kalang Avenue. Although zoned as residential it is currently occupied by the St Marys Senior High School. For the purpose of this assessment we have assumed that the high school would remain, and the land would not be redeveloped as low density residential.	No
R3 Medium Density Residential zone, located to the east of Gipps Street and south of Great Western Highway, Claremont Meadows, is currently undeveloped. This area will be located above the future tunnel. However, the area is also identified as the site of the Claremont Meadows service facility and as such future residential development has not been assumed for this assessment.	No
RU2 Rural Landscape and E2 Environmental Conservation zones are located south of the M4 Western Motorway to the pipelines. Future residential development of this land is currently not contemplated.	No
B4 Mixed Use and B7 Business Park zones located south of the pipelines and north of Luddenham Road. Future commercial and residential development of this land is contemplated.	Yes
RU2 Rural Landscape and E2 Environmental Conservation zones are located south of Luddenham Road to Elizabeth Drive. Future residential development of this land is currently not contemplated.	No
SP1 Special Activities (Commonwealth Activities) zone located south of Elizabeth Drive is set aside for the future Western Sydney International and as such future residential development of this land is not contemplated.	No
RU1 Primary Production, RU4 Primary Production Small Lots and SP2 Infrastructure zones are located south of the future Western Sydney International. Future residential development of this land is currently not contemplated.	No

Western Sydney Aerotropolis Plan

The Western Sydney Aerotropolis Plan presents the vision and planning framework for the Aerotropolis as Australia’s next global gateway, built around Western Sydney International, becoming an ‘inviting place to live, work and invest’ and being situated within a ‘cool, green and connected’ Western Parkland City.

The Western Sydney Aerotropolis Plan has been developed to be consistent with the 30-minute city vision outlined in the *Greater Sydney Region Plan* and sets out 10 objectives to shape decision-making across the four themes of productivity, sustainability, infrastructure and collaboration, and liveability. The Western Sydney Aerotropolis Plan also includes 47 landscape, urban design and planning principles that give effect to the objectives.

The Western Sydney Aerotropolis Plan sets out an approach to precinct planning that will optimise investment in major infrastructure and create the impetus for early activation of the Aerotropolis. This includes the establishment of 10 precincts, six of which would be planned for early (referred to as the initial precincts). The project would traverse the Northern Gateway and Aerotropolis Core precincts, located north and south of Western Sydney International, respectively.

Penrith to Eastern Creek Growth Investigation Area

The Penrith to Eastern Creek Growth Investigation Area connects the Penrith CBD and St Marys through to the M7 Motorway/Eastern Creek, connected by new mass transit lines. This provides the opportunity to integrate land use and transport planning at a suitable scale. Growth in appropriate locations can contribute to a connected, vibrant Western Parkland City with more homes, jobs, services and open space.

The first stage of a North South Rail Line from St Marys to Western Sydney Airport and Badgerys Creek (the project), intersecting with existing heavy rail corridors, was identified to create opportunities for renewal and revitalisation.

The Penrith to Eastern Creek Growth Investigation Area will build on the existing assets and the opportunities created by the broader Western Economic Corridor. The Growth Area includes the activity nodes of the Penrith strategic centre, the Penrith health and education precinct and the centres of St Marys, Mount Druitt and Rooty Hill. New land release areas will also be considered in the Penrith LGA, including around Orchard Hills.

3.2 Existing noise environment (on-airport)

The existing noise environment on the airport is characteristic of a semi-rural landscape, most influenced by natural sounds, with the majority of the area having little to no road traffic, and generally characterised by low background noise levels. Traffic along sub-arterial roads such as Badgerys Creek Road and Elizabeth Drive, and arterial roads such as The Northern Road, are the main noise sources within this area.

Construction work is currently being undertaken at the Western Sydney International. Noise generated by these works has been observed to have little impact on the existing noise environment at the nearest sensitive receivers. This observation is consistent with the results from the construction noise assessment for Western Sydney International, which suggests that due to the large size of the site, construction noise experienced off-airport is anticipated to be localised to the areas adjacent where bulk earthworks occur.

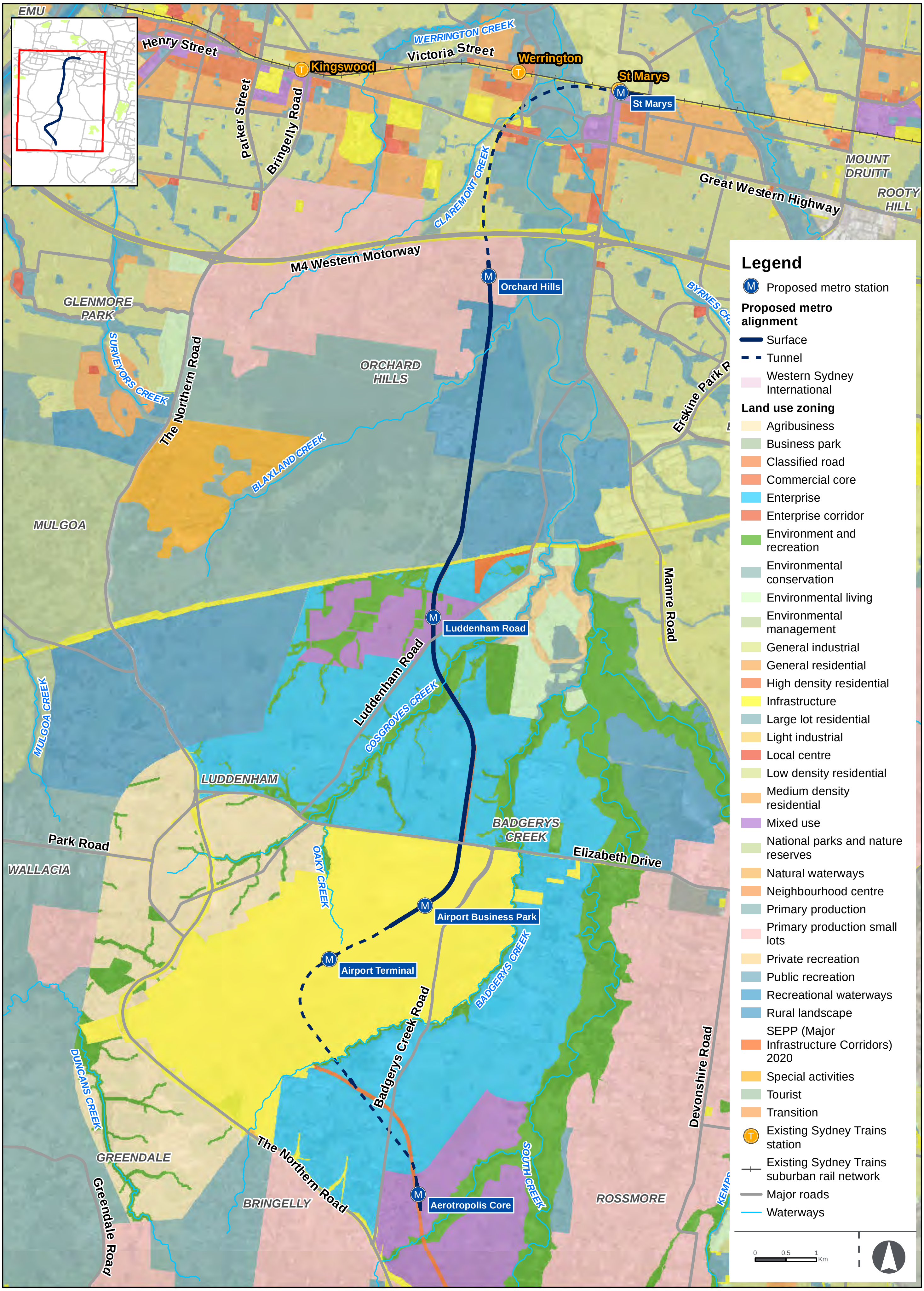
No sensitive receivers currently exist on-airport land. However, receivers are expected to be built as part of the approved Western Sydney International. These on-airport sensitive receivers will broadly consist of the new Airport terminal and ancillary buildings, and the proposed Airport business park, that are to be constructed as part of Western Sydney International. As these receivers have not yet been built and will not be occupied during construction, they have not been considered as part of the construction noise and vibration assessment. These receivers have been considered as part of the operational noise and vibration assessment.

3.3 Future noise environment

Western Sydney is a fast-growing area due to heavy economic investment. projects either currently approved or planned, such as the Western Sydney International and the future M12 Motorway project, together with this project, will substantially change (increase) the existing noise environment, especially the semi-rural noise environment currently encountered south of the M4 Western Motorway.

The future noise environment will consist of noise generated from the construction of infrastructure and private and residential development, increased operational transport infrastructure (road and rail), high levels of aircraft noise (during the day, evening and night), and higher density residential areas.

The effect of an increased background noise would result in any future acoustic assessment that relies on background noise levels to set noise criteria (such as the NPfI and ICNG (DECCW, 2009)) to result in higher noise criteria than currently adopted for this assessment. The assessment of construction noise impacts and non-rail operational noise sources in this assessment, while relevant, would be considered conservative in the near future. As such, when considering feasible and reasonable mitigation of noise impacts it is important to consider what the future noise environment would be like, and how this might affect the noise mitigation approach.



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Land use zoning surrounding the Project

Figure 3-2

4 Assessment of construction impacts

4.1 Construction noise and vibration guidelines (off-airport)

This section provides assessment criteria for construction activities associated with the project where they occur off-airport in line with relevant State legislation and guidelines. The ICNG and the Sydney Metro Construction Noise and Vibration Standard (CNVS) (Sydney Metro, 2020) contain applicable goals for the construction of the off-airport components of the project.

4.1.1 Construction noise management levels

The CNVS identifies the ICNG as the reference document for the determination of construction noise management levels. The CNVS supplements the ICNG to address the unique requirements of the project. The ICNG has been developed to provide a framework for identifying and understanding the impact of airborne construction noise on sensitive land uses.

As outlined in the ICNG, a quantitative assessment requires the development of Noise Management Levels (NML) and a comparison of predicted construction noise levels with the developed NMLs.

The recommended standard hours defined in the ICNG represent the times of the day when receivers are likely to be less sensitive to noise impacts. Where work is proposed outside of standard hours, justification is required and more stringent NMLs apply. NMLs for residential receivers are derived based on existing RBLs. For all other receiver types, the NMLs only apply when the receiver location is occupied or in use. Table 4-1 sets out the application of the management levels for noise at residential receivers.

Table 4-1 ICNG noise management levels for residential receivers

Time of Day	NML, dBA $L_{eq, 15 min}$	How to Apply
Recommended standard hours: • Monday to Friday 7am to 6pm • Saturday 8am to 1pm • 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 Leq,15 min is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted 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 level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that certain 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.

Time of Day	NML, dBA $L_{eq, 15 min}$	How to Apply
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would be required for works undertaken outside of 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 consult with the community.

NMLs have been derived for the identified land uses, and representative RBLs for residential receivers are based on noise monitoring of the existing environment, as described in Chapter 3. Figure 4-1 presents the NMLs for residential receivers within each defined NCA. These NMLs are also tabulated in Table 4-9.

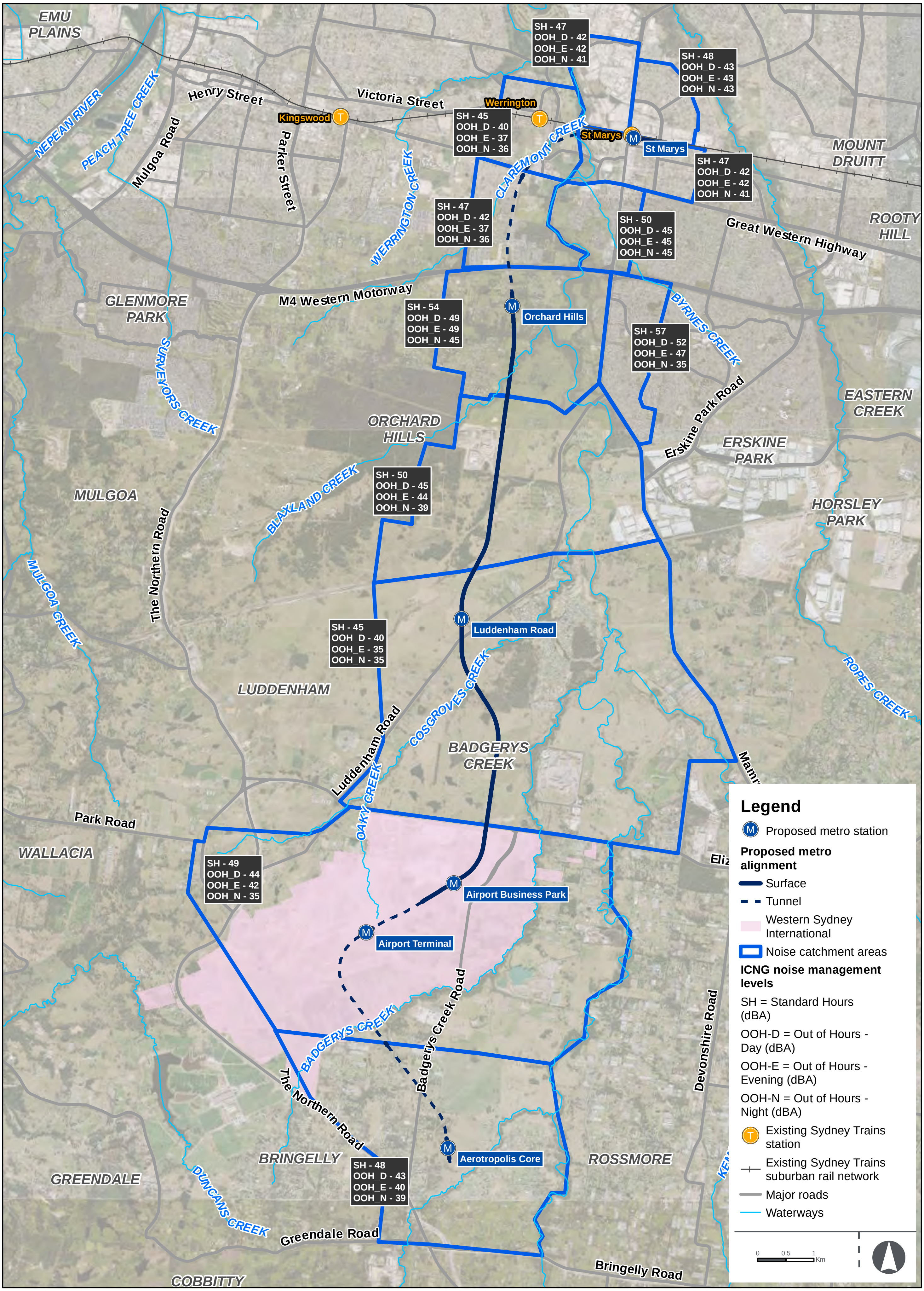
Table 4-2 presents the NMLs for non-residential sensitive receivers.

Feasible and reasonable mitigation and management measures, as defined in the ICNG, would be implemented where NMLs are exceeded either during or outside of recommended standard hours for construction work.

Table 4-2 Noise management levels for non-residential sensitive receivers

Land Use	Noise Management Level (External) dBA $L_{eq, 15 min}$
Educational	55[1]
Commercial (offices, retail outlets)	70
Commercial (industrial)	75
Active recreation	65
Passive recreation	60
Place of worship	55[1]
Child care centres	55[1]

(1) An internal to external correction of +10 dB has been applied as per the ICNG



Sydney Metro – Western Sydney Airport

Noise management levels at residential receivers

Figure 4-1

Indicative only, subject to design development

4.1.2 Sleep disturbance and awakening

Construction noise during the night (10pm to 7am Monday to Saturday, 10pm to 8am Sunday) has the potential to awaken residents from sleep. The CNVS refers to the Road Traffic Authority's (RTA) 'Environmental Noise Management Manual' (ENMM) (RTA, 2001) and DECCW's Environmental Criteria for Road Traffic Noise (ECRTN) (RTA,1999) for guidance relevant to the assessment of sleep disturbance and awakening. These guidelines have been superseded by the Road Noise Policy (RNP) (DECCW, 2011).

The RNP notes that the ECRTN discussed a guideline, aimed at limiting sleep disturbance due to environmental noise of, $L_{AF1,1min}$ should not exceed the ambient L_{A90} + 15 dB. Section 5.4 of the RNP then goes on to state that:

> *Maximum internal noise levels below 50 to 55 dBA L_{max} would be unlikely to awaken people from sleep; and*
>
> *One or two noise events per night, with maximum internal noise levels of 65-70 dBA, are not likely to affect health and wellbeing significantly.*

The guidance within the RNP indicates that internal noise levels of 50 to 55 dBA L_{max} are unlikely to cause sleep awakenings. It follows that at levels above 55 dBA L_{max}, sleep awakening would be considered likely. Assuming receivers may have windows partially open for ventilation, a +10 dB inside to outside correction has been adopted as indicated in the ICNG.

The NPfI also contains guidance on sleep disturbance and awakening, using the following screening levels to identify where further investigation of sleep disturbance and awakening should be undertaken:

- $L_{eq,15min}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{Fmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is the greater.

The assessment of $L_{eq,15\ minute}$ against the prevailing RBL plus 5 aligns with construction noise management levels (as defined in Section 4.1.1), and would be covered under the assessment against construction noise management levels. The assessment L_{max} against the prevailing RBL plus 15dB aligns with the ECRTN guidance.

Therefore, sleep disturbance and awakening external noise level screening levels of RBL+15 dB and L_{max} 65 dBA, whichever is most conservative (lowest) within each NCA, has been adopted.

4.1.3 Construction ground-borne noise and vibration guidelines

The CNVS contains applicable management levels for construction ground-borne noise and vibration impacts generated by the off-airport sections of the project.

Ground-borne noise

Ground-borne noise is generated by vibration transmitted through the ground and into a structure. The CNVS refers to guidance in the ICNG, which specifies ground-borne noise management levels for residences. The ICNG management levels indicate when management actions should be implemented. These are as follows:

- day (7am to 6pm) $L_{eq,15min}$ 45 dBA at residences
- day (7am to 6pm) $L_{eq,15min}$ 50 dBA at commercial receivers
- evening (6pm to 10pm) $L_{eq,15min}$ 40 dBA at residences
- night-time (10pm to 7am) $L_{eq,15min}$ 35 dBA at residences.

These levels are only applicable when ground-borne noise levels are higher than airborne noise levels (i.e. for tunnelling works). These levels are to be assessed at the centre of the most affected habitable room.

Vibration

Vibration as a result of construction activities, depending on the level, may lead to:

- cosmetic and structural building damage
- loss of amenity due to perceptible vibration, termed human comfort.

Importantly, cosmetic damage is regarded as minor in nature; as it is readily repairable and does not affect a building's structural integrity. Damage of this nature is typically described as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks, and separation of partitions or intermediate walls from load bearing walls. If there is no significant risk of cosmetic damage, then structural damage is not considered a significant risk and is not further assessed.

Cosmetic building damage

The CNVS refers to the EPA's *Assessing Vibration – A technical guideline* (AVTG) which recommends the use of British Standard BS 7385-2: Evaluation and measurement for vibration in buildings, Guide to damage levels from ground-borne vibration (BS7385-2) in defining frequency dependent guideline values and assessment methods as they "are applicable to Australian conditions". However, the SEARs specifies German Standard DIN 4150-3: Structural vibration – Effects of vibration on structures (DIN 4150). DIN 4150 provides the more conservative guidance, and hence, adoption of DIN 4150 as recommended results in compliance with the CNVS. Table 4-3 summarises the recommended limits outlined in DIN 4150 to ensure minimal risk of cosmetic damage to residential and industrial buildings.

Table 4-3 Recommended vibration limits for cosmetic damage

Type of structure	Guideline values for velocity, v_i, in mm/s, of vibration in horizontal plane of highest floor, at all frequencies(1)
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	10
Dwellings and buildings of similar design and/or occupancy	5
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	2.5

(1) If a building is subjected to harmonic vibration, then the maximum values can also occur in floors other than the top floor, or in the foundation. The values given in the table also apply in these cases.

On this basis, conservative general vibration screening levels (Peak Particle Velocity (PPV)) are provided for intermittent vibration sources as follows:

- reinforced or framed structures: 10 mm/s
- unreinforced or light framed structures 5 mm/s.

At locations where the predicted and/or measured vibration levels are greater than shown above, monitoring should be performed during construction. A more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would also be performed to determine the applicable safe vibration level.

Human comfort

With regards to assessing loss of amenity due to perceptible vibration, the CNVS requires the assessment of vibration impacts on human comfort in accordance with *Assessing Vibration – A technical guideline* (DEC, 2006) (AVTG). AVTG presents preferred and maximum vibration values (vibration dose values), above which there is considered to be a risk that the amenity and comfort of people occupying buildings would be adversely affected by construction work. The preferred vibration values are not mandatory limits but should be sought to be achieved through application of all feasible and reasonable mitigation measures.

Intermittent vibration is expected to be generated from most construction works, and can be defined as interrupted periods of continuous vibration (e.g. a drill), or repeated periods of impulsive vibration (e.g. a pile driver). The applicable criteria for intermittent vibration are shown in Table 4-4 as vibration dose value ($m/s^{1.75}$).

The vibration guideline also specifies limits for continuous and impulsive vibration. These summarised vibration limits are expressed in acceleration (m/s^2) and PPV (mm/s) as presented in Table 2.2 and Appendix C of the AVTG and summarised in Table 4-5.

When short-term works such as piling, demolition and construction give rise to impulsive vibrations, undue restriction on vibration values may significantly prolong these operations and result in greater annoyance. Where work is short term, feasible and reasonable mitigation measures have been applied, then higher vibration values may apply.

Table 4-4 Vibration limits for human exposure from intermittent vibration

Location	Assessment period(1)	Vibration dose value ($m/s^{1.75}$)	
		Preferred value	Maximum value
Residences	Daytime	0.2	0.4
	Night	0.13	0.26
Offices, schools, educational institutions, and places of worship	Anytime	0.4	0.8
Workshops	Anytime	0.8	1.6

(1) Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am

Table 4-5 Preferred and maximum values for continuous and impulsive vibration

Location	Assessment period	[1]RMS acceleration m/s^2				[2]Peak Particle Velocity mm/s	
		Preferred values		Maximum values		Preferred values	Maximum values
		Z-Axis	X and Y axes	Z-axis	X and Y axes		
Continuous vibration							
Critical areas	Day or night- time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime[3]	0.010	0.0071	0.020	0.017	0.28	0.56
	Night-time	0.007	0.005	0.014	0.010	0.20	0.40
Offices, schools, educational institutions, and places of worship	Day or night-time	0.020	0.014	0.040	0.028	0.56	1.1
Workshops	Day or night-time	0.04	0.029	0.080	0.058	1.1	2.2
Impulsive vibration							
Critical areas	Day or night-time	0.0050	0.0036	0.010	0.0072	0.14	0.28
Residences	Daytime[3]	0.3	0.21	0.60	0.42	8.6	17.0
	Night-time	0.10	0.071	0.20	0.14	2.8	5.6
Offices, schools, educational institutions, and places of worship	Day or night-time	0.64	0.46	1.28	0.92	18.0	36.0

<table>
<tr><th rowspan="3">Location</th><th rowspan="3">Assessment period</th><th colspan="4">[1]RMS acceleration m/s^2</th><th colspan="2">[2]Peak Particle Velocity mm/s</th></tr>
<tr><th colspan="2">Preferred values</th><th colspan="2">Maximum values</th><th rowspan="2">Preferred values</th><th rowspan="2">Maximum values</th></tr>
<tr><th>Z-Axis</th><th>X and Y axes</th><th>Z-axis</th><th>X and Y axes</th></tr>
<tr><td>Workshops</td><td>Day or night-time</td><td>0.64</td><td>0.46</td><td>1.28</td><td>0.92</td><td>18.0</td><td>36.0</td></tr>
</table>

(1) Values derived from z-axis critical frequency range 4–8 Hz. Where required, a more detailed analysis can be conducted as per BS 6472–1992.

(2) Values given for the most critical frequency range >8 Hz assuming sinusoidal motion. Where required, a more detailed analysis can be conducted as per

(3) AS 2670.2–1990. Sufficient justification should accompany the use of a peak velocity approach if used in an assessment.

(4) Specific values depend on social and cultural factors, psychological attitudes and expected degree of intrusion.

Heritage structures

Heritage structures in the study area have been identified in Section 3.1. Heritage listed structures should not be assumed to be more sensitive to vibration unless they are structurally unsound, which is unlikely for a regularly maintained structure. Where a historic structure is deemed to be sensitive to damage from vibration following inspection by qualified structural and/or civil engineers, more conservative superficial cosmetic damage criterion (3 mm/s PPV) should be considered, as noted in Table 4-3.

Buildings that are potentially at risk of threshold or cosmetic damage would be identified by the contractor prior to the commencement of construction works. A CNVMP should include management at these locations including building condition surveys before the commencement of construction activities and after construction is completed.

Warragamba to Prospect Water Supply Pipelines

Guidelines for Development Adjacent to the Upper Canal and Warragamba Pipelines (WaterNSW, 2020) outlines that excavation methods would be undertaken in accordance with German Standard DIN 4150-3:2016 (2.5 mm/s PPV) for construction works occurring in proximity to the pipelines.

Sensitive scientific and medical equipment

Based on a review of current land use, no sensitive scientific and/or medical instruments are likely to be in use within the study area and as such, this has not been considered any further in this assessment.

Other vibration sensitive structures and utilities

Where structures and utilities sensitive to vibration are encountered, or where that asset provides an essential service for the community, a vibration goal, which is more stringent than structural damage goals may need to be adopted. Examples of such structures and utilities include:

- tunnels
- pipelines
- fibre optic cables.

Specific vibration criteria would be determined on a case-by-case basis. The construction contractor would be responsible for liaising with the structure or utility's owner to determine acceptable vibration levels.

In lieu of specific vibration criteria being provided by the asset owner, screening criteria would be adopted from guidance provided in DIN 4150-3 for buried pipework. The screening criteria is outlined in Table 4-6.

Table 4-6 Guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework

Pipe material	Guideline values for velocity measured on the pipe, v_i, in mm/s
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

4.1.4 Construction road traffic noise guidelines

The CNVS outlines guidance for the assessment of road traffic noise generated by construction vehicles be taken from the Road Noise Policy (RNP) (NSW EPA, 2011). As the RNP provides guidance with relation to operational noise impacts, and noise from construction traffic is non-permanent, further guidance has been taken from the Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime, 2016).

The RNP provides guidance on the assessment of noise impacts on sensitive receivers from additional road traffic generated by the project operating on a public road network. Where vehicles operate within the boundaries of a construction site, noise impacts generated by these vehicles are included in the overall $L_{eq,15min}$ construction site noise emissions undertaken in line with the ICNG.

The RNP makes a distinction between the assessment of freeway/arterial/sub-arterial roads and local roads. Freeway/arterial/sub-arterial roads are assessed over day (7am to 10pm) and night (10pm to 7am) periods.

Table 4-7 presents a summary of the applicable road traffic criteria for residential receivers.

The CNVG states that ‘an initial screening test should first be applied by evaluating whether noise levels will increase by more than 2 dBA due to construction traffic or a temporary reroute due to a road closure. Where increases are 2 dBA or less then no further assessment is required’.

Therefore, if the road traffic noise levels increase by more than 2 dBA as a result of the proposed construction traffic, and the criteria in Table 4-7 are exceeded, investigation of mitigation options would be required.

Table 4-7 Road traffic noise criteria for residential receivers on existing roads affected by additional traffic from land use developments

Road type	Road Traffic Noise Criteria	
	Day (7am to 10pm)	Night (10pm to 7am)
Freeway/Arterial/Sub-arterial	60 $L_{eq,15hr}$ dBA	55 $L_{eq,9hr}$ dBA
Local roads	55 $L_{eq,1hr}$ dBA	50 $L_{eq,1hr}$ dBA

4.2 Construction airborne noise and vibration guidelines (on-airport)

Construction noise generated by works undertaken on-airport land is regulated by *Airports (Environment Protection) Regulations 1997* (Airports Regulations) made under the *Airports Act 1996* (Cth) (the Airports Act). This regulation provides specific criteria to be met at the site of sensitive receivers. Sensitive receivers are defined as a dwelling (permanent or impermanent in a place designated for impermanent dwellings), hotel, educational institute, medical centre, or place of worship.

The criteria, outlined in Section 4 of the Airports Regulations, designates a sound pressure level of $L_{A10,\ 15\ min}$ of 75 dB, from noise generated by the construction, maintenance, or demolition of a structure, to be met at the site of any sensitive receptor. For commercial receptors, the same criteria apply, but the time of day, duration, characteristics of noise, background noise level, and nature business conducted at the site should be considered when determining whether noise is excessive.

Commonwealth legislation contains no criteria in relation to the assessment of construction ground-borne noise and vibration impacts. In the absence of suitable criteria, NSW guidelines and standards have been adopted. Therefore, a consistent approach to the assessment of ground-borne noise and vibration impacts will be undertaken across both on-airport and off-airport construction sites.

4.3 Construction airborne noise assessment methodology

4.3.1 Construction sites and timing

The proposed construction works have been segregated into scenarios over which similar construction activities are expected to occur. These works would occur both on Commonwealth land, at the location of the Western Sydney International (on-airport), and land regulated by the NSW government (off-airport)..

Construction noise impacts generated by works occurring on-airport and off-airport are managed under different guidelines. Therefore, construction works occurring on and off-airport have been assessed separately in consideration of the different applicable guidance and criteria.

4.3.2 Construction working hours

Construction works are expected to typically be undertaken during standard construction hours, as defined by the ICNG. These include:

- 7am to 6pm from Monday to Friday
- 8am to 1pm on Saturday
- No work on Sundays or public holidays.

Activities resulting in impulsive or tonal noise emissions would be limited to these hours, except as permitted by an environment protection licence and the planning approval issued by the Minister for Planning and Public Spaces.

Activities that may be carried out outside the standard construction hours include:

- utility works
- bored tunnel excavation
- tunnel fit-out and associated works
- construction during road and rail possessions
- spoil haulage, deliveries and the tunnel boring machine (TBM) activities at St Marys, Orchard Hills, Western Sydney International tunnel portal, Airport terminal and Aerotropolis Core
- construction activities at the tunnel and viaduct segment production and storage facility within the airport construction support site
- work predicted not to exceed with the relevant noise management level (NML) at the nearest sensitive receiver
- works on major roads in accordance with a Road Occupancy Licence
- the delivery of materials outside approved hours as required by the NSW Police or other authorities (including Transport for NSW) for safety reasons
- emergency situations where it is required to avoid the loss of lives and property and/or to prevent environmental harm
- situations where agreement is reached with affected receivers.

With the exception of emergencies and subject to the terms of the planning approval and the environmental protection licence, activities would not take place outside standard construction hours without prior notification of the affected community and the NSW Environment Protection Authority (NSW EPA) as required. The noise criteria for construction works taking place on-airport apply to the project regardless of the time of day over which they occur. Therefore, the assessment for works occurring on-airport applies to works taking place both during and outside of the standard hours.

4.3.3 Indicative construction program

Construction of the project is expected to start in 2021, subject to planning approval, and take around five years to complete. An indicative construction program is provided in Table 4-8.

Table 4-8 Indicative construction program

Construction activity	Overview of activity																							
	2021				2022				2023				2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling works																								
Station and tunnel portal excavation																								
Earthworks																								
Tunnel construction																								
Station construction and fitout																								
Rail systems fitout																								
Finishing, testing and commissioning																								

4.3.4 Construction assessment scenarios

An outline of the assessed construction scenarios is provided below, including the construction activities associated with each scenario. Construction vehicle movements and haulage which does not occur on public roads are included in this assessment (construction vehicle movements on public roads are assessed separately in Section 4.10). The full list of activities considered in each scenario is presented in Appendix B.1.

It is noted that the assessment includes a conservative list of plant and equipment and is therefore considered to represent the worst case construction noise impacts. As detailed construction planning continues, construction-related noise and vibration impacts and mitigation would be managed in accordance with the CNVS.

Scenario 1 (SC01) – Enabling works

Key noise generating construction activities undertaken as part of the assessed enabling works scenario would include:

- demolition of buildings and other structures where required
- transport network adjustments to facilitate construction vehicle access
- relocating, adjusting and protecting utilities and services affected by the project
- supplying power, water and other utilities to construction compounds and other areas within the construction work area (whether temporary or permanent supplies)
- vegetation clearance (as required)
- establishing construction compounds and work sites, including fencing and hoarding.

High noise generating plant utilised as part of these activities include:

- use of hydraulic hammers (~5% utilisation per shift) during site establishment works at St Marys
- use of concrete vibrators (~20% utilisation per shift) during site establishment works at the Claremont Meadows services facility, and Aerotropolis Core
- use of dozers (~80% utilisation per shift) during site establishment at Orchard Hills, along the off-airport construction corridor, and the Western Sydney International tunnel portal

Scenario 2 (SC02) - Tunnelling and associated works

Key noise generating construction activities undertaken as part of the assessed tunnelling and associated works scenario would include:

- St Marys to Orchard Hills tunnel and Western Sydney International to Bringelly tunnel (TBM tunnels) and associated tunnel spoil handling (including haulage), including:
  - TBM build
  - TBM tunnelling
  - XP Excavation and Lining
  - TBM extraction
  - TBM demobilisation
- other techniques including the use of road-headers or excavators to excavate non-standard sections of tunnels including cross-passages and tunnel stubs.
- tunnelling support activities (including tunnel section segment manufacture and storage, material handling and grout batching).

High noise generating plant utilised as part of these activities include:

- tunnel boring between St Marys to Orchard Hills, and Western Sydney International to Aerotropolis Core
- use of multiple hydraulic hammers (~30% utilisation per shift) during tunnelling site demobilisation at 4 Orchard Hills and the Western Sydney International tunnel portal

Scenario 3 (SC03) - Bridge and viaduct construction

Key noise generating construction activities undertaken as part of the assessed bridge and viaduct construction works scenario would include:

- substructure construction, likely to be from cast in-situ concrete in the following sequence:
- bored pile construction
- pile cap construction including localised excavation
- pier or column construction
- headstock construction
- construction of the superstructure, likely through the placement of precast concrete segments (typically through the use of a viaduct gantry or crane)
- viaduct segment manufacture and storage.

High noise generating plant utilised as part of these activities include:

- use of hydraulic hammers (~60% utilisation per shift) during bridge construction works along the off-airport construction corridor
- use of concrete vibrators (~20% utilisation per shift) during viaduct segment casting at the Airport construction support site

Scenario 4 (SC04) - Earthworks and excavation

Key noise generating construction activities undertaken as part of the assessed earthworks and excavation works scenario would include:

Earthworks and / or excavation, station and crossover excavation, Orchard Hills portal cut-and-cover, Western Sydney International tunnel portal cut-and-cover and permanent fill site, Airport terminal excavation, and the Claremont Meadows and Bringelly service facilities. These works include:

- ground stabilisation works as required
- construction of bored pile wall or similar infrastructure where required
- earthworks cut and fill to design levels
- construction of retaining structures and drainage elements where required as the earthworks progresses.

High noise generating plant utilised as part of these activities include:

- use of hydraulic hammers (~30% utilisation per shift) during excavation works at St Marys, Claremont Meadows services facility, Orchard Hills, the Western Sydney International tunnel portal, Airport business park, Bringelly services facility, and Aerotropolis Core
- use of dozers and articulated dump trucks (~80% utilisation per shift) during rail embankment works along the off-airport construction corridor

Scenario 5 (SC05) – Station construction

Key noise generating construction activities undertaken as part of the assessed station construction works scenario would include:

- above ground structural works at all stations involving:
  - support columns and foundations for vertical transport structures and the station buildings
  - the platform structure
  - vertical transport structure and the pedestrian accesses
  - the platform canopy
  - the emergency egress stairs
  - the station buildings.

High noise generating plant utilised as part of these activities include:

- use of concrete vibrators (~50% utilisation per shift) during station concrete works at St Marys
- use of concrete saws and hydraulic hammers (~20% utilisation per shift) during station concrete works at Orchard Hills, Airport Terminal station, and Aerotropolis Core Station
- use of jackhammers (~60% utilisation per shift) during station concrete works at Luddenham Road

Scenario 6 (SC06) – Construction of stabling and maintenance and other ancillary facilities

Key noise generating construction activities undertaken as part of the assessed construction of stabling and maintenance and other ancillary facilities works scenario would include:

- structural works associated with the construction of the stabling facility, including ancillary facilities within the stabling and maintenance facility (e.g. carpark, control centre, etc.), and other ancillary facilities including:
  - the Claremont Meadows and Bringelly service facilities
  - substations.

High noise generating plant utilised as part of these activities include:

- use of concrete saws (~80% utilisation per shift) during structural works at the Stabling and maintenance facility

Scenario 7 (SC07) – Rail systems fitout

Key noise generating construction activities undertaken as part of the assessed rail systems fitout works scenario would include:

- fitout of mechanical and electrical ventilation
- track slab and rail fastening
- rail track installation, fixing and welding.

High noise generating plant utilised as part of these activities include:

- use of concrete vibrators (~20% utilisation per shift) during track construction along the off-airport construction corridor

Scenario 8 (SC08) – Station fitout, precinct and transport integration works

Key noise generating construction activities undertaken as part of the assessed station fitout, precinct and transport integration works scenario would include:

- architectural fitout of the stations and the construction of roads and other transport integration infrastructure including:
  - intersection modifications, including traffic signal changes
  - kerb and guttering
  - surfacing including asphalt, concrete and pavers
  - transport interchange facilities, including commuter car parking and bus layover.

High noise generating plant utilised as part of these activities include:

- use of concrete vibrators (~50% utilisation per shift) during station fitout works at St Marys
- use of concrete saws (~20% utilisation per shift) during station fitout works at Luddenham Road, Airport Terminal station, and Aerotropolis Core Station.

Scenario 9 (SC09) – Finishing works

Key noise generating construction activities undertaken as part of the assessed finishing works scenario would include:

- site reinstatement and rehabilitation carried out progressively during the works, including:
  - demobilising site compounds and facilities
  - remove materials, waste and redundant structures from the works sites
  - forming and stabilising of spoil mounds
  - decommission temporary haulage roads that are no longer required.
- landscaping works would generally involve:
  - earthworks
  - drainage works.

High noise generating plant utilised as part of these activities include:

- use of hydraulic hammers (~30% utilisation per shift) during site demobilisation works at St Marys, Orchard Hills, Western Sydney International (including the Airport construction support site), and Bringelly services facility

4.3.5 Noise modelling inputs and parameters

A noise model was prepared for the assessment of airborne noise using the SoundPlan V8.2 Industrial Module implementing the Propagation of Noise From Petroleum And Petrochemical Complexes To Neighbouring Communities (CONCAWE, 1981) calculation method.

A three-dimensional representation of the physical environment within the study area was developed. Modelling inputs for each scenario included topography, ground and air absorption, locations of sensitive receivers, noise-generating equipment and buildings surrounding the project.

The following assumptions were used in the modelling:

- all outdoor noise sources modelled at two metres above surface level
- topography for the area has been sourced from NSW Spatial Services at one metre contours
- receiver heights 1.5 metres above ground level, or at the most affected storey
- noise enhancing meteorological conditions, with stability category F and 2 m/s source-to-receiver winds.

Realistic worst case and typical scenarios for noise emissions from construction have been assessed as follows:

- realistic worst case – noisiest equipment are assessed as working within the equipment work area, operating at 100% duty for the 15 minute assessment period
- typical case – all equipment are assessed as working within the equipment work area, operating over a proportion of the 15 minute assessment period based on the expected utilisation.

Modelled noise source levels

Sound power levels have been sourced from the following documents (note that these have been listed in order of priority):

- Sydney Metro Construction Noise and Vibration Standard (CNVS)
- Australian Standard AS 2436:2010 – *Guide to noise and vibration control on construction, demolition and maintenance sites*
- Department for Environment, Food and Rural Affairs (United Kingdom), Update of noise database for prediction of noise on construction and open sites – Phase 3: Noise measurement data for construction plant used on quarries (DEFRA noise database)
- consultant data sourced from similar projects.

The nominated equipment for the construction work scenarios and the SWL of each item, and the number of plant items and assumed utilisation for each activity that comprises the assessed scenarios are presented in Appendix B.2.

4.4 Overview of predicted noise levels (off-airport works)

Construction noise levels were predicted for all off-airport works (separately to on-airport works, which are covered in Sections 4.6 and 4.7). The predicted noise levels for each of the nine construction work scenarios (as outlined in Section 4.3.4) in each NCA are presented in Appendix B.3. Table 4-9 outlines the highest noise level experienced at a residential receiver in each NCA for each activity.

Table 4-10 and Figure 4-2 outlines the number of sensitive receivers that are highly noise affected (residences that experience noise levels greater than 75 dB during standard hours) in each NCA for each activity. Predicted maps showing the noise level at each receiver. within the study area are presented in Appendix B.4.

The predicted noise levels are representative of the ‘typical’ expected noise levels. The predicted noise levels representative of the ‘worst case’ expected noise levels (as defined in Section4.3.5) are presented in in brackets in Table 4-9.

The noise model includes a conservative list of plant and equipment, as it includes all of the possible construction equipment that may be used during construction and is therefore considered to represent conservative construction noise impacts. Should the project receive approval, as detailed construction planning continues construction-related noise and vibration impacts and mitigation would be managed in accordance with the CNVS.

Sensitive receivers may be potentially impacted by cumulative noise levels associated with separate construction scenarios occurring simultaneously at adjacent worksites. In most cases the cumulative noise impact experienced at these receivers will be equivalent to the highest construction noise level, or in worst case scenarios up to 3dBA higher than the highest noise level. These cumulative impacts would be experienced for limited periods of time when the highest noise generating construction activities in each area are occurring simultaneously.

During standard hours, all NCAs are predicted to experience some exceedances of NMLs during most scenarios. During out-of-hours works, exceedances are predicted to occur during tunnelling and associated works, and finishing works. During tunnelling and associated works, exceedances are predicted to occur at NCA 01 through to NCA 08 (excluding NCA 02). During finishing works, exceedances are predicted to occur (typically to a lesser extent than during tunnelling and associated works) at all NCAs, excluding NCA 02, NCA 09, and NCA 10.

Highly noise affected receivers occur in NCA 03, NCA 06 and NCA 08 predominantly in association with excavation and earthworks (Scenario 4) and, to a lesser extent, finishing works (Scenario 9).

Receivers predicted to experience exceedances of sleep disturbance and awakening screening levels occur predominantly within NCA03, NCA06, and NCA08 in association with tunnelling and associated works, and finishing works (Scenarios 2 and 9). Exceedances of sleep disturbance and awakening screening levels are predicted to a lesser extent within NCA 01, NCA 04, NCA 11, and NCA 12 during finishing works (Scenario 9).

Table 4-9 Highest predicted noise level – typical and (worst case)

NCA	Period	NML	Highest predicted noise level (dB)								
			SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08	SC09
NCA01 – (765 receivers assessed within NCA)	SH	48	54 (65)	50 (56)	N/A	67 (71)	50 (56)	53 (63)	N/A	59 (63)	62 (68)
	OOH - D	43	N/A	53 (53)	N/A	N/A	N/A	N/A	N/A	N/A	44 (51)
	OOH - E	43	N/A	53 (53)	N/A	N/A	N/A	N/A	N/A	N/A	44 (51)
	OOH - N	43	N/A	53 (53)	N/A	N/A	N/A	N/A	N/A	N/A	44 (51)
NCA02 – (41 receivers assessed within NCA)	SH	75	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	OOH - D	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	OOH - E	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	OOH - N	41	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NCA03 - (1385 receivers assessed within NCA)	SH	47	69 (80)	65 (71)	N/A	82 (86)	65 (71)	68 (78)	N/A	74 (78)	77 (83)
	OOH - D	42	N/A	61 (61)	N/A	N/A	N/A	N/A	N/A	N/A	58 (65)
	OOH - E	42	N/A	61 (61)	N/A	N/A	N/A	N/A	N/A	N/A	58 (65)
	OOH - N	41	N/A	61 (61)	N/A	N/A	N/A	N/A	N/A	N/A	58 (65)
NCA04 - (26 receivers assessed within NCA)	SH	45	63 (71)	60 (67)	N/A	63 (68)	64 (72)	49 (59)	N/A	55 (59)	61 (67)
	OOH - D	40	N/A	33 (33)	N/A	N/A	N/A	N/A	N/A	N/A	42 (54)
	OOH - E	37	N/A	33 (33)	N/A	N/A	N/A	N/A	N/A	N/A	42 (54)
	OOH - N	36	N/A	33 (33)	N/A	N/A	N/A	N/A	N/A	N/A	42 (54)
NCA05 - (1051 receivers assessed within NCA)	SH	50	60 (69)	62 (67)	N/A	65 (70)	60 (68)	48 (58)	55 (59)	54 (58)	61 (66)
	OOH - D	45	N/A	47 (47)	N/A	N/A	N/A	N/A	N/A	N/A	42 (50)
	OOH - E	45	N/A	47 (47)	N/A	N/A	N/A	N/A	N/A	N/A	42 (50)
	OOH - N	45	N/A	47 (47)	N/A	N/A	N/A	N/A	N/A	N/A	42 (50)

NCA	Period	NML	Highest predicted noise level (dB)								
			SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08	SC09
NCA06 – (1315 receivers assessed within NCA)	SH	47	71 (80)	73 (78)	59 (62)	75 (80)	69 (77)	54 (56)	63 (67)	63 (67)	71 (77)
	OOH - D	42	N/A	58 (58)	N/A	N/A	N/A	N/A	N/A	N/A	53 (60)
	OOH - E	37	N/A	58 (58)	N/A	N/A	N/A	N/A	N/A	N/A	53 (60)
	OOH - N	36	N/A	58 (58)	N/A	N/A	N/A	N/A	N/A	N/A	53 (60)
NCA07 – (999 receivers assessed within NCA)	SH	57	59 (61)	60 (65)	61 (64)	64 (69)	55 (63)	61 (63)	62 (66)	54 (56)	61 (65)
	OOH - D	52	N/A	42 (42)	N/A	N/A	N/A	N/A	N/A	N/A	40 (46)
	OOH - E	47	N/A	42 (42)	N/A	N/A	N/A	N/A	N/A	N/A	40 (46)
	OOH - N	35	N/A	42 (42)	N/A	N/A	N/A	N/A	N/A	N/A	40 (46)
NCA08 – (229 receivers assessed within NCA)	SH	54	75 (77)	75 (80)	74 (77)	83 (88)	70 (78)	68 (70)	77 (81)	65 (69)	78 (82)
	OOH - D	49	N/A	62 (62)	N/A	N/A	N/A	N/A	N/A	N/A	55 (61)
	OOH - E	49	N/A	62 (62)	N/A	N/A	N/A	N/A	N/A	N/A	55 (61)
	OOH - N	45	N/A	62 (62)	N/A	N/A	N/A	N/A	N/A	N/A	55 (61)
NCA09 – (68 receivers assessed within NCA)	SH	50	65 (70)	52 (57)	68 (71)	68 (70)	51 (55)	67 (69)	67 (71)	60 (62)	65 (68)
	OOH - D	45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32 (38)
	OOH - E	44	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32 (38)
	OOH - N	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32 (38)
NCA10 – (378 receivers assessed within NCA)	SH	45	68 (69)	N/A	66 (70)	70 (72)	64 (67)	40 (42)	69 (70)	62 (68)	68 (72)
	OOH - D	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	OOH - E	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	OOH - N	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NCA11 – (68 receivers assessed within NCA)	SH	49	59 (68)	58 (65)	57 (64)	62 (67)	54 (61)	N/A	57 (58)	61 (68)	59 (63)
	OOH - D	44	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38 (51)
	OOH - E	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38 (51)
	OOH - N	35	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38 (51)

NCA	Period	NML	Highest predicted noise level (dB)								
			SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08	SC09
NCA12 - (396 receivers assessed within NCA)	SH	48	69 (78)	67 (74)	N/A	71 (77)	65 (72)	N/A	N/A	70 (77)	59 (67)
	OOH - D	43	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50 (61)
	OOH - E	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50 (61)
	OOH - N	39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50 (61)

(1) ICNG standard hours includes Monday to Friday 7am to 6pm and Saturday 8 am to 1pm, Out of Hours Day any time within 1pm to 6pm Saturday and 8am to 6pm Sunday, and outside standard hours, Out of Hours – Evening any time from 6pm to 10pm & Out of Hours – Night at all other times

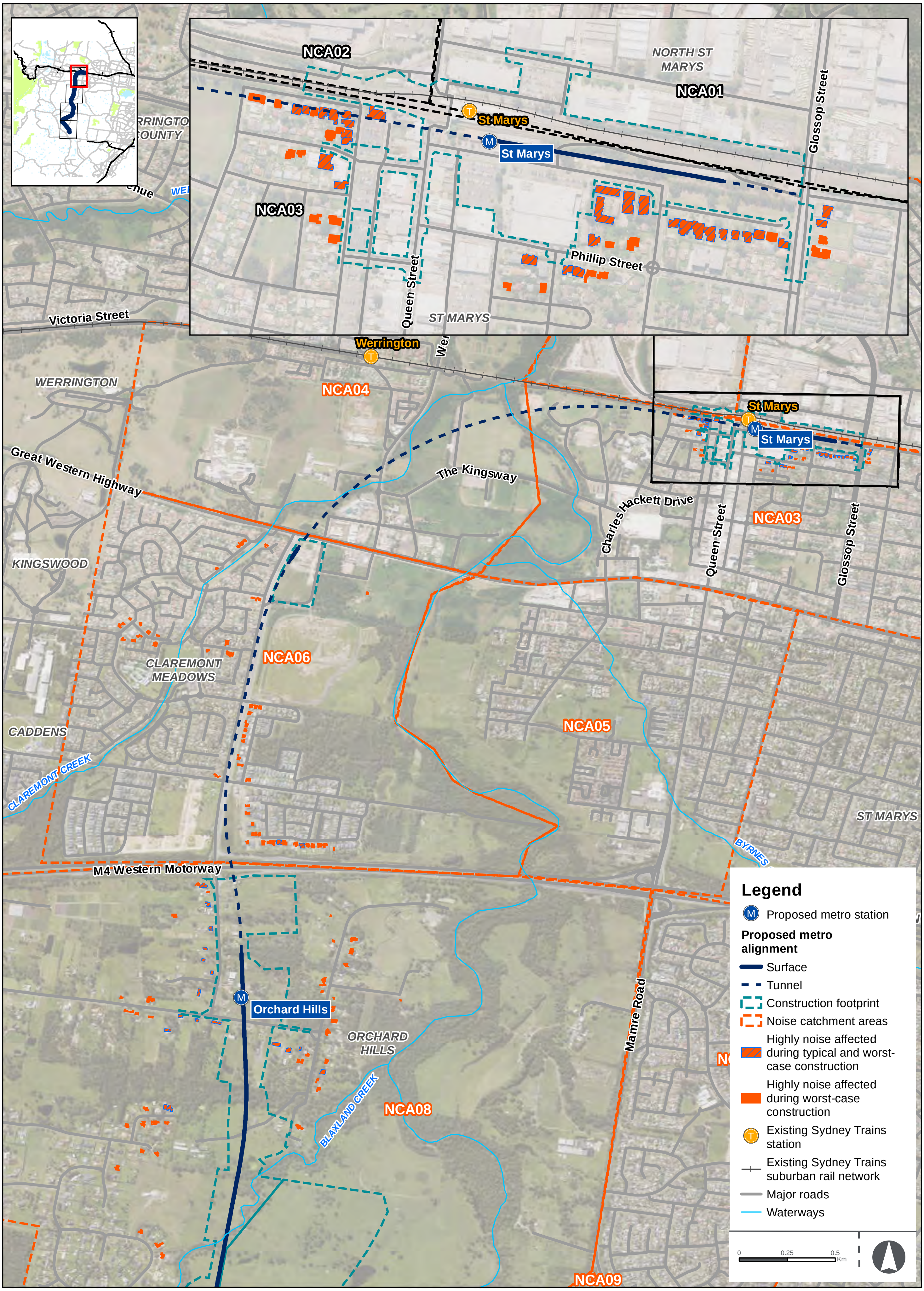
(2) Yellow cells indicate an exceedance of NMLs between 0 and 10 dB for typical construction works; Orange cells indicate an exceedance of NMLs between 10 and 20 dB for typical construction works; Red cells indicate an exceedance of NMLs >20dB for typical construction works;

(3) Results in brackets indicate noise level predictions assuming full utilisation of plant (i.e. realistic worst case).

Table 4-10 Number of highly noise affected receivers – typical and (worst case)

NCA	Number of highly noise affected receivers (typical and worst case)								
	SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08	SC09
NCA01 – (765 receivers assessed within NCA)	0 (0)	0 (0)	N/A	0 (0)	0 (0)	0 (0)	N/A	0 (0)	0 (0)
NCA02 – (41 receivers assessed within NCA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NCA03 - (1385 receivers assessed within NCA)	0 (23)	0 (0)	N/A	30 (49)	0 (0)	0 (11)	N/A	0 (11)	7 (38)
NCA04 - (26 receivers assessed within NCA)	0 (0)	0 (0)	N/A	0 (0)	0 (0)	0 (0)	N/A	0 (0)	0 (0)
NCA05 - (1051 receivers assessed within NCA)	0 (0)	0 (0)	N/A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NCA06 – (1315 receivers assessed within NCA)	0 (31)	0 (8)	0 (0)	2 (16)	0 (10)	0 (0)	0 (0)	0 (0)	0 (4)
NCA07 – (999 receivers assessed within NCA)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NCA08 – Orchard Hills, west of St Claire	0 (1)	0 (19)	0 (3)	18 (53)	0 (9)	0 (0)	1 (6)	0 (0)	1 (26)
NCA09 – Orchard Hills, north of the pipelines	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NCA10 – (229 receivers assessed within NCA)	0 (0)	N/A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NCA11 – (68 receivers assessed within NCA)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	N/A	0 (0)	0 (0)	0 (0)
NCA12 - (396 receivers assessed within NCA)	0 (1)	0 (0)	N/A	0 (9)	0 (0)	N/A	N/A	0 (2)	0 (0)

(1) Results in brackets indicate number of receivers exceeding highly noise affected NMLs assuming full utilisation of plant (i.e. realistic worst case).

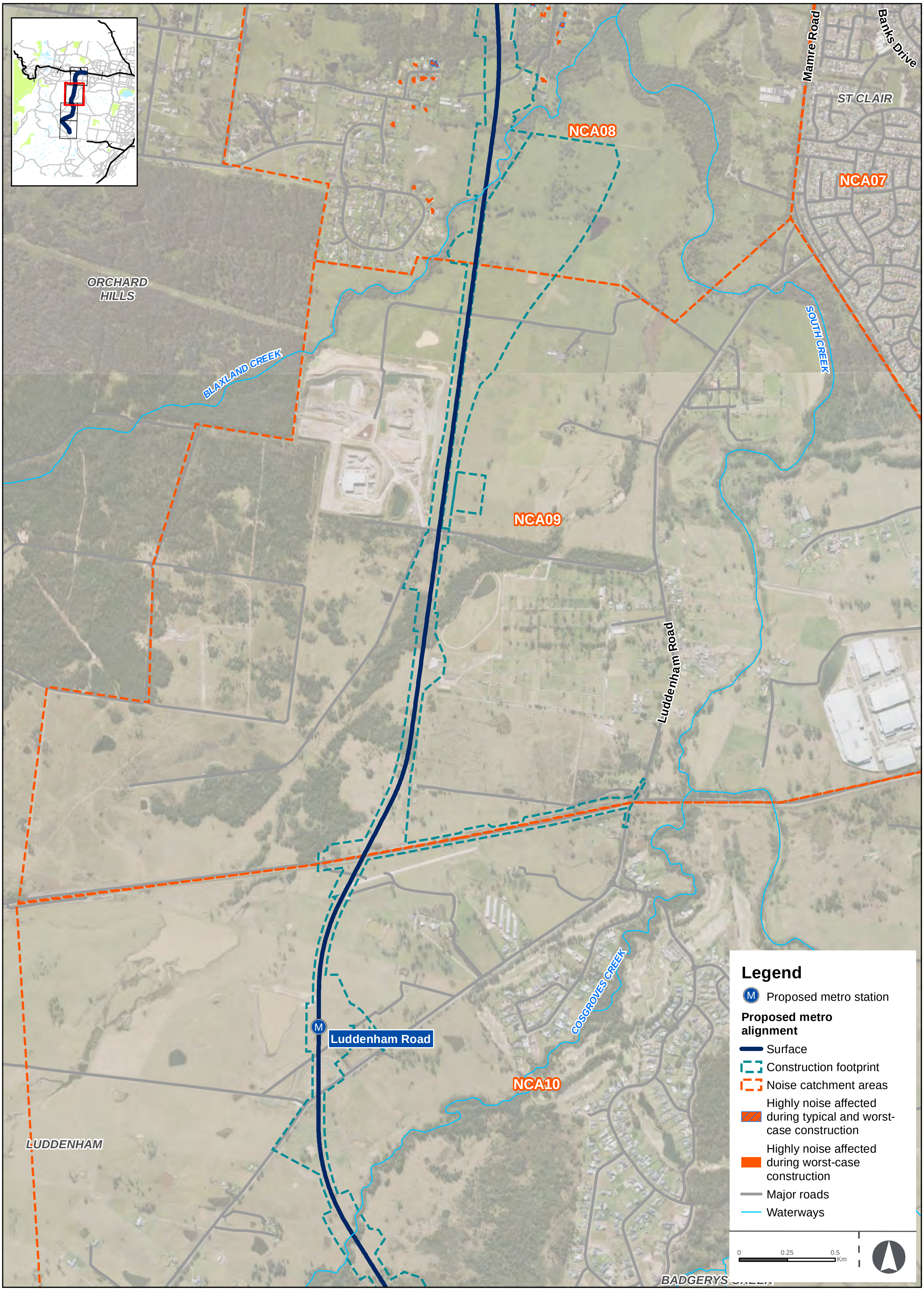


Sydney Metro – Western Sydney Airport

Off-airport - highly noise affected receivers

Figure 4-2a

Indicative only, subject to design development

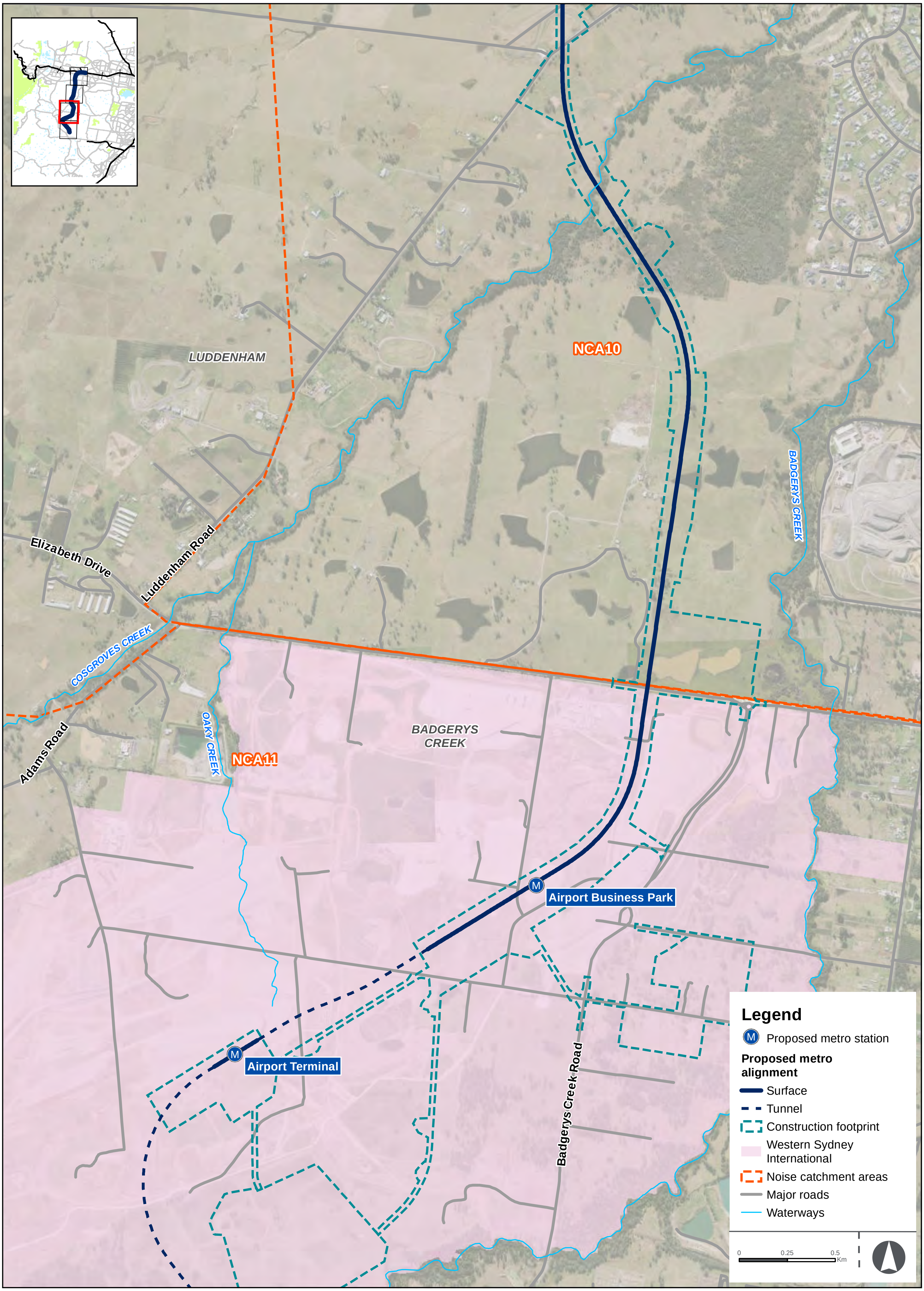


Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Off-airport - highly noise affected receivers

Figure 4-2b

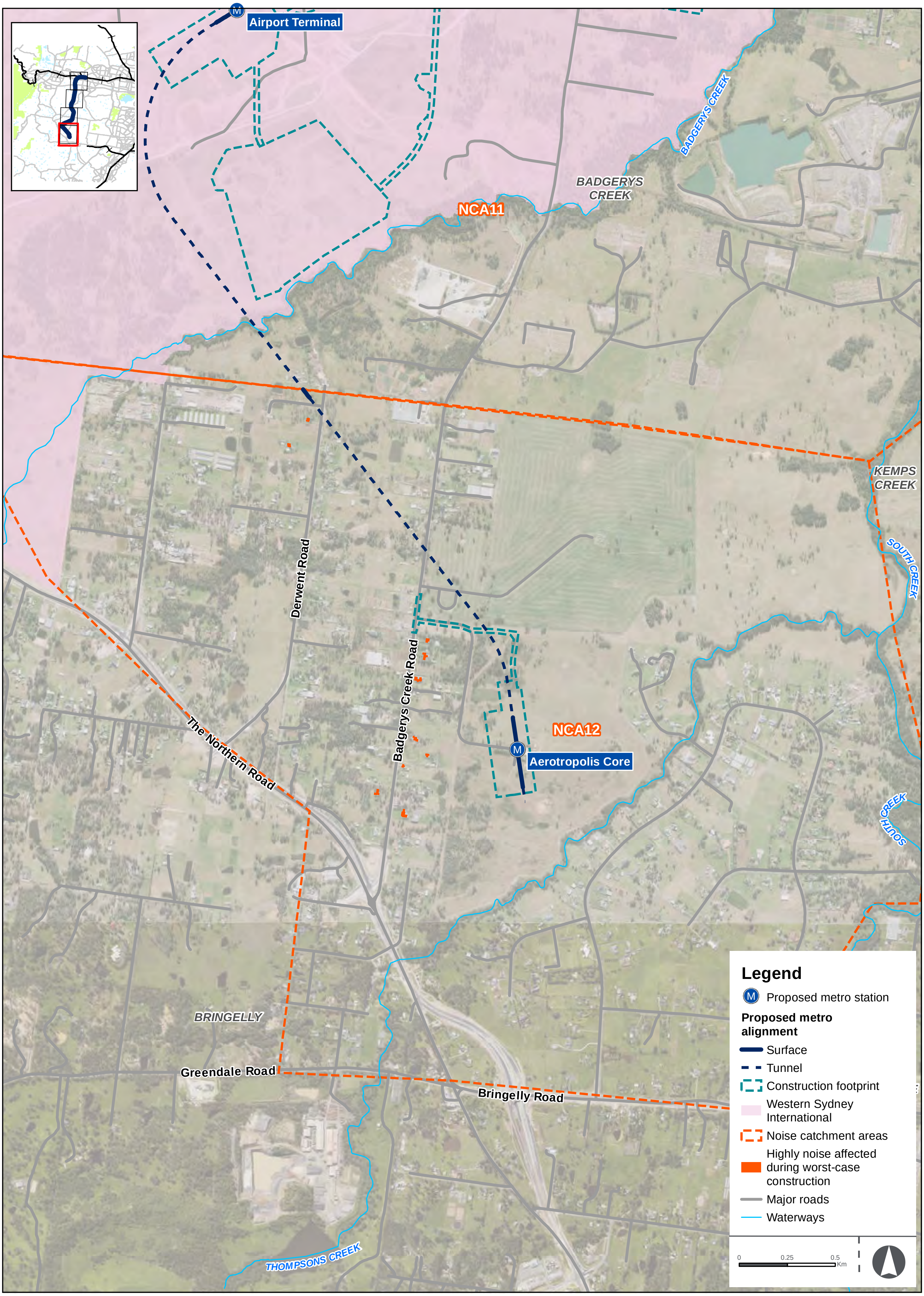


Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Off-airport - highly noise affected receivers

Figure 4-2c



Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Off-airport - highly noise affected receivers

Figure 4-2d

4.5 Noise catchment Area Assessment (off-airport works)

During construction, construction noise levels could significantly impact the closest receivers, predominantly during standard hours, with limited exceedances during out-of-hours works. These impacts include exceedance of NMLs and highly noise affected receivers, and in some cases, potential sleep disturbance and awakening. Where exceedances have been predicted to occur during the worst case 15 minute periods (when all machinery is operating at full utilisation), these impacts are indicative of highest likely noise levels that may occur. Typical construction noise levels would be expected throughout most of the construction and would be lower than the worst case periods.

A summary of the main findings from the construction noise assessment results are provided below.

NCA01 (St Marys North, east of Forrester Road)

The location of the construction footprint within NCA01 is shown below in Figure 4-3.

Figure 4-3 NCA01 construction areas

A total of 765 noise sensitive receivers were assessed for NCA01. The predicted NML exceedances within NCA01 are presented in Table 4-11. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of highly noise affected management levels are predicted to occur within NCA01.

Table 4-11 NCA01 – overview of NML exceedances at residential receivers – typical and (worst case)

Activity	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
		Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
		0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	N/A	142 (377)	0 (190)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	0	13 (238)	0 (0)	0 (0)	25 (25)	0 (0)	0 (0)	25 (25)	0 (0)	0 (0)	25 (25)	0 (0)	0 (0)
SC03 - Bridge and viaduct construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	N/A	320 (181)	280 (405)	0 (40)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	0	13 (238)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC06 - Construction of stabling and maintenance and other ancillary facilities	N/A	113 (406)	0 (113)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	N/A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	N/A	358 (406)	4 (113)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	26	417 (285)	71 (319)	0 (2)	4 (206)	0 (0)	0 (0)	4 (206)	0 (0)	0 (0)	4 (206)	0 (0)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Glossop Street. Some of the highest impact works occur during:

- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers
- Station fitout, precinct and transport integration works (Scenario 8) – predicted noise levels are most influenced by the use of multiple concrete vibrators
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station box excavation works at St Marys, exceeding NMLs by up to 17 dB to 21 dB. Figure 4-4 shows the distribution of NML exceedances during this activity for residential receivers within NCA01.

The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 5 dB.

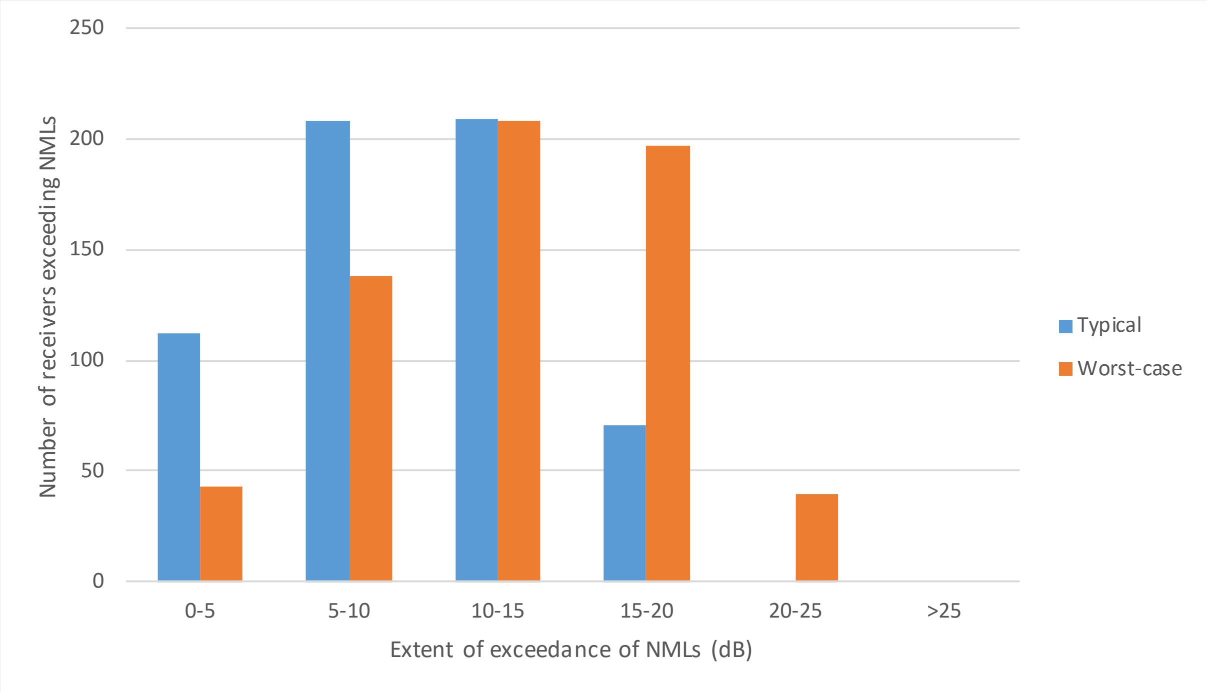


Figure 4-4 NCA01 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA01 only experiences exceedances during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

Residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of the TBMs at St Marys, exceeding NMLs by up to 10 dB. Figure 4-5 shows the distribution of NML exceedances during this activity for residential receivers within NCA01. While the worst case impacts may result in a <10 dB exceedance of the out-of-hours NMLs, this is limited to 25 receivers, with most of the receivers being subject to noise levels below out-of-hours NMLs during typical construction.

The exceedances of the sleep disturbance and awakening screening levels occur during testing and commissioning as part of the finishing works (Scenario 9), and are most influenced by heavy vehicle movements, exceeding NMLs by up to 3 dB.

Airborne noise from the TBMs would be most audible for a short period when each of the two TBMs break through to the station box cutting, with approximately three months respite in between arrival of each of the two TBMs.

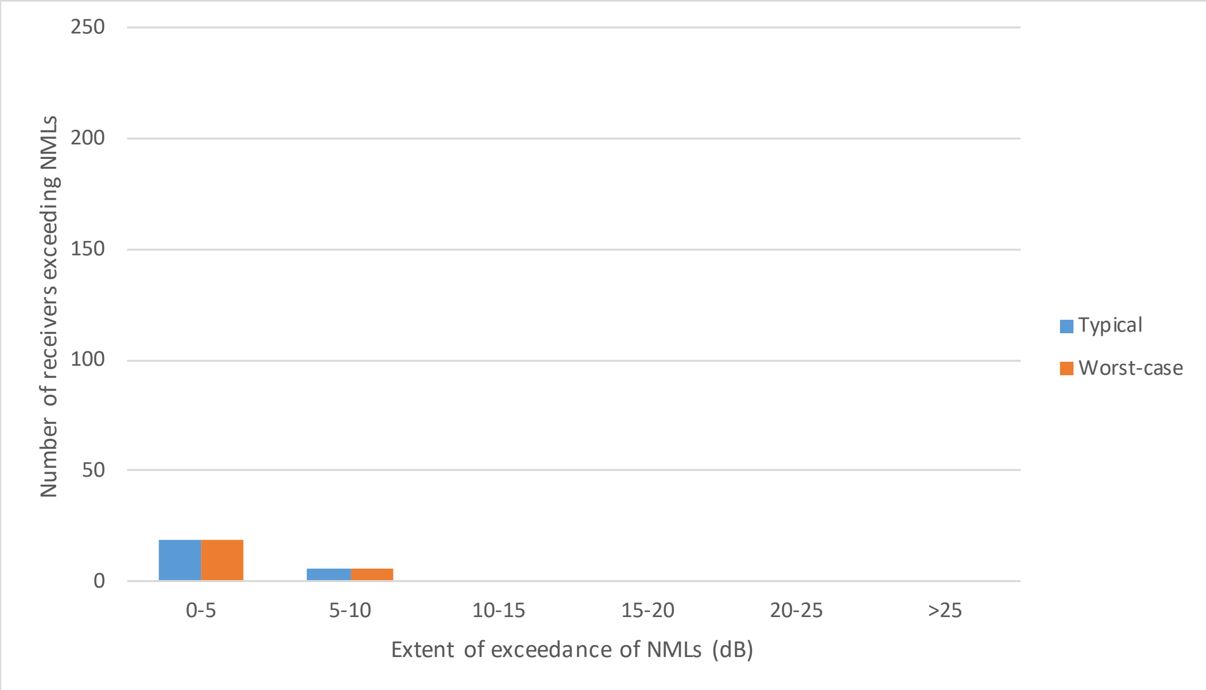


Figure 4-5 NCA01 NML exceedances – out-of-hours – tunnelling and associated works

Summary of non-residential receivers

Figure 4-6 shows the non-residential receivers predicted to experience exceedances during construction.

Figure 4-6 NCA01 NML exceedances – non-residential receivers – typical construction

Exceedances of NMLs are predicted at St Marys North Public School during excavation and earthworks, station fitout, and finishing works (Scenarios 4, 8 and 9). The school is predicted to be most affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is most influenced by hydraulic hammers during station box excavation works at St Marys, exceeding NMLs by up to 10 dB to 14 dB. The hydraulic hammers are expected to be used intermittently for around 8 months of the construction period.

Industrial receivers along Harris Street are also predicted to experience exceedances of NMLs, of up to 5 dB to 7 dB, only during excavation and earthworks (Scenario 4).

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the Sydney Metro Construction Noise and Vibration Standard (CNVS) (Sydney Metro, 2020). Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which may reduce the number of exceedances of NMLs by around 30 to 50%.

NCA02 (St Marys North, west of Forrester Road)

One exceedance of NMLs is predicted in NCA02 during all typical construction scenarios, occurring during excavation and earthworks (Scenario 4) at the closest industrial receiver along Forrester Road. During worst case construction periods, the closest industrial receiver along Forrester Road may experience exceedances of NMLs during site establishment, excavation and earthworks, and finishing (Scenarios 1, 4, and 9) by up to 7 dB.

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS.

NCA03 (St Marys, east of South Creek, north of Great Western Hwy)

The location of the construction footprint within NCA03 is shown below in Figure 4-7.

Figure 4-7 NCA03 construction areas

A total of 1385 noise sensitive receivers were assessed for NCA03. The predicted NML exceedances within NCA03 are presented in Table 4-12. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods.

Table 4-12 NCA03 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Highly noise affected	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
			Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
			0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	0 (23)	N/A	314 (588)	56 (322)	7 (78)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	0 (0)	36	174 (371)	38 (75)	0 (17)	122 (122)	33 (33)	0 (0)	122 (122)	33 (33)	0 (0)	143 (143)	35 (35)	1 (1)
SC03 - Bridge and viaduct construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	30 (49)	N/A	631 (518)	350 (476)	88 (223)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	0 (0)	0	209 (344)	38 (114)	0 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC06 - Construction of stabling and maintenance and other ancillary facilities	0 (11)	N/A	232 (560)	42 (232)	7 (48)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	N/A	N/A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	0 (11)	N/A	392 (563)	130 (232)	30 (48)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	7 (38)	323	526 (621)	200 (393)	48 (127)	107 (316)	28 (67)	0 (12)	107 (316)	28 (67)	0 (12)	140 (354)	31 (76)	0 (19)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Station Street. Some of the highest impact works occur during:

- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers
- Station fitout, precinct and transport integration works (Scenario 8) – predicted noise levels are most influenced by the use of multiple concrete vibrators
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station box excavation works at St Marys, exceeding NMLs by up to 40 dB to 44 dB. Figure 4-8 shows the distribution of NML exceedances during this activity for residential receivers within NCA03.

The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 5 dB.

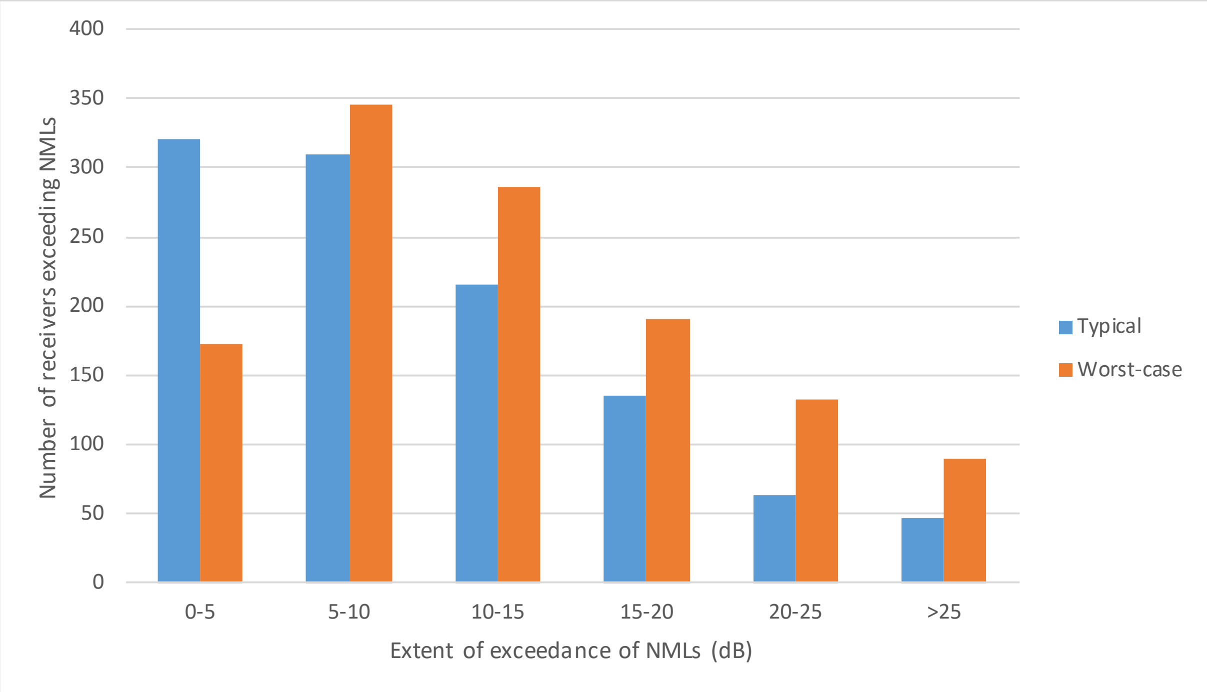


Figure 4-8 NCA03 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA03 only experiences exceedances during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

Residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of the TBMs at St Marys, exceeding NMLs by up to 18 dB. Figure 4-9 shows the distribution of NML exceedances during this activity for residential receivers within NCA03. While most residential receivers exceeding out-of-hours NMLs may experience a <10 dB exceedance, 36 receivers are predicted to experience an exceedance between 10 to 20 dB. The rest of the receivers in this NCA would be subject to noise levels below out-of-hours NMLs during typical construction.

The exceedances of the sleep disturbance and awakening screening levels occur during testing and commissioning as part of the finishing works (Scenario 9), and are most influenced by heavy vehicle movements, exceeding NMLs by up to 31 dB.

Airborne noise from the TBMs would be most audible for a short period when each of the two TBMs break through to the station box cutting, with approximately three months respite in between arrival of each of the two TBMs.

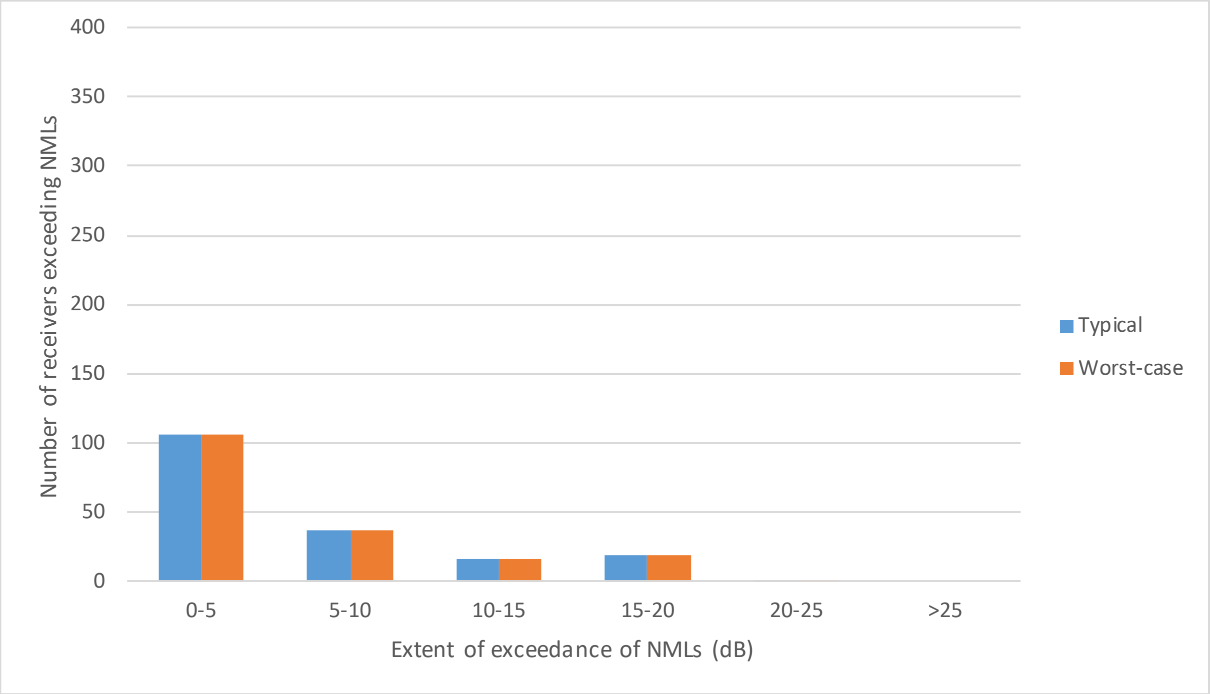


Figure 4-9 NCA03 NML exceedances – out-of-hours – tunnelling and associated works

Summary of non-residential receivers

Figure 4-10 shows the non-residential receivers predicted to experience exceedances during construction.

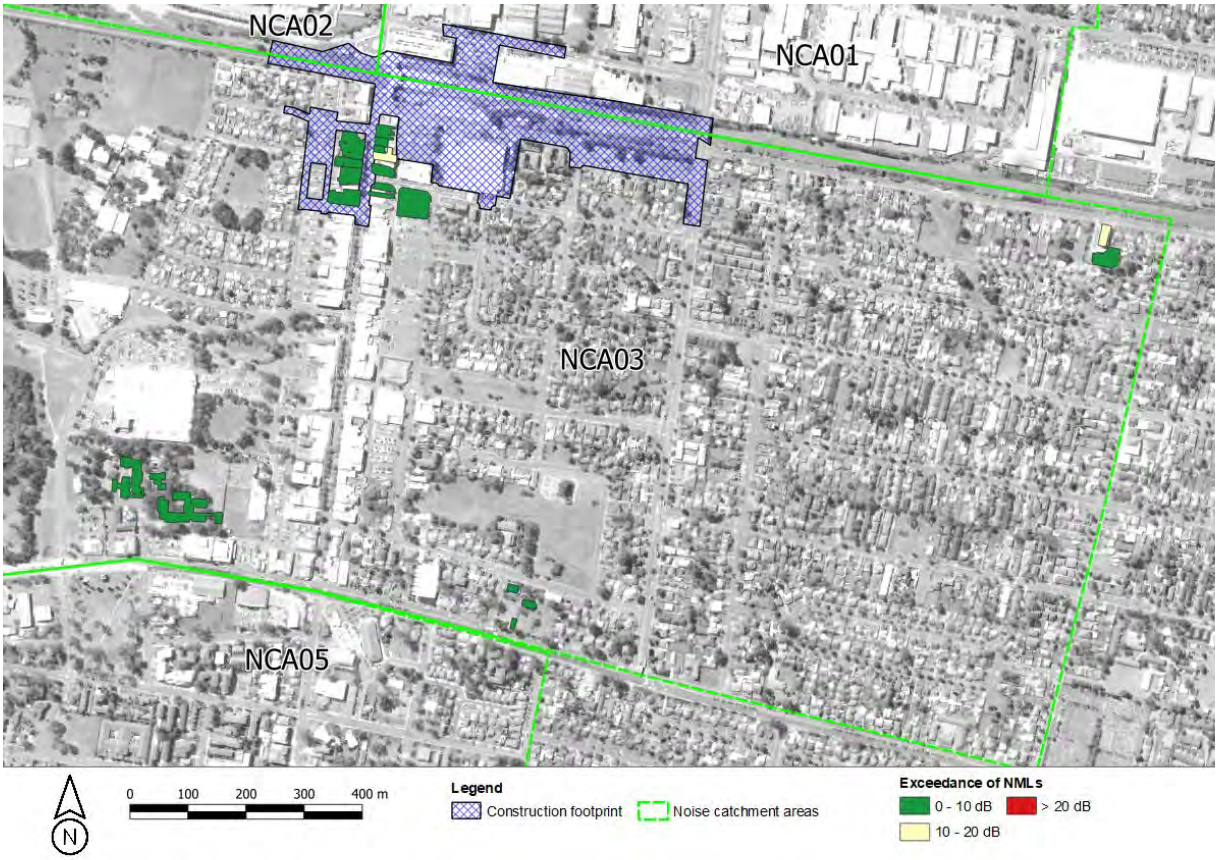


Figure 4-10 NCA03 NML exceedances – non-residential receivers – typical construction

Exceedances of NMLs are predicted at commercial receivers located along Queen Street, and St Demetrios Orthodox Church during excavation and earthworks, station fitout, and finishing works (Scenarios 4, 8 and 9). Exceedances of NMLs are predicted at St Marys Public School and St Marys Anglican Church only during excavation and earthworks (Scenario 4).

The identified receivers are predicted to be most affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is most influenced by hydraulic hammers during station box excavation works at St Marys, exceeding NMLs by up to 10 to 14 dB at the commercial receivers and St Demetrios Orthodox Church, 4 to 8 dB at St Marys Public School, and 6 to 10 dB at St Marys Anglican Church. The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period.

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which may reduce the number of exceedances of NMLs by around 30 to 50%.

NCA04 (St Marys, west of South Creek, north of Great Western Hwy)

The location of the construction footprint within NCA04 is shown below in Figure 4-11.

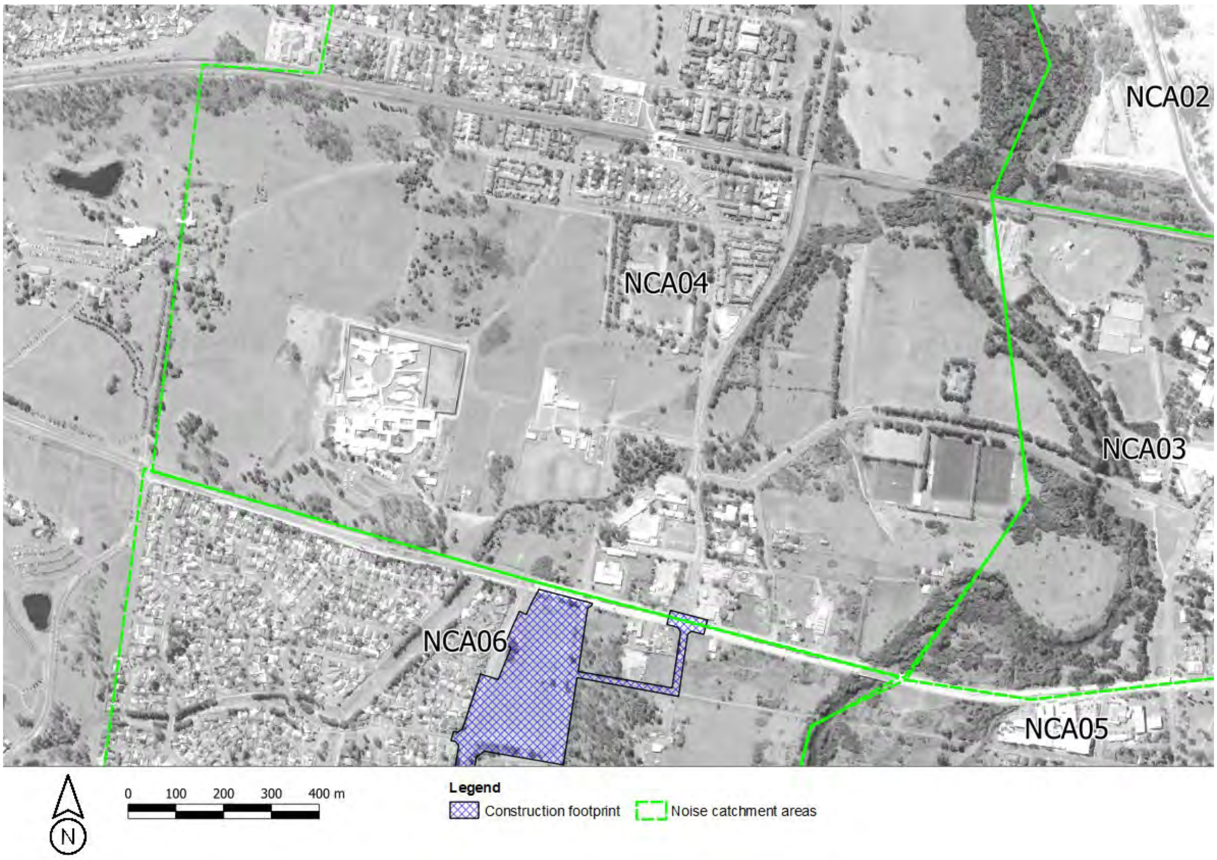


Figure 4-11 NCA04 construction areas

A total of 26 noise sensitive receivers were assessed for NCA04. The predicted NML exceedances within NCA04 are presented in Table 4-13. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of highly noise affected management levels are predicted to occur within NCA04.

Table 4-13 NCA04 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
		Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
		0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	N/A	0 (0)	3 (0)	0 (3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	0	0 (0)	3 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC03 - Bridge and viaduct construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	N/A	0 (0)	3 (1)	0 (2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	N/A	1 (0)	0 (0)	0 (3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	N/A	3 (0)	0 (3)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	N/A	3 (0)	0 (3)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	3	0 (0)	3 (1)	0 (2)	3 (0)	0 (3)	0 (0)	3 (0)	0 (3)	0 (0)	3 (0)	0 (3)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Tennant Road. Some of the highest impact works occur during:

- Tunnelling and associated works (Scenario 2) – predicted noise levels are most influenced by the use of concrete vibrators
- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during excavation works at Claremont Meadows services facility, exceeding NMLs by up to 18 dB to 23 dB. Figure 4-12 shows the distribution of NML exceedances during this activity for residential receivers within NCA04.

The hydraulic hammers are expected to be used intermittently for around 6 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 3 dB.

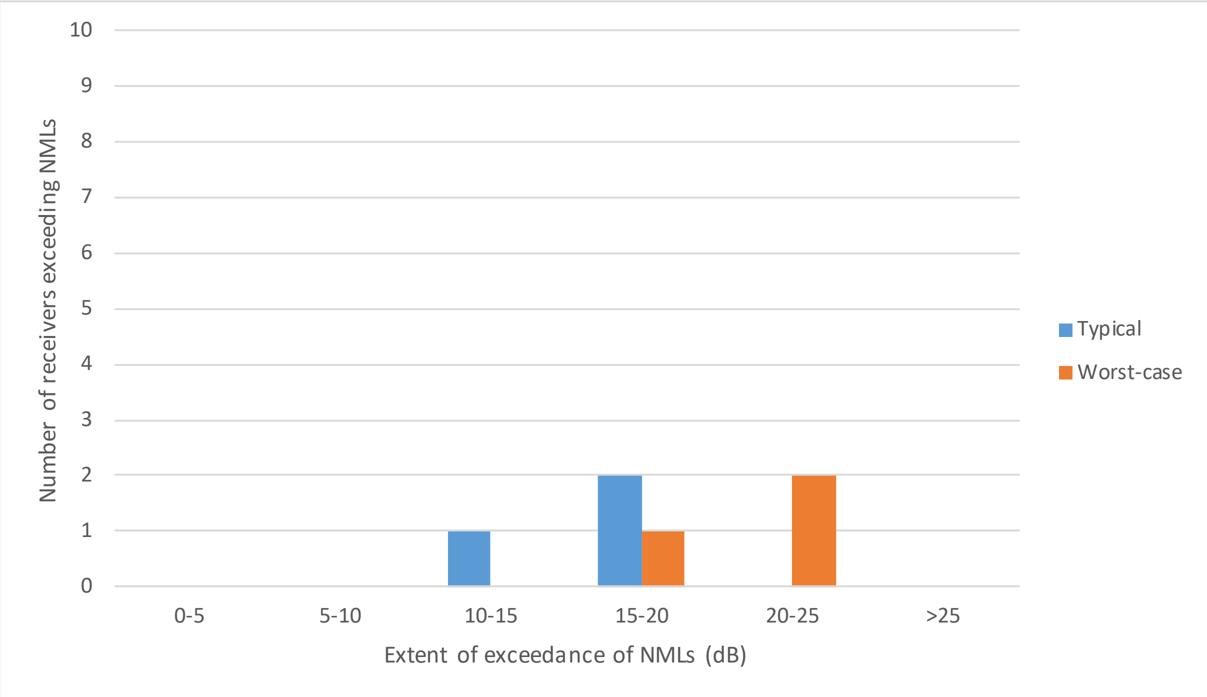


Figure 4-12 NCA04 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA04 only experiences exceedances during finishing works (Scenario 9). Exceedances are associated with the testing and commissioning of the Claremont Meadows services facility during finishing works.

The exceedances of NMLs are as a result of the use of the heavy vehicles during testing and commissioning at Claremont Meadows, exceeding NMLs by up to 6 to 18 dB. Figure 4-5 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA04. While most residential receivers exceeding out-of-hours NMLs may experience a <10 dB exceedance during typical construction, the remainder would be subject to noise levels below out-of-hours NMLs during typical construction.

The exceedances of the sleep disturbance and awakening screening levels occur during testing and commissioning as part of finishing works (Scenario 9), and are most influenced by heavy vehicle movements, exceeding by up to 11 dB.

The heavy vehicles are expected to be periodically used for around 12 months.

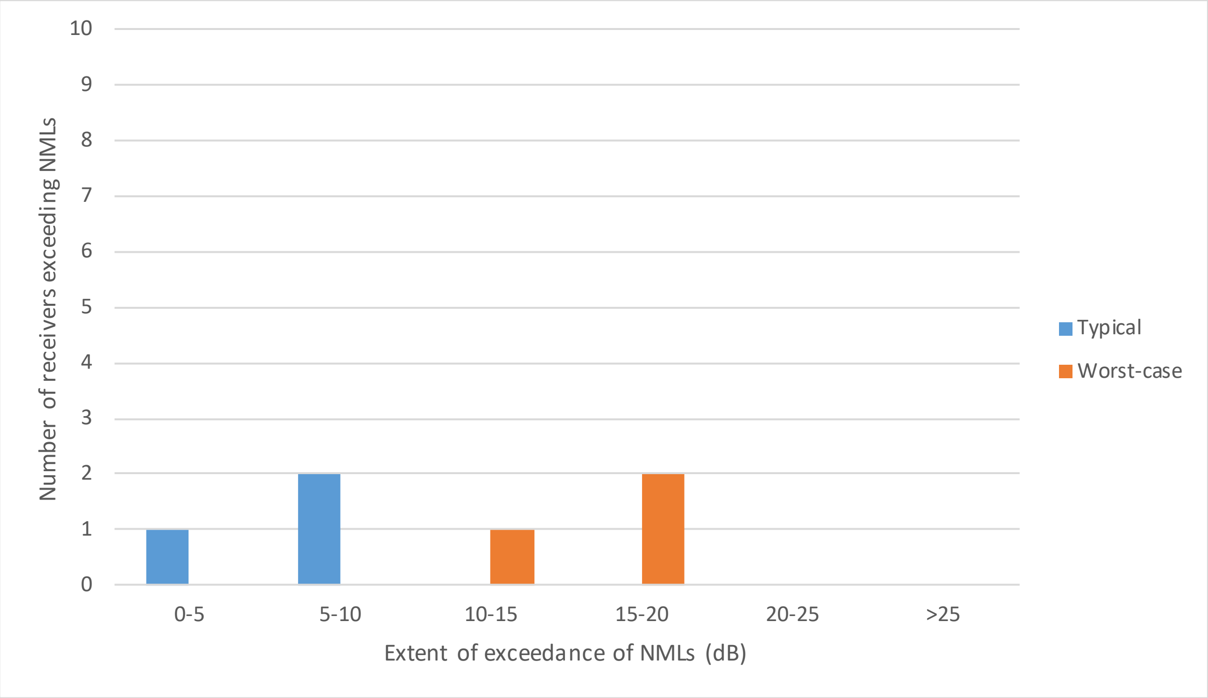


Figure 4-13 NCA04 NML exceedances – out-of-hours – finishing works

Summary of non-residential receivers

Figure 4-14 shows the non-residential receivers predicted to experience exceedances during construction.

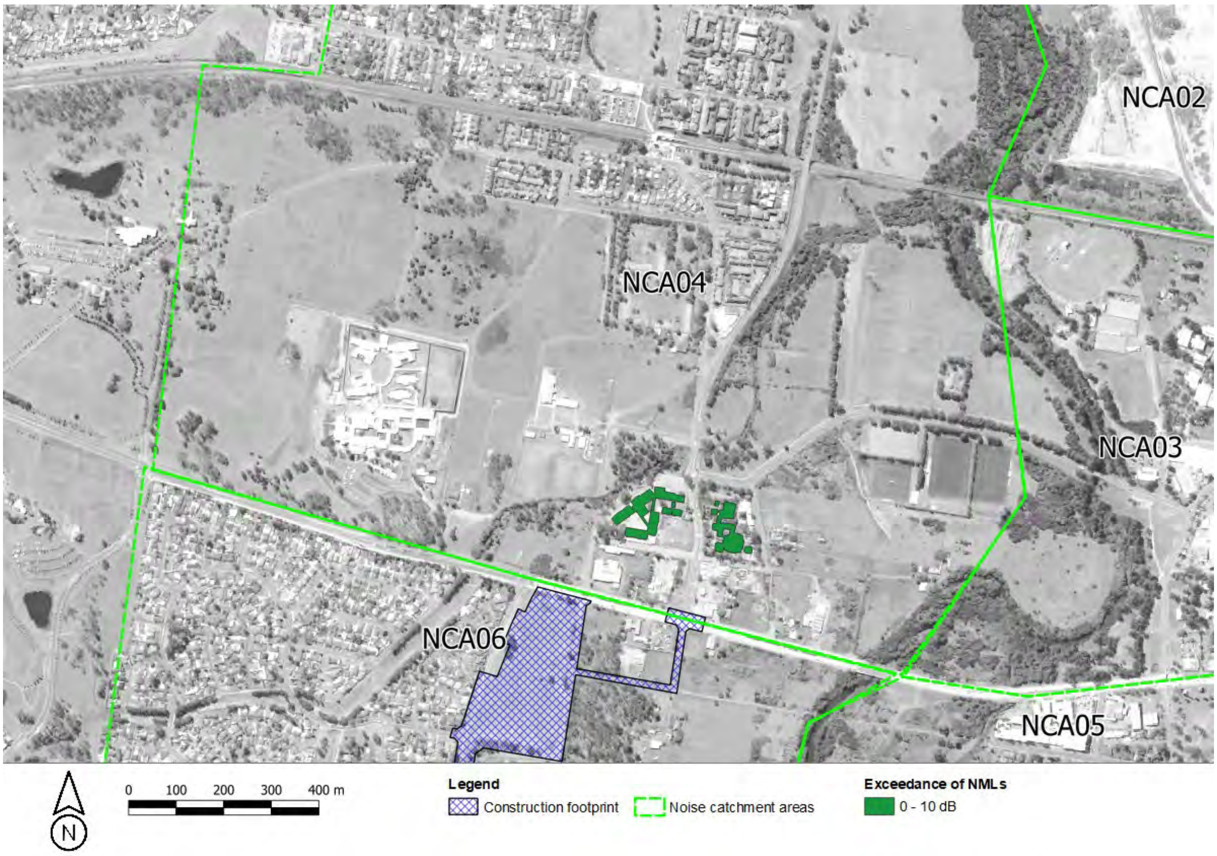


Figure 4-14 NCA04 NML exceedances – non-residential receivers – typical construction

Exceedances of NMLs are predicted at Kurrambee School during site establishment, tunnelling and associated works, earthworks and excavation, and finishing works (Scenarios 1, 2, 4, and 9).

The identified receivers are predicted to be most affected during excavation and earthworks (Scenario 4). The construction noise during this scenario is most influenced by hydraulic hammers during excavation works at Claremont Meadows services facility, exceeding NMLs by up to 6 to 10 dB. The hydraulic hammers are expected to be used intermittently for around 6 months during the construction period.

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which may reduce the number of exceedances of NMLs by around 30 to 50%.

NCA05 (St Marys, south of Great Western Highway, north of M4 Western Motorway)

The location of the construction footprint within NCA05 is shown below in Figure 4-15.

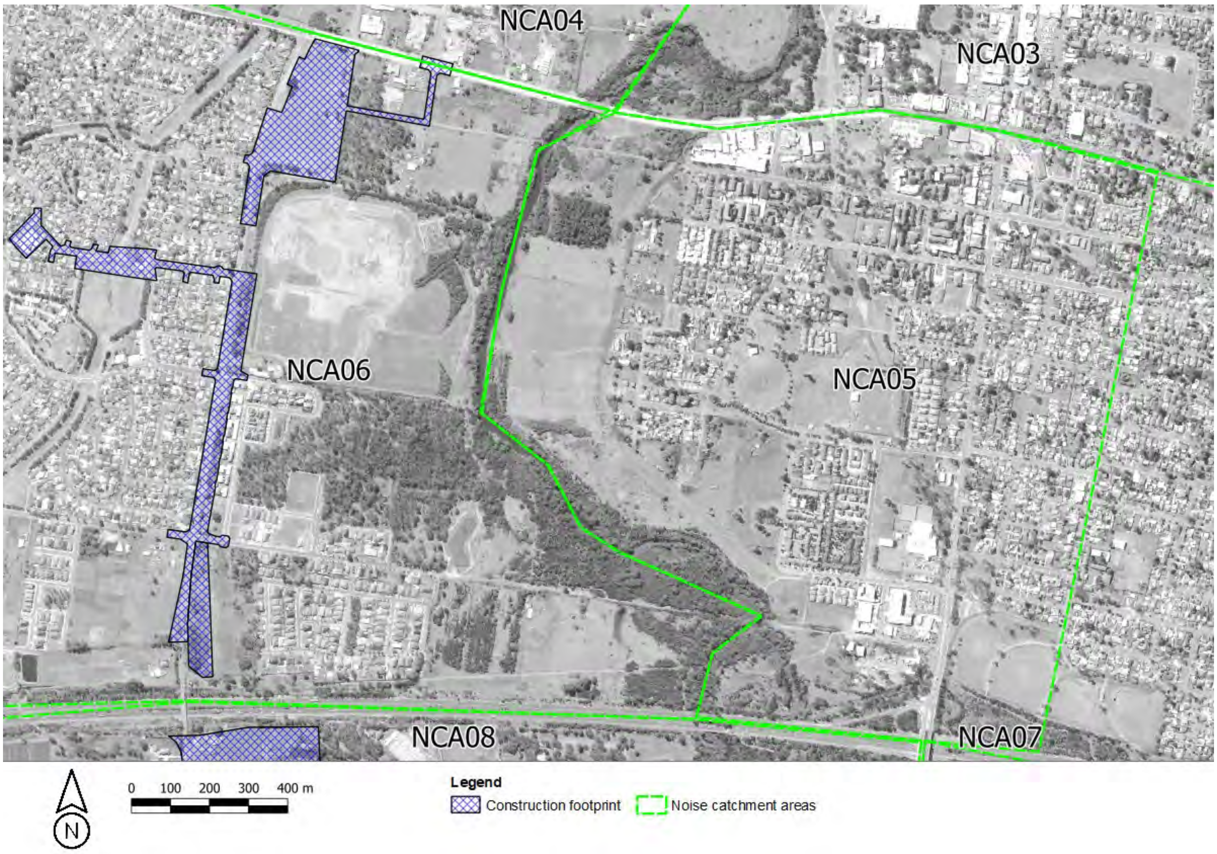


Figure 4-15 NCA05 construction areas

A total of 1051 noise sensitive receivers were assessed for NCA05. The predicted NML exceedances within NCA05 are presented in Table 4-14. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of sleep disturbance and awakening screening levels, or highly noise affected management levels are predicted to occur within NCA05.

Table 4-14 NCA05 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Number of receivers exceeding NML – typical and (worst case)											
	Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	272 (594)	2 (169)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	216 (476)	3 (73)	0 (0)	2 (2)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)
SC03 - Bridge and viaduct construction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	509 (719)	40 (189)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	53 (473)	0 (171)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC06 - Construction of stabling and maintenance and other ancillary facilities	0 (96)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	17 (38)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	17 (192)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	308 (648)	1 (86)	0 (0)	0 (76)	0 (0)	0 (0)	0 (76)	0 (0)	0 (0)	0 (76)	0 (0)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Schleicher Street. Some of the highest impact works occur during:

- Site establishment (Scenario 1) - predicted noise levels are most influenced by the use of concrete saws
- Tunnelling and associated works (Scenario 2) – predicted noise levels are most influenced by the use of hydraulic hammers
- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station and portal excavation works at Orchard Hills and excavation works at Claremont Meadows, exceeding NMLs by up to 15 dB to 20 dB. Figure 4-16 shows the distribution of NML exceedances during this activity for residential receivers within NCA05.

The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 5 dB.

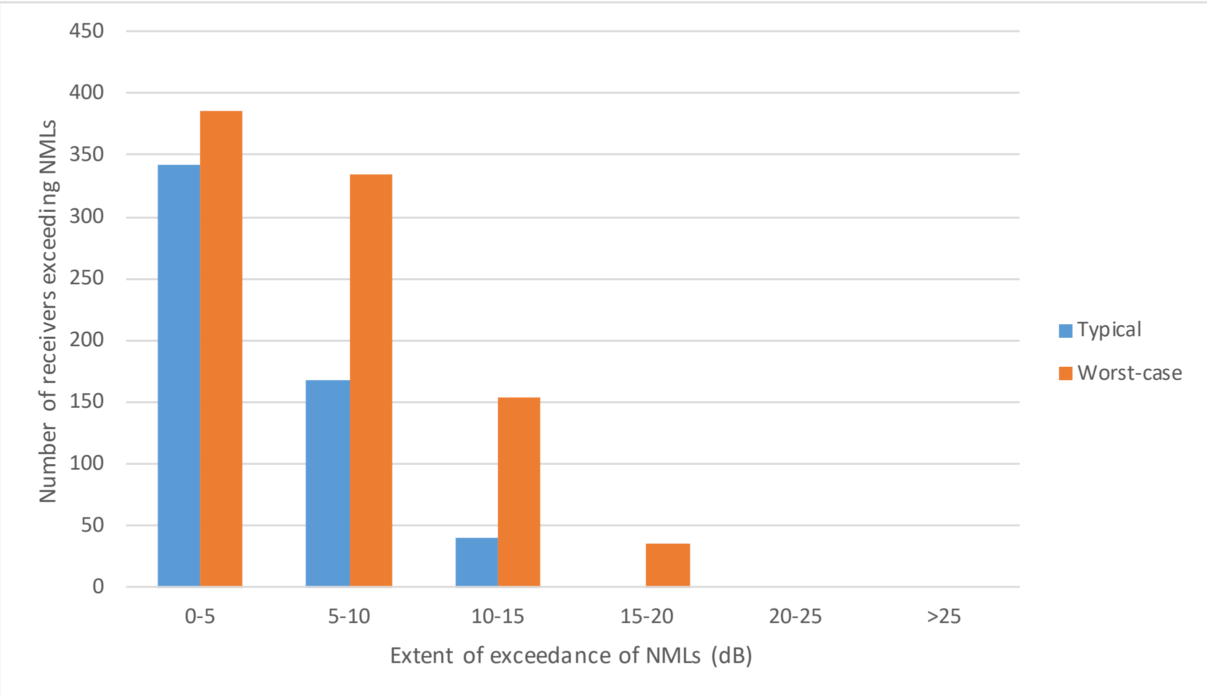


Figure 4-16 NCA05 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA05 only experiences exceedances during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

Residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of the TBMs at Orchard Hills, exceeding NMLs by up to 2 dB. Figure 4-17 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA05. Only two residential receivers are exceeding out-of-hours NMLs and may experience a <5 dB exceedance, with the rest of the receivers in this NCA subject to noise levels below out-of-hours NMLs during typical construction.

Airborne noise from the TBMs is expected to be audible for a period of around one month during each of the two TBM launches, with approximately three months respite in between.

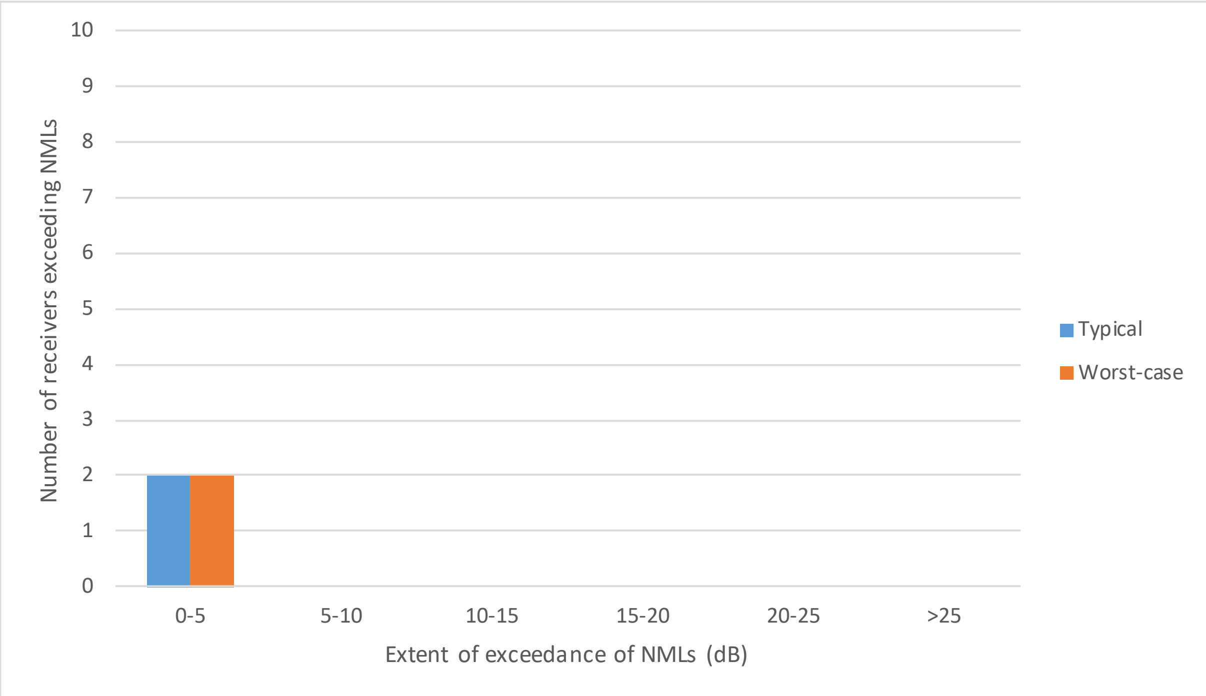


Figure 4-17 NCA05 NML exceedances – out-of-hours – tunnelling and associated works

Summary of non-residential receivers

Figure 4-18 shows the non-residential receivers predicted to experience exceedances during construction.

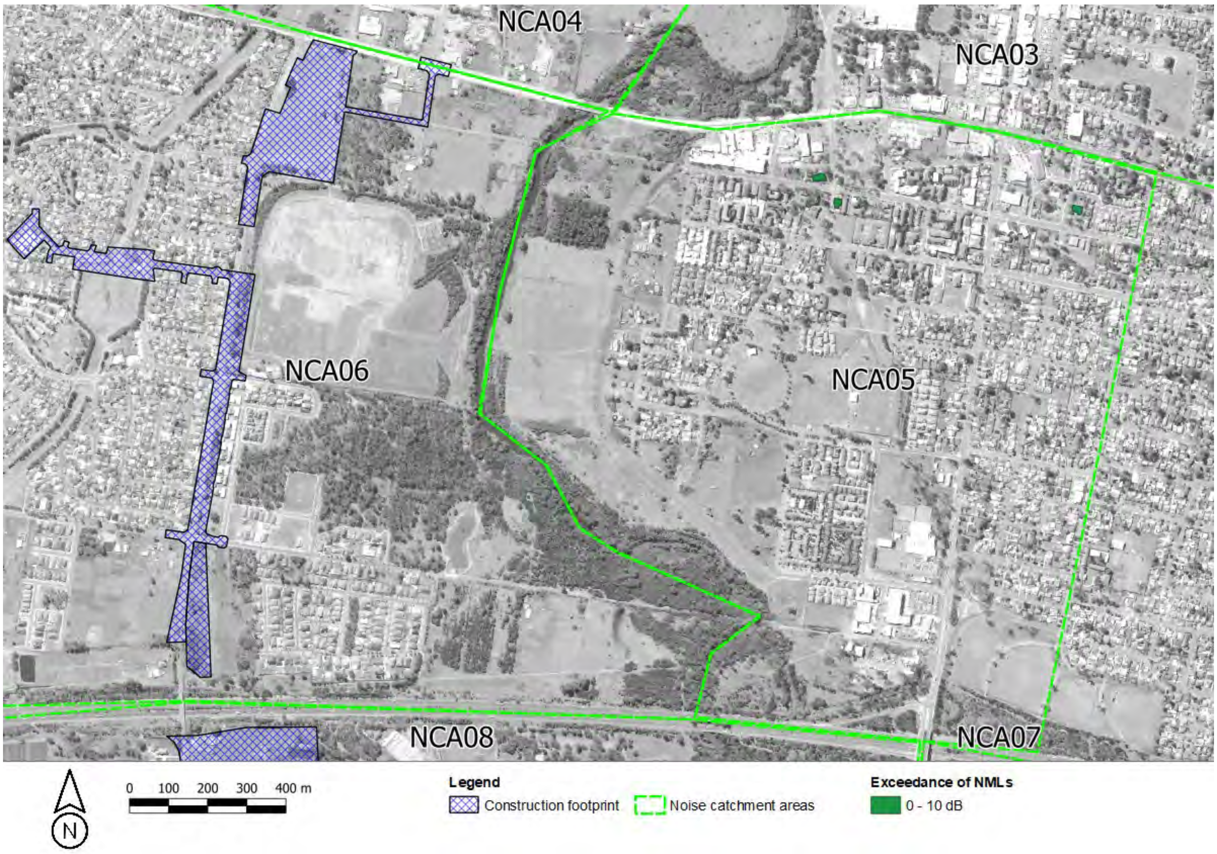


Figure 4-18 NCA05 NML exceedances – non-residential receivers – typical construction

Exceedances of NMLs are predicted at Mirrabooka Study Centre, My First School Daycare Centre, and Koala Corner Children's Centre during earthworks and excavation (Scenario 4), and at Koala Corner Children's Centre during finishing works (Scenario 9).

The identified receivers are predicted to be most affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is most influenced by hydraulic hammers during excavation works at Claremont Meadows services facility and St Marys, exceeding NMLs by up to 5 to 9 dB at Mirrabooka Study Centre, 4 to 8 dB at My First School Daycare Centre, and 8 to 12 dB at Koala Corner Children's Centre. The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period.

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which may reduce the number of exceedances of NMLs by around 30 to 50%.

NCA06 (Claremont Meadows)

The location of the construction footprint within NCA06 is shown below in Figure 4-19.

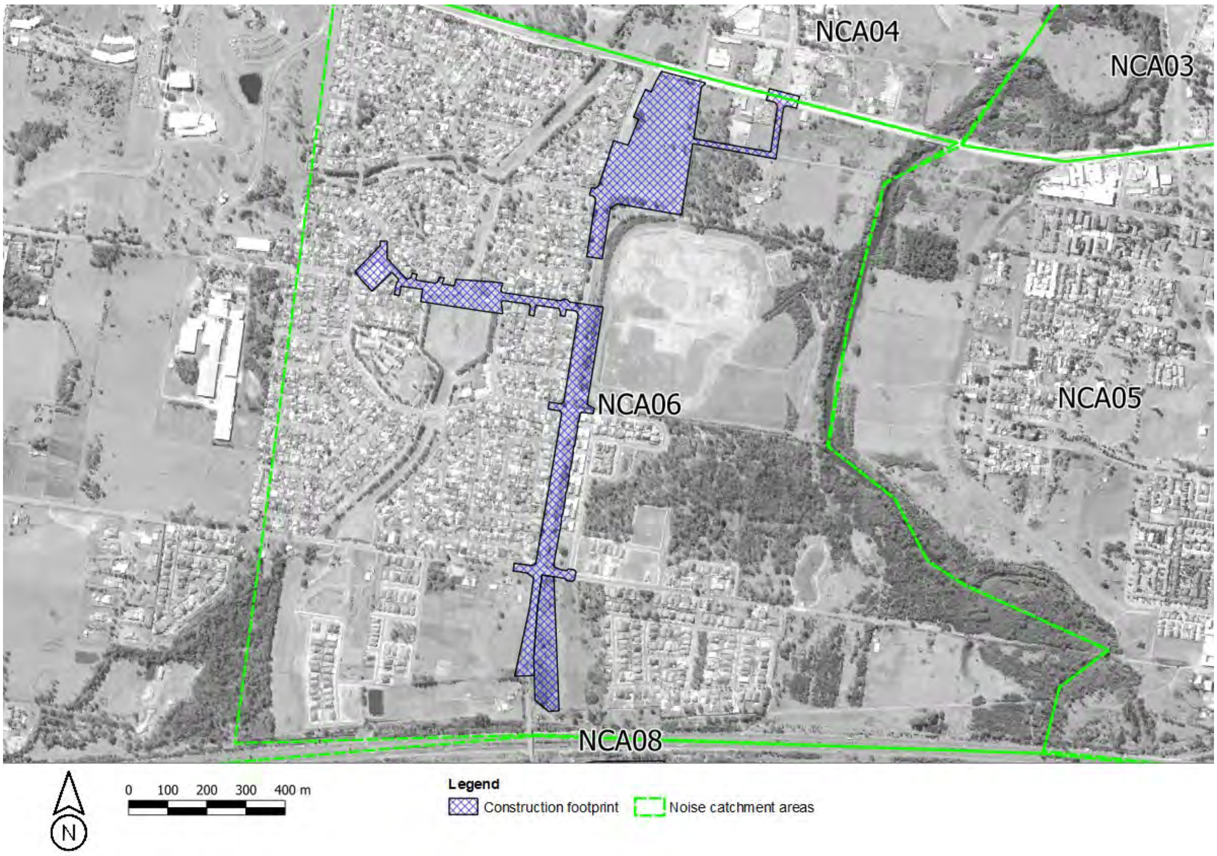


Figure 4-19 NCA06 construction areas

A total of 1315 noise sensitive receivers were assessed for NCA06. The predicted NML exceedances within NCA06 are presented in Table 4-15. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods.

Table 4-15 NCA06 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Highly noise affected	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
			Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
			0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	0 (31)	N/A	818 (155)	373 (861)	12 (271)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	0 (8)	5	788 (531)	314 (642)	18 (109)	57 (57)	19 (19)	0 (0)	187 (187)	39 (39)	4 (4)	235 (235)	38 (38)	6 (6)
SC03 - Bridge and viaduct construction	0 (0)	N/A	113 (118)	9 (40)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	2 (16)	N/A	762 (344)	427 (738)	52 (203)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	0 (10)	N/A	385 (415)	78 (687)	3 (184)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	0 (0)	N/A	46 (73)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	0 (0)	0	277 (331)	64 (178)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	0 (0)	N/A	292 (621)	18 (94)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	0 (4)	43	782 (544)	315 (634)	15 (104)	115 (608)	3 (58)	0 (0)	374 (785)	20 (287)	0 (7)	451 (785)	27 (363)	0 (12)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The worst affected receivers are predicted to be located along Doncaster Avenue. Some of the highest impact works occur during:

- Site establishment (Scenario 1) - predicted noise levels are most influenced by the use of concrete saws
- Tunnelling and associated works (Scenario 2) – predicted noise levels are most influenced by the use of hydraulic hammers
- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station and portal excavation works at Orchard Hills and Claremont Meadows services facility, exceeding NMLs by up to 28 dB to 33 dB. Figure 4-20 shows the distribution of NML exceedances during this activity for residential receivers within NCA06.

These hydraulic hammers are expected to be used intermittently for around 8 months of the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 5 dB.

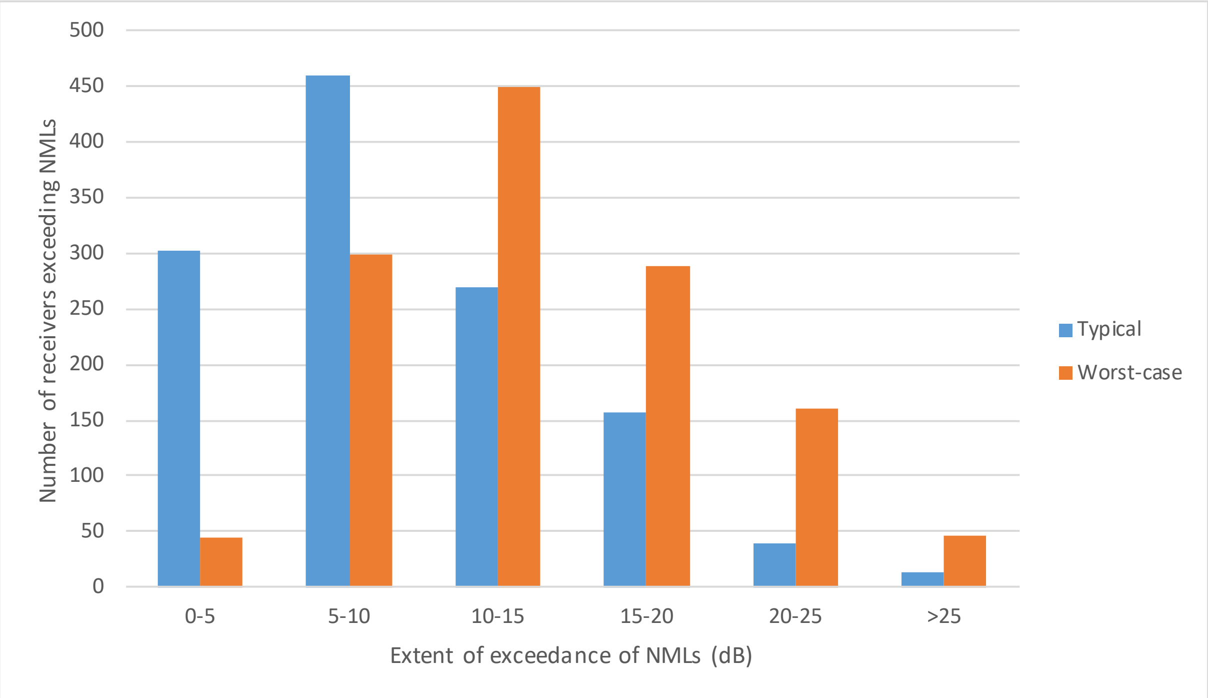


Figure 4-20 NCA06 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA06 only experiences exceedances during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Exceedances are associated with the operation of the TBMs at Orchard Hills during tunnelling and associated activities, and testing and commissioning of the Orchard Hills construction site during finishing works. Exceedances of sleep disturbance and awakening screening levels are predicted to occur during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

While a greater number of receivers exceed NMLs during finishing works, receivers are expected to be subjected to NML exceedances more consistently during tunnelling and associated works. Therefore, residential receivers are expected to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of the TBMs at Orchard Hills, exceeding NMLs by up to 22 dB. Figure 4-21 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA06. Most residential receivers exceeding out-of-hours NMLs may experience a <20 dB exceedance, while 18 receivers are predicted to experience an exceedance >20 dB.

The exceedances of the sleep disturbance and awakening screening levels during testing and commissioning as part of finishing works, and are a result of the use of heavy vehicles, exceeding by up to 14 dB.

Airborne noise from the TBMs is expected to be audible for a period of around one month during each of the two TBM launches, with approximately three months respite in between.

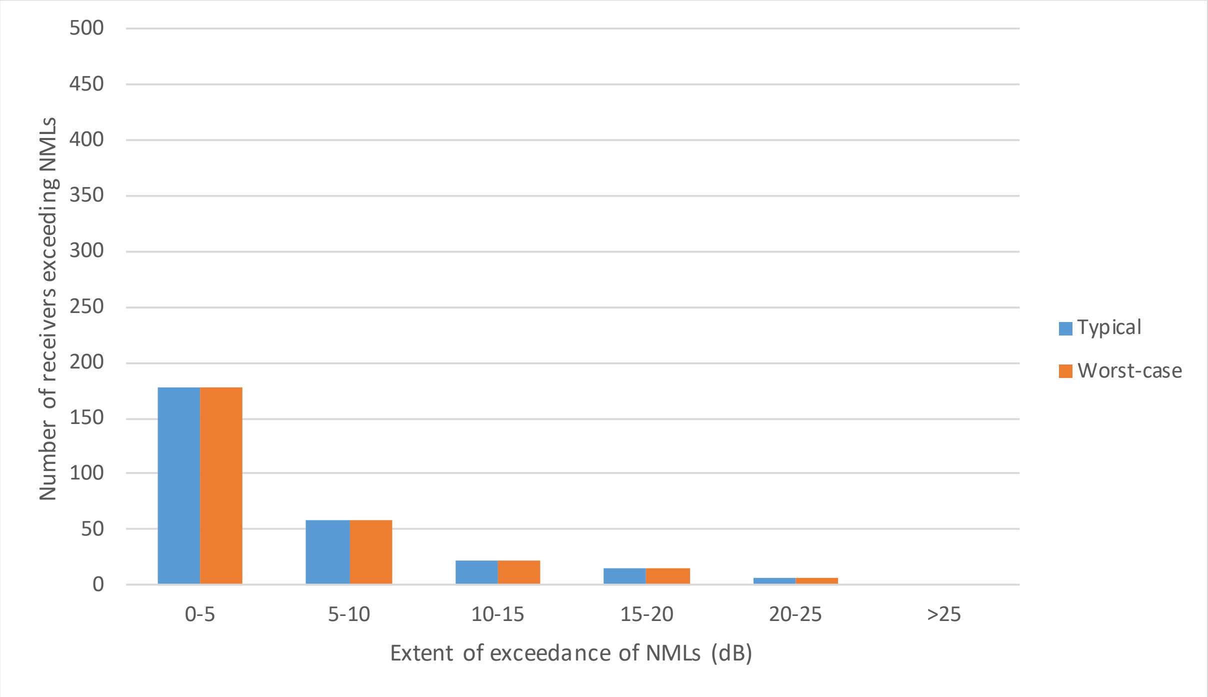


Figure 4-21 NCA06 NML exceedances – out-of-hours – tunnelling and associated works

Summary of non-residential receivers

Figure 4-22 shows the non-residential receivers predicted to experience exceedances during construction.

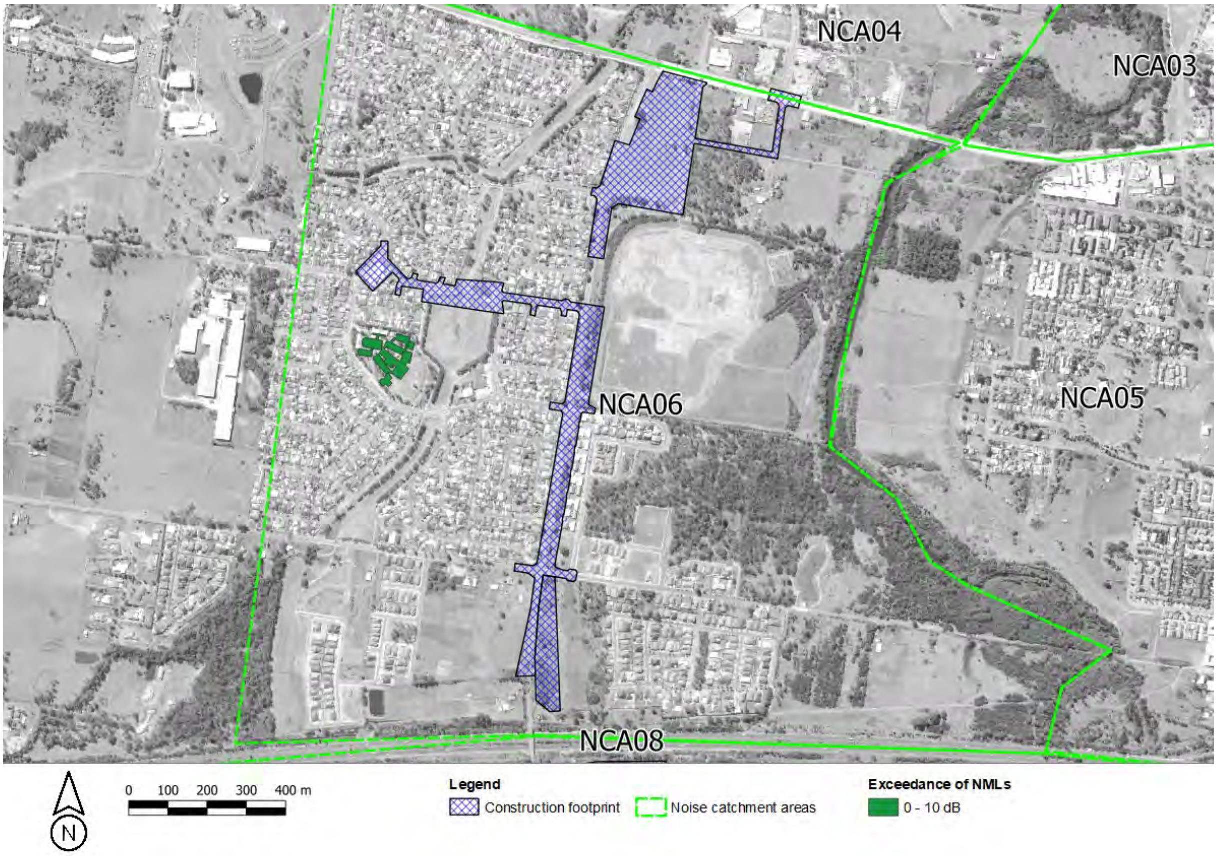


Figure 4-22 NCA06 NML exceedances – non-residential receivers – typical construction

Exceedances of NMLs are predicted at Claremont Meadows Public School during all scenarios, except construction of ancillary facilities, and station and rail fitout works (Scenarios 6, 7, and 8).

The identified receivers are predicted to be most affected during excavation and earthworks (Scenario 4). The exceedances of NMLs during this scenario is as a result of hydraulic hammers during excavation works at Claremont Meadows services facility and Orchard Hills, exceeding NMLs by up to 8 to 13 dB.

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which may reduce the number of exceedances of NMLs by around 30 to 50%.

NCA07 (St Claire)

The location of the construction footprint relative to NCA07 is shown below in Figure 4-23.

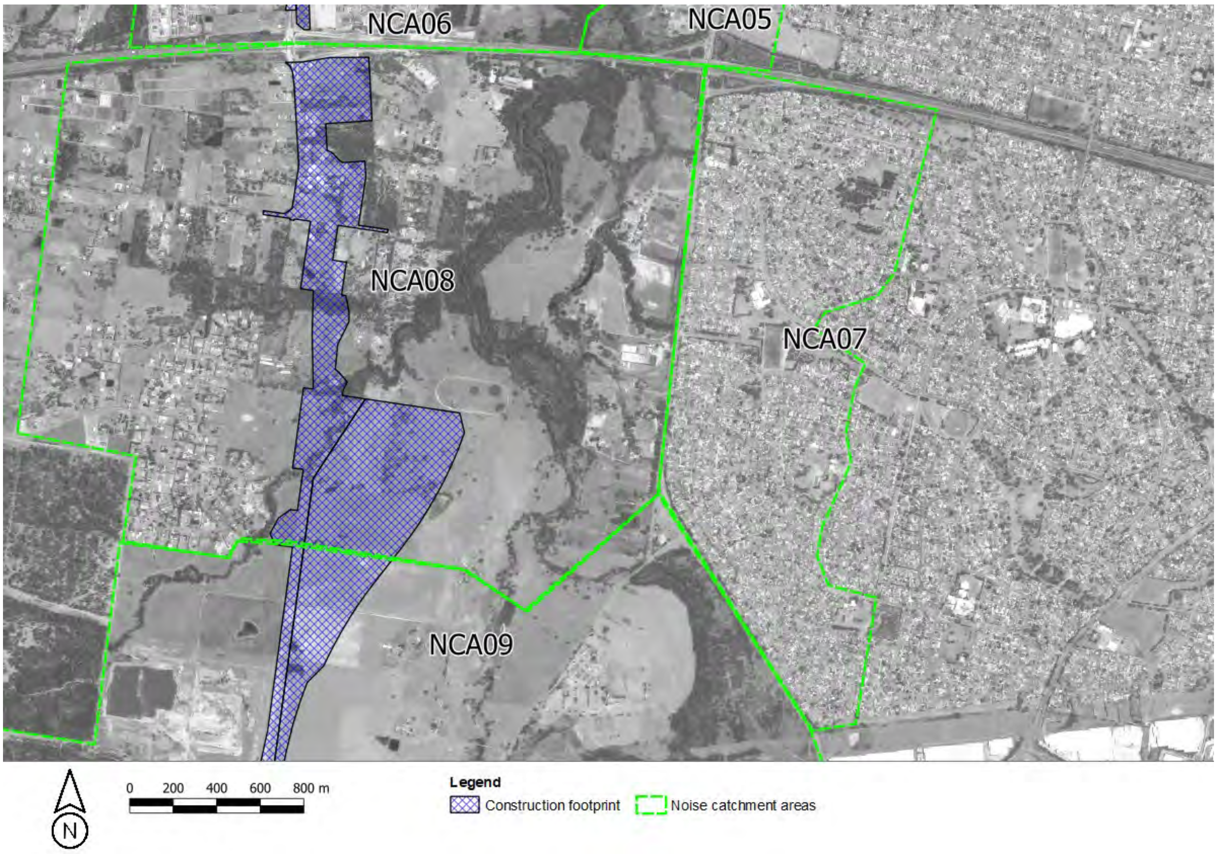


Figure 4-23 NCA07 construction areas

A total of 999 noise sensitive receivers were assessed for NCA07. The predicted NML exceedances within NCA07 are presented in Table 4-16. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of highly noise affected management levels are predicted to occur within NCA07.

Table 4-16 NCA07 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Number of receivers exceeding NML – typical and (worst case)											
	Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	28 (97)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	41 (188)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	63 (63)	0 (0)	0 (0)
SC03 - Bridge and viaduct construction	49 (146)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	226 (435)	0 (19)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	0 (125)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	52 (99)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	78 (231)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	0 (0)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	78 (259)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	103 (295)	0 (10)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Mamre Road. Residential receivers are predicted to be most affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station and portal excavation works at Orchard Hills, exceeding NMLs by up to 7 dB to 12 dB. Figure 4-24 shows the distribution of NML exceedances during this activity for residential receivers within NCA07.

The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 5 dB.

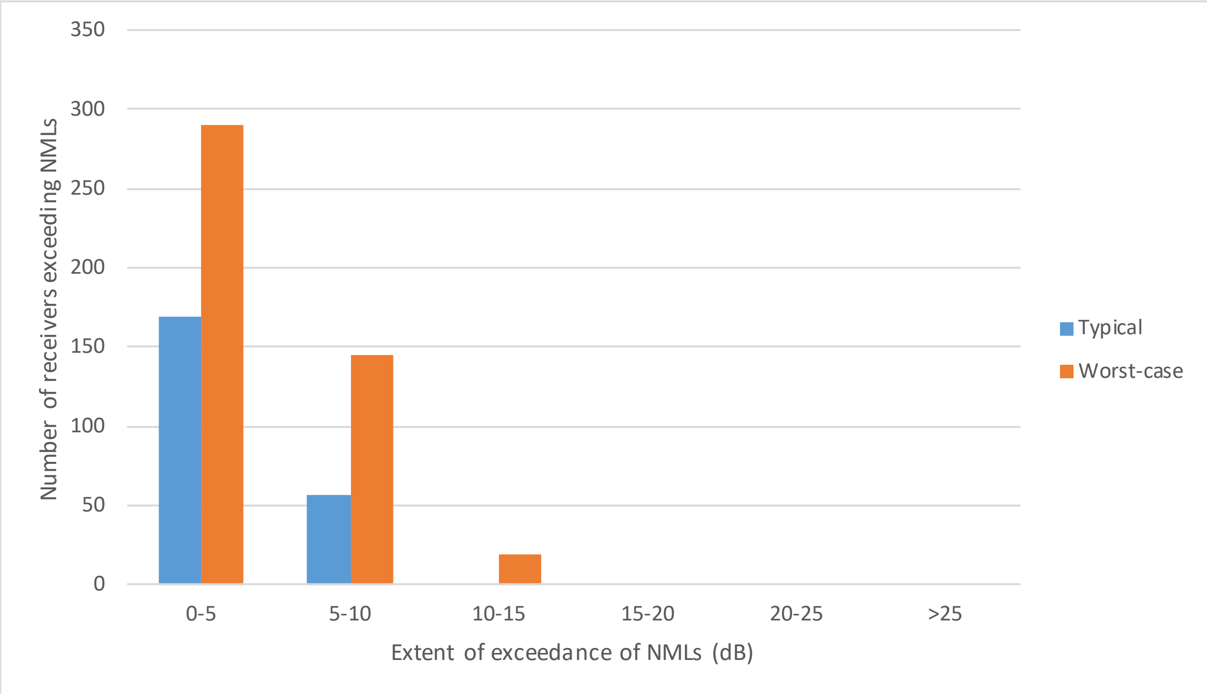


Figure 4-24 NCA07 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA07 only experiences exceedances during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

While a greater number of receivers exceed NMLs during finishing works, receivers are expected to be subjected to NML exceedances more consistently with the operation of the TBMs during tunnelling and associated works. Hence, residential receivers are expected to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of the TBM at St Marys, exceeding NMLs by up to 7 dB. Figure 4.25 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA07. Most residential receivers exceeding out-of-hours NMLs may experience a <5 dB exceedance, and only 12 receivers are predicted to experience an exceedance between 5 to 10 dB.

Airborne noise from the TBMs is expected to be audible for a period of around one month during each of the two TBM launches, with approximately three months respite in between.

No exceedances of sleep disturbance and awakening screening levels are predicted to occur.

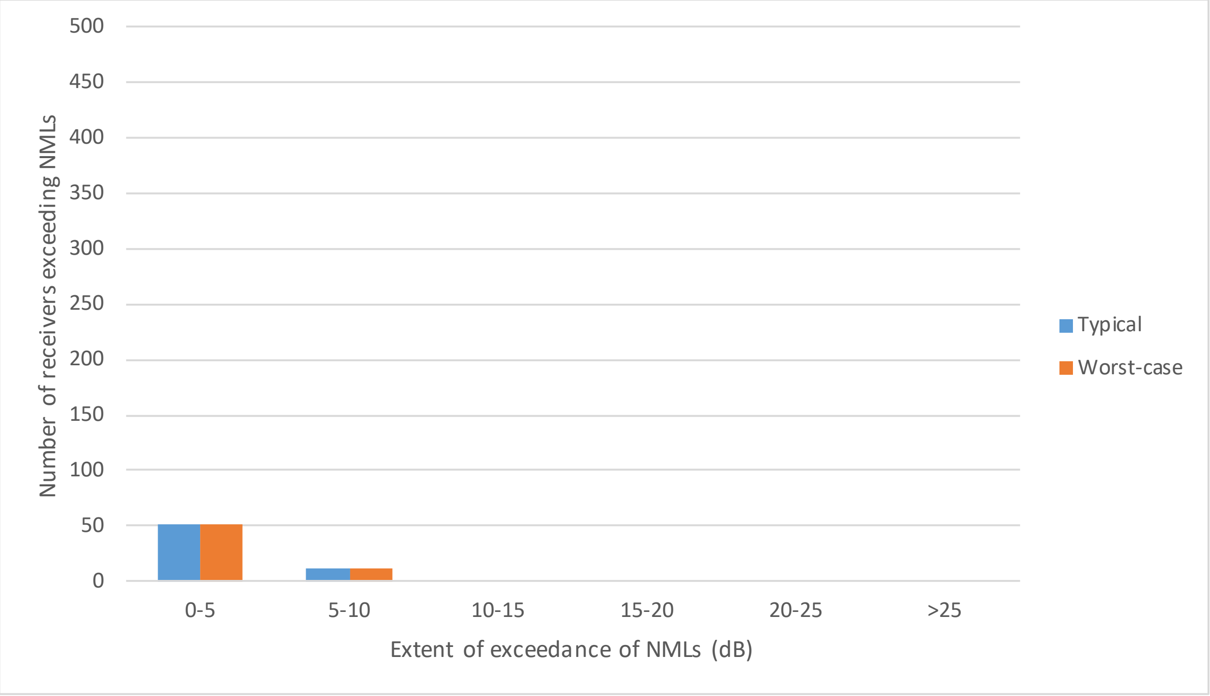


Figure 4.25 NCA07 NML exceedances – out-of-hours – tunnelling and associated works

Summary of non-residential receivers

Figure 4-26 shows the non-residential receivers predicted to experience exceedances during construction.

Figure 4-26 NCA07 NML exceedances – non-residential receivers – typical construction

No exceedances of NMLs are predicted at Banks Public School during station construction and station fitout works (Scenarios 5 and 8).

The identified receiver is predicted to be most affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is most influenced by hydraulic hammers during station and portal excavation works at Orchard Hills, exceeding NMLs by up to 7 to 11 dB at Banks Public school. The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period.

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which mat reduce the number of exceedances of NMLs by around 30 to 50%.

NCA08 (Orchard Hills, west of St Claire)

The location of the construction footprint within NCA08 is shown below in Figure 4-27.

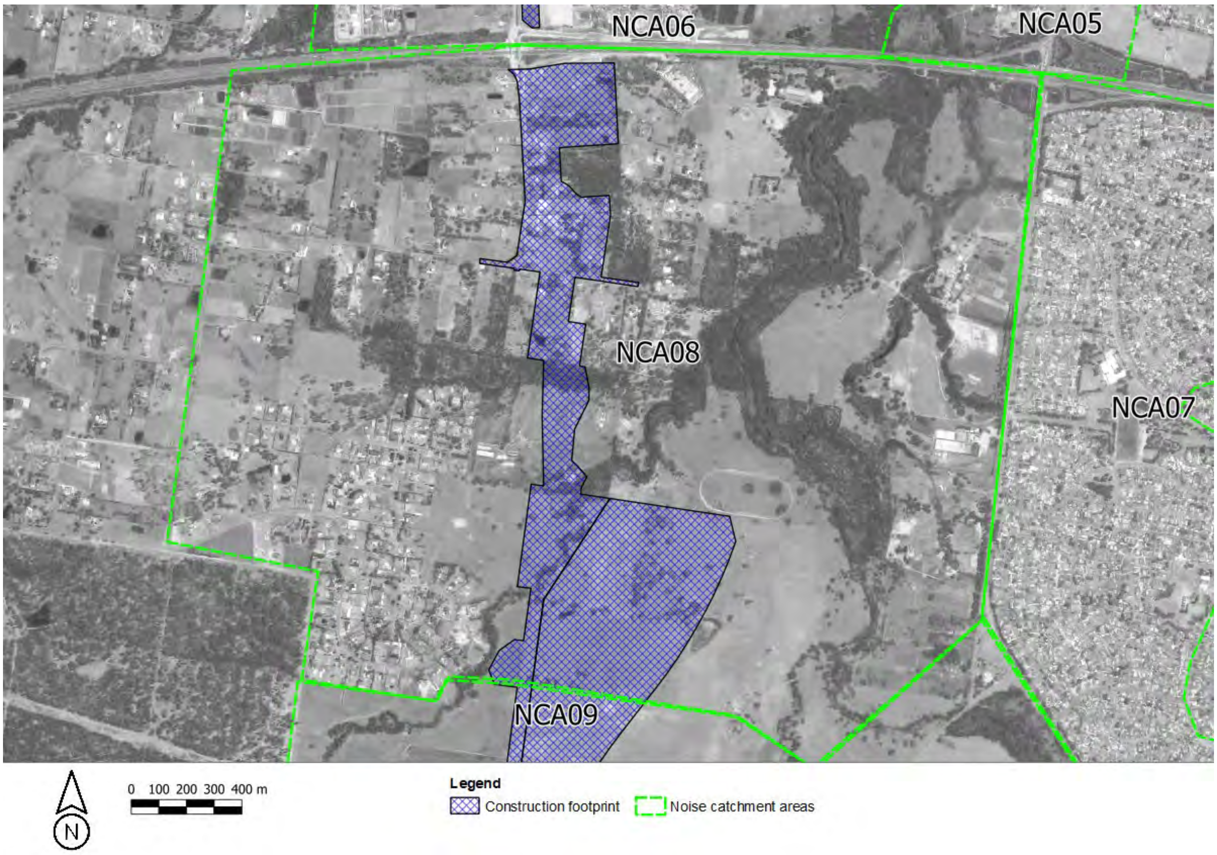


Figure 4-27 NCA08 construction areas

A total of 229 noise sensitive receivers were assessed for NCA08. The predicted NML exceedances within NCA08 are presented in Table 4-17. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of NMLs are predicted at non-residential receivers within NCA08.

Table 4-17 NCA08 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Highly noise affected	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
			Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
			0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	0 (1)	N/A	116 (72)	79 (124)	1 (1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	0 (19)	5	124 (74)	50 (89)	2 (29)	22 (22)	3 (3)	0 (0)	22 (22)	3 (3)	0 (0)	53 (53)	5 (5)	0 (0)
SC03 - Bridge and viaduct construction	0 (3)	N/A	95 (58)	85 (124)	0 (6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	18 (53)	N/A	13 (6)	157 (129)	28 (64)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	0 (9)	N/A	89 (98)	29 (74)	0 (15)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	0 (0)	N/A	140 (127)	25 (47)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	1 (6)	0	66 (23)	123 (157)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	0 (0)	N/A	125 (157)	2 (20)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	1 (26)	43	70 (10)	126 (153)	1 (36)	30 (57)	0 (9)	0 (0)	30 (57)	0 (9)	0 (0)	48 (93)	0 (29)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Kent Road. Some of the highest impact works occur during:

- Tunnelling and associated works (Scenario 2) – predicted noise levels are most influenced by the use of hydraulic hammers
- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station and portal excavation works at Orchard Hills, exceeding NMLs by up to 26 dB to 29 dB. Figure 4-28 shows the distribution of NML exceedances during this activity for residential receivers within NCA08.

The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 5 dB.

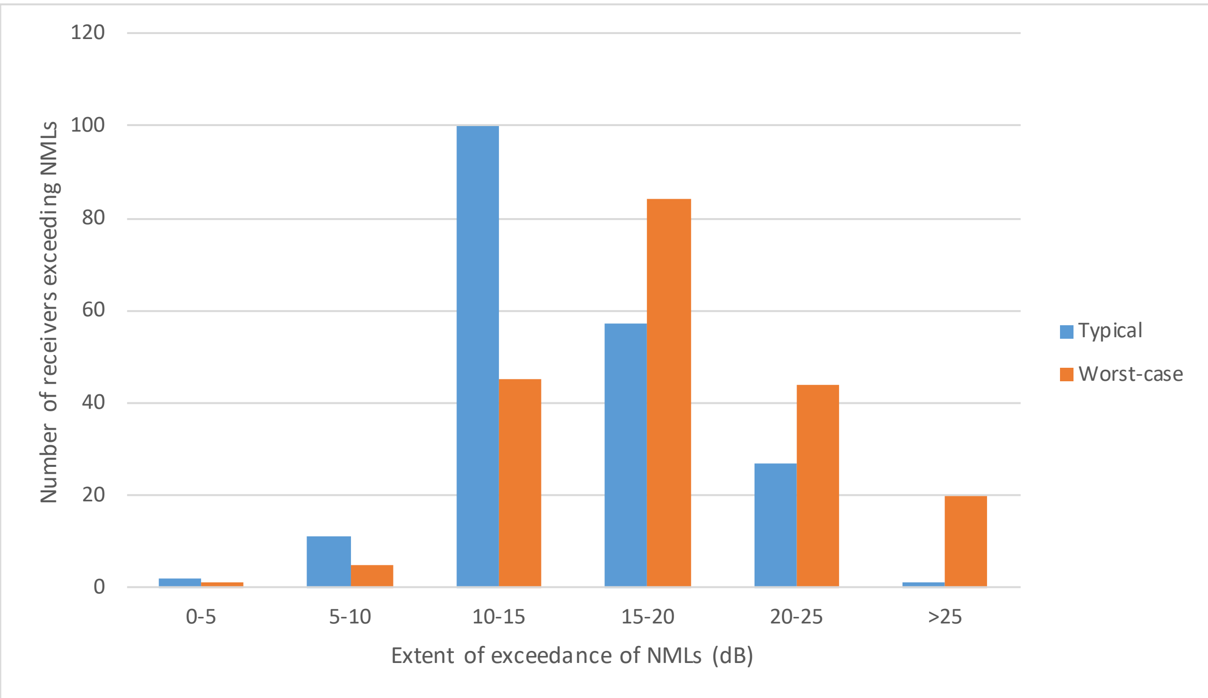


Figure 4-28 NCA08 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA08 only experiences exceedances during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

Residential receivers are predicted to be most affected with the operation of the TBMs during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of the TBM at St Marys, exceeding NMLs by up to 17 dB. Figure 4-29 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA08.

Airborne noise from the TBMs is expected to be audible for a period of around one month during each of the two TBM launches, with approximately three months respite in between.

Exceedances of sleep disturbance and awakening screening levels are predicted to occur during tunnelling and associated works, and finishing works (Scenarios 2 and 9). The exceedances of the sleep disturbance and awakening screening levels during testing and commissioning as part of finishing works, are a result of the use of heavy vehicles, exceeding by up to 15 dB.

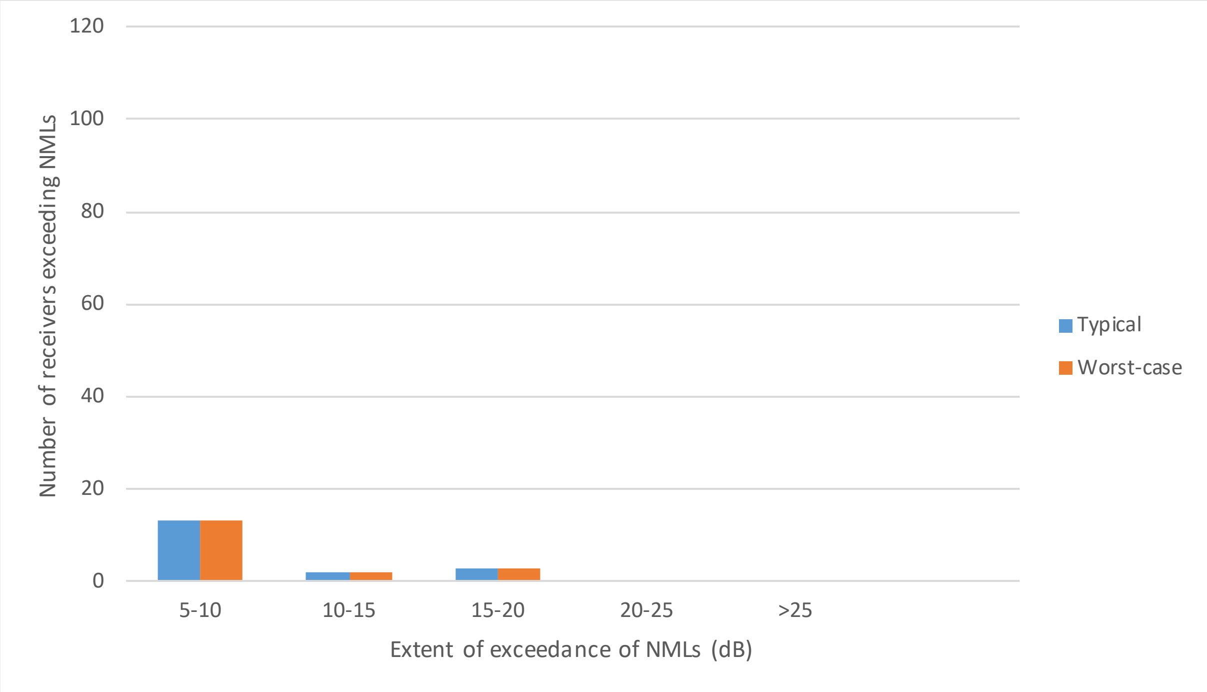


Figure 4-29 NCA08 NML exceedances – out-of-hours – tunnelling and associated works

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which mat reduce the number of exceedances of NMLs by around 30 to 50%.

NCA09 (Orchard Hills, north of the pipelines)

The location of the construction footprint within NCA09 is shown below in Figure 4-30.

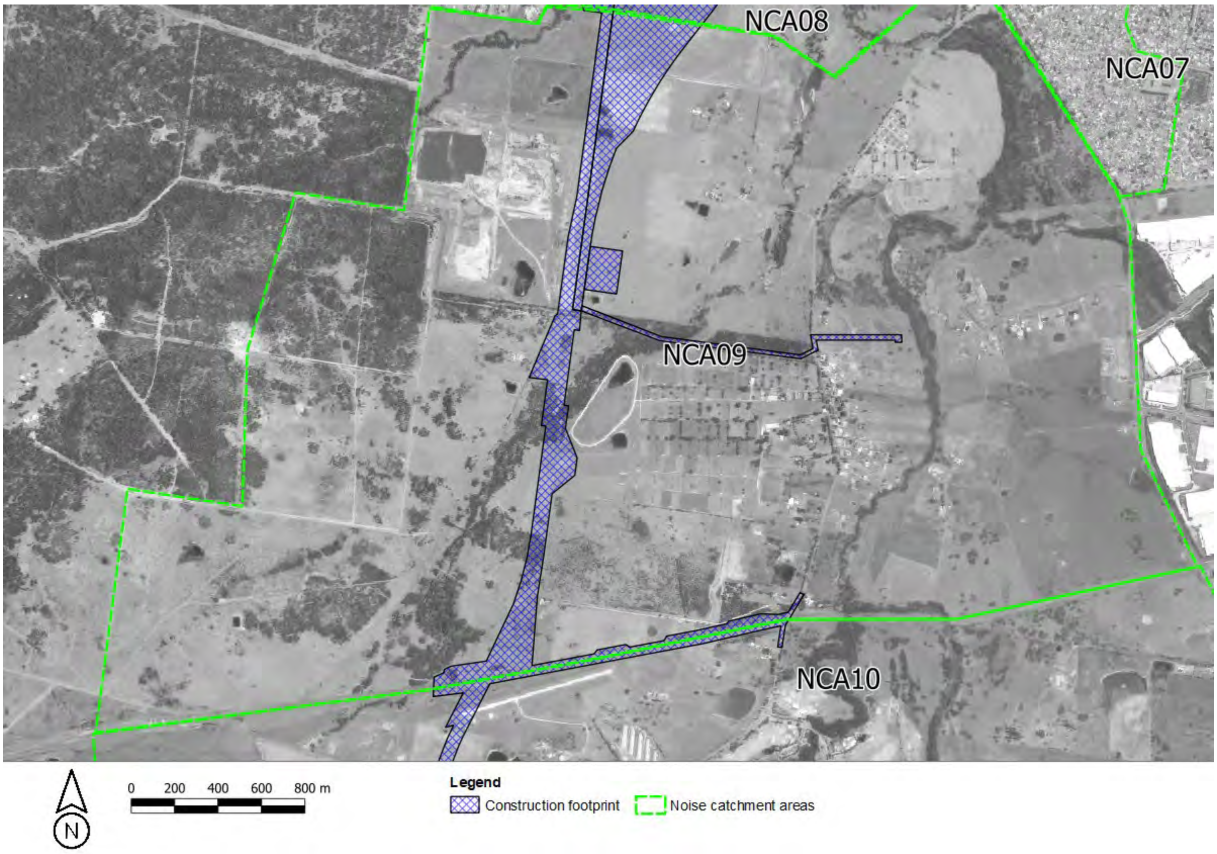


Figure 4-30 NCA09 construction areas

A total of 68 noise sensitive receivers were assessed for NCA09. The predicted NML exceedances within NCA09 are presented in Table 4-18. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of out-of-hours NMLs, highly noise affected management levels, at residential receivers, and no exceedances of NMLs at non-residential receivers are predicted to occur within NCA09.

Table 4-18 NCA09 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Number of receivers exceeding NML – typical and (worst case)											
	Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	30 (6)	13 (34)	0 (3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC03 - Bridge and viaduct construction	11 (7)	30 (33)	0 (2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	34 (29)	5 (10)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	1 (2)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	17 (22)	3 (6)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	23 (10)	18 (29)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC08 - Station fitout, precinct and transport integration works	7 (13)	0 (2)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	28 (12)	13 (29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Luddenham Road. Some of the highest impact works occur during:

- Enabling works (Scenario 1) – predicted noise levels are most influenced by the use of dozers
- Bridge and viaduct construction (Scenario 3) – predicted noise levels are most influenced by the use of hydraulic hammers
- Rail systems fitout (Scenario 7) – predicted noise levels are most influenced by the use of concrete vibrators, dozers, and loaders

Most residential receivers are predicted to be affected during bridge and viaduct construction (Scenario 3). The highest construction noise during this scenario is a result of the use of hydraulic hammers along the off-airport construction corridor, exceeding NMLs by up to 17 dB to 20 dB. Figure 4-31 shows the distribution of NML exceedances during this activity for residential receivers within NCA09.

The hydraulic hammers are expected to be used intermittently for around 12 months during the construction period. When in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 3 dB.

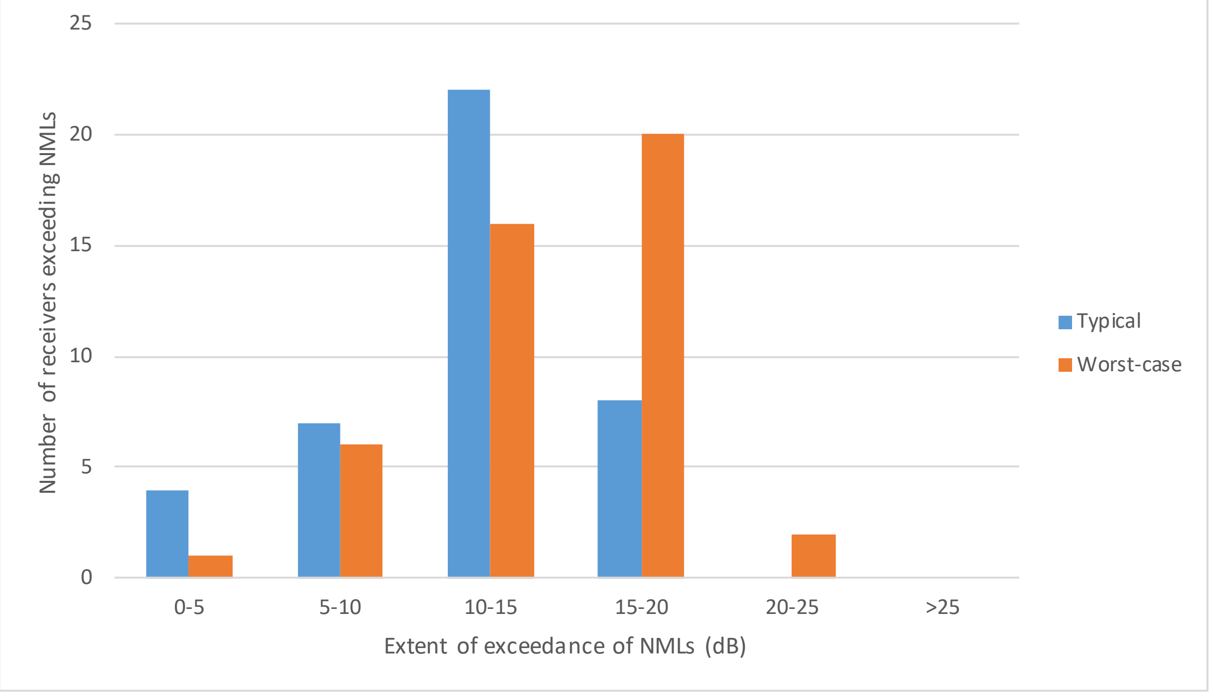


Figure 4-31 NCA09 NML exceedances – standard hours – bridge and viaduct construction

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS.

NCA10 (Luddenham, north of Elizabeth Drive)

The location of the construction footprint within NCA10 is shown below in Figure 4-32.

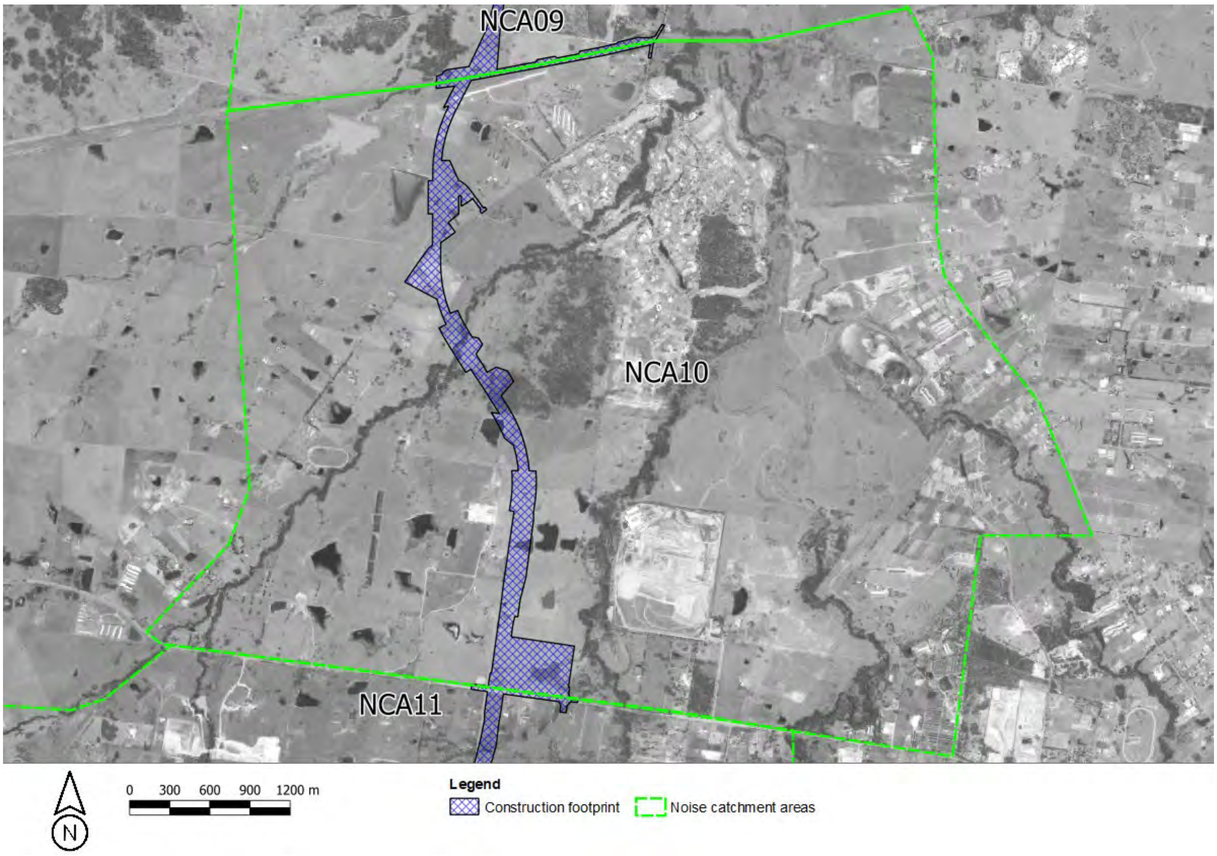


Figure 4-32 NCA10 construction areas

A total of 378 noise sensitive receivers were assessed for NCA10. The predicted NML exceedances within NCA10 are presented in Table 4-19. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of out-of-hours NMLs, highly noise affected management levels, at residential receivers, and no exceedances of NMLs at non-residential receivers are predicted to occur within NCA10.

Table 4-19 NCA10 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Number of receivers exceeding NML – typical and (worst case)											
	Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	93 (65)	245 (266)	3 (11)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC03 - Bridge and viaduct construction	105 (41)	212 (259)	3 (34)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	204 (171)	77 (127)	2 (3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	188 (70)	78 (207)	0 (5)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	0 (0)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	195 (165)	111 (155)	1 (1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC08 - Station fitout, precinct and transport integration works	205 (65)	50 (213)	0 (7)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	199 (78)	105 (240)	1 (6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Luddenham Road and along the western edge of Twin Creeks. Some of the highest impact works occur during:

- Enabling works (Scenario 1) – predicted noise levels are most influenced by the use of dozers
- Bridge and viaduct construction (Scenario 3) – predicted noise levels are most influenced by the use of hydraulic hammers
- Earthworks and excavation (Scenario 4) - predicted noise levels are most influenced by the use of dump trucks and graders
- Rail systems fitout (Scenario 7) – predicted noise levels are most influenced by the use of concrete vibrators, dozers, and loaders

Most residential receivers are predicted to be affected during bridge and viaduct construction (Scenario 3). The highest construction noise during this scenario is a result of the use of hydraulic hammers along the off-airport construction corridor, exceeding NMLs by up to 20 dB to 25 dB. Figure 4-33 shows the distribution of NML exceedances during this activity for residential receivers within NCA10.

The hydraulic hammers are expected to be used intermittently for around 12 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 3 dB.

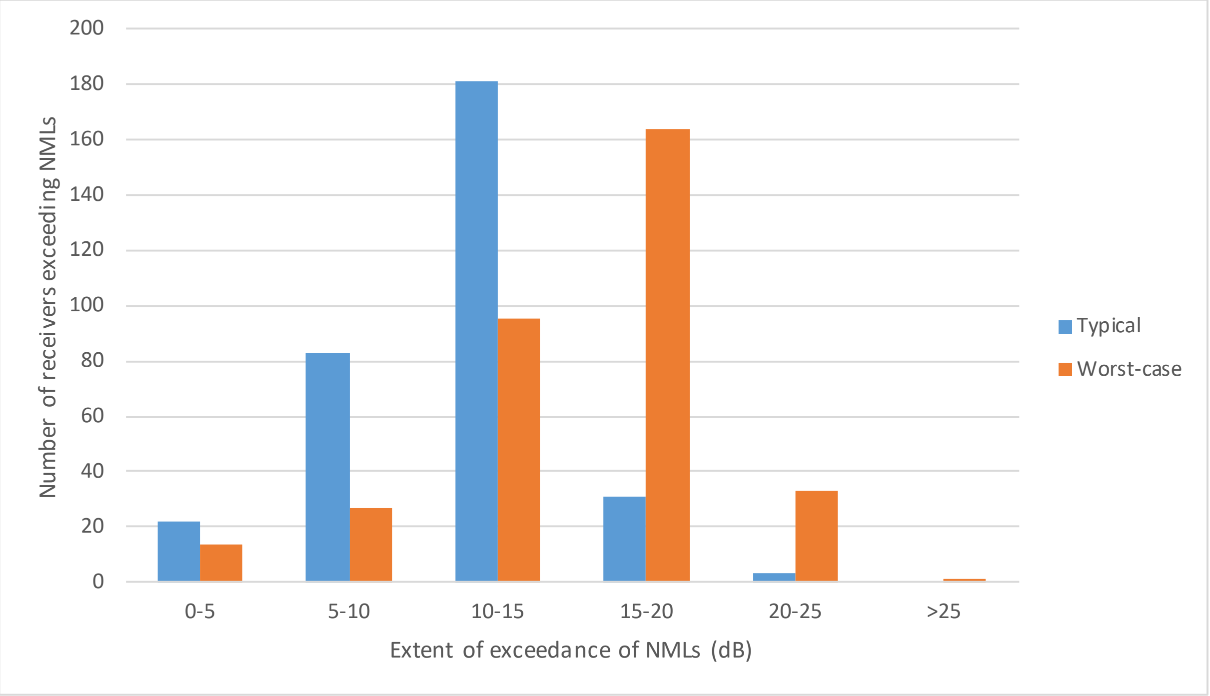


Figure 4-33 NCA10 NML exceedances – standard hours – bridge and viaduct construction

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS.

NCA11 (Luddenham and Badgerys Creek, south of Elizabeth Drive)

The location of the construction footprint within NCA11 is shown below in Figure 4-34.

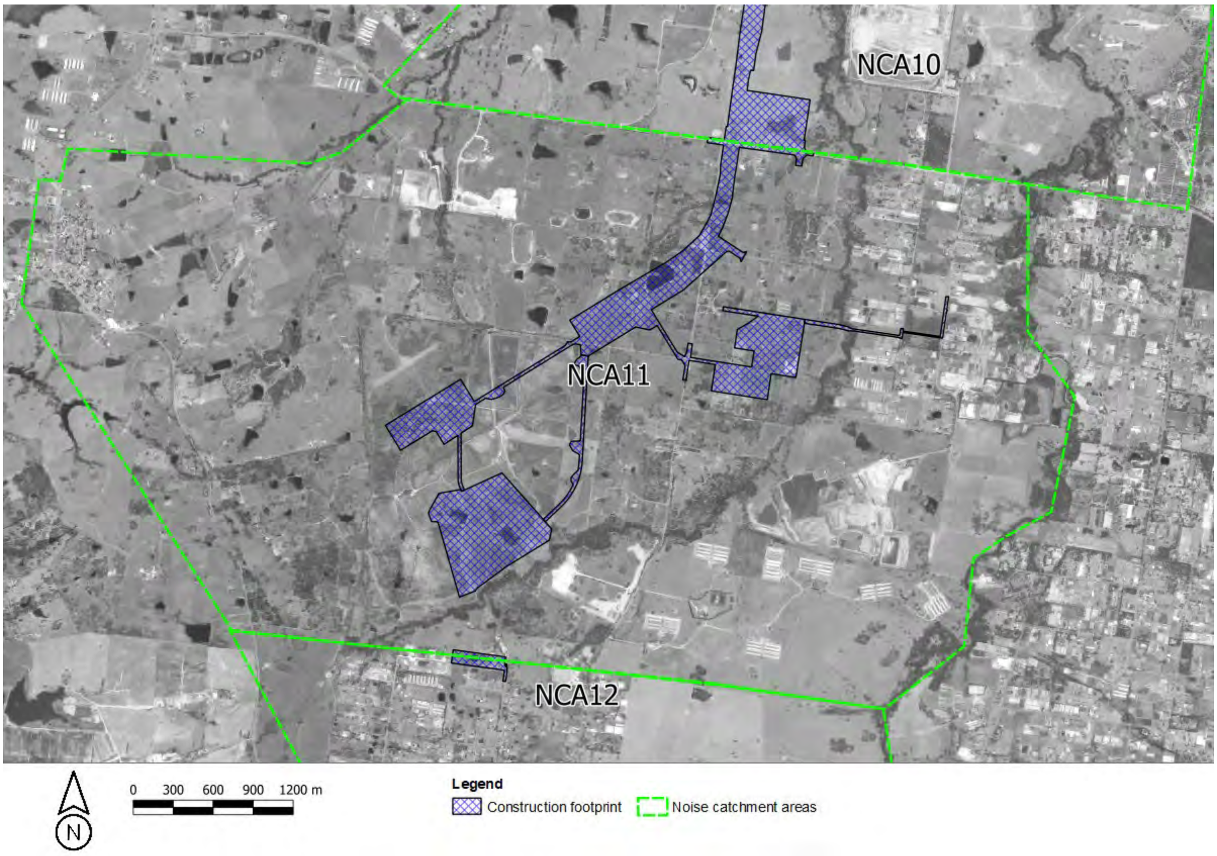


Figure 4-34 NCA11 construction areas

A total of 68 noise sensitive receivers were assessed for NCA11. The predicted NML exceedances within NCA11 are presented in Table 4-20. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of highly noise affected management levels at residential receivers, and no exceedances of NMLs at non-residential receivers are predicted to occur within NCA11.

Table 4-20 NCA11 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
		Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
		0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	N/A	43 (31)	0 (20)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	N/A	2 (0)	0 (2)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC03 - Bridge and viaduct construction	N/A	28 (21)	0 (12)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	N/A	30 (32)	2 (3)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	N/A	1 (1)	0 (1)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	N/A	23 (28)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC08 - Station fitout, precinct and transport integration works	N/A	0 (0)	2 (2)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	2	33 (29)	0 (8)	0 (0)	0 (2)	0 (0)	0 (0)	0 (2)	0 (0)	0 (0)	2 (0)	0 (2)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Lawson Road. Some of the highest impact works occur during:

- Enabling works (Scenario 1) – predicted noise levels are most influenced by the use of dozers
- Bridge and viaduct works (Scenario 3) – predicted noise levels are most influenced by the use of hydraulic hammers
- Earthworks and excavation (Scenario 4) - predicted noise levels are most influenced by the use of graders, dump trucks and dozers.
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of dump trucks and dozers.

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of graders, dump trucks and dozers during rail embankment cut works along the off-airport construction corridor, exceeding NMLs by up to 13 dB to 18 dB. Figure 4-35 shows the distribution of exceedances during this activity for residential receivers within NCA10.

These items of construction equipment are expected to be used for around 12 months of the construction period.

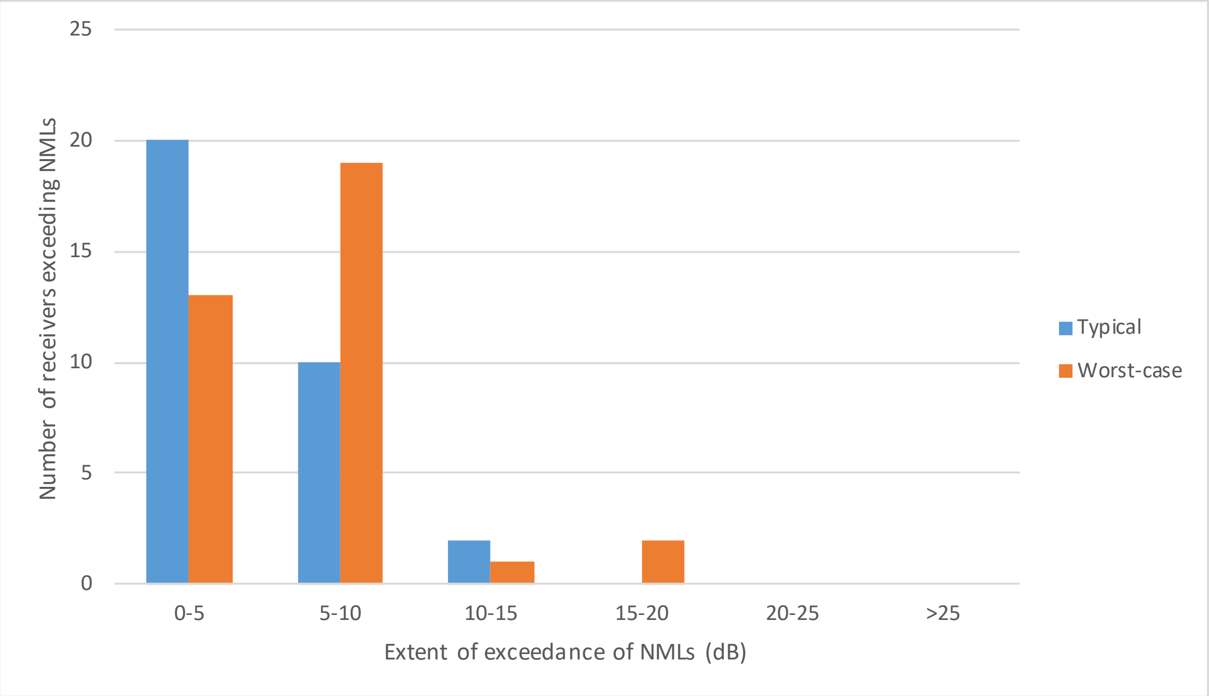


Figure 4-35 NCA11 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA11 only experiences exceedances during finishing works (Scenario 9).

Exceedances are associated with heavy vehicle movements during testing and commissioning at the Bringelly services facility, exceeding NMLs by up to 3 to 16dB. Figure 4-36 shows the distribution of NML exceedances during finishing works (Scenario 9) for residential receivers within NCA11.

Exceedances of sleep disturbance and awakening screening levels are only predicted to occur during finishing works (Scenario 9) and are a result of the use of heavy vehicle movements, exceeding by up to 6 dB. The heavy vehicles are expected to be periodically used for a period of around 12 months.

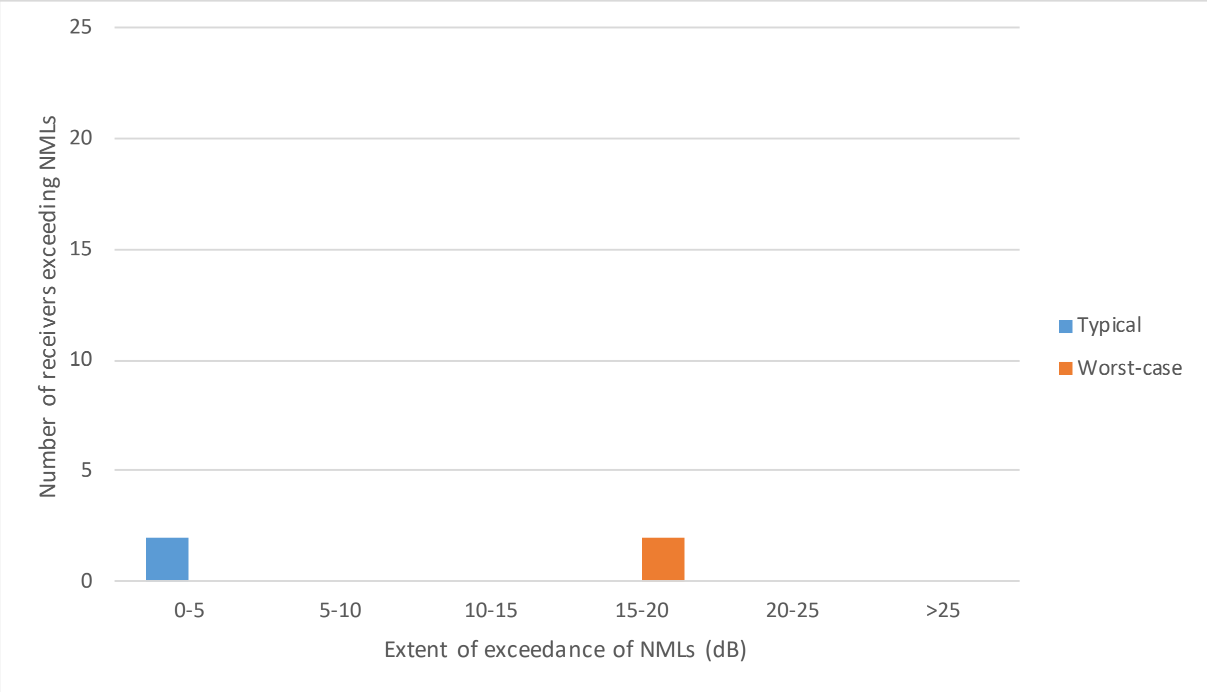


Figure 4-36 NCA11 NML exceedances – out-of-hours – finishing works

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS.

NCA12 (Bringelly)

The location of the construction footprint within NCA12 is shown below in Figure 4-37.

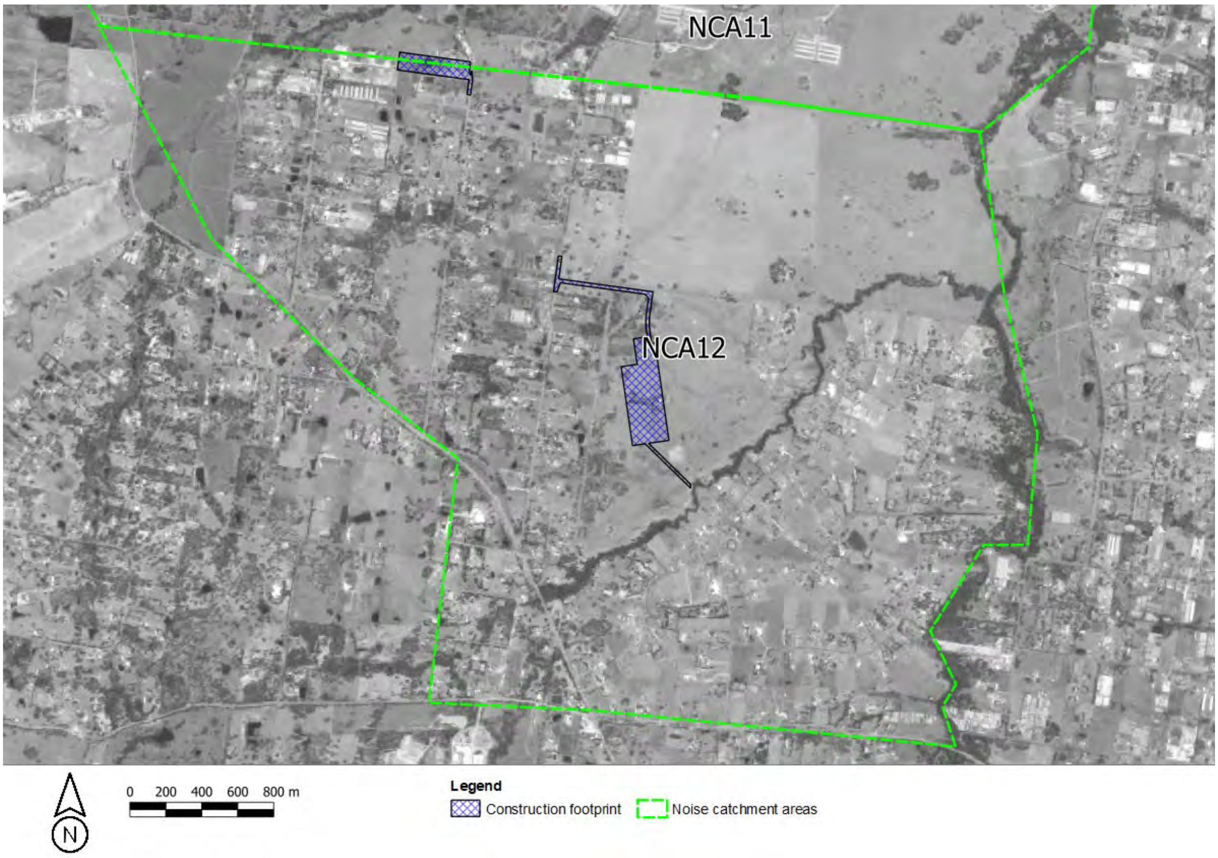


Figure 4-37 NCA12 construction areas

A total of 396 noise sensitive receivers were assessed for NCA12. The predicted NML exceedances within NCA12 are presented in Table 4-21. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods. No exceedances of highly noise affected management levels at residential receivers, and no exceedances of NMLs at non-residential receivers are predicted to occur within NCA12.

Table 4-21 NCA12 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Highly noise affected	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
			Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
			0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	0 (1)	N/A	227 (101)	105 (241)	1 (27)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	0 (0)	N/A	77 (45)	19 (69)	0 (6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC03 - Bridge and viaduct construction	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC04 - Earthworks and excavation	0 (9)	N/A	75 (31)	273 (179)	22 (173)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	0 (0)	N/A	220 (59)	96 (248)	0 (38)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	0 (0)	N/A	0 (0)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC08 - Station fitout, precinct and transport integration works	0 (2)	N/A	206 (51)	142 (264)	2 (58)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	0 (0)	30	114 (263)	1 (60)	0 (0)	4 (66)	0 (9)	0 (0)	11 (78)	0 (22)	0 (1)	14 (79)	1 (27)	0 (1)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Badgerys Creek Road and northern Dawson Road. Some of the highest impact works occur during:

- Enabling works (Scenario 1) – predicted noise levels are most influenced by the use of concrete vibrators and dump trucks at both the Bringelly service facility and Aerotropolis Core Station
- Earthworks and excavation (Scenario 4) - predicted noise levels are most influenced by the use of hydraulic hammers at both the Bringelly service facility and Aerotropolis Core Station
- Station construction (Scenario 5) - predicted noise levels are most influenced by the use of hydraulic hammers and concrete saws at Aerotropolis Core Station
- Station fitout, precinct and transport integration works (Scenario 8) – predicted noise levels are most influenced by the use of multiple mobile cranes at Bringelly service facility and Aerotropolis Core Station.

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of hydraulic hammers during station excavation works at the Aerotropolis Core Station, and excavation at the Bringelly service facility, exceeding NMLs by up to 23 dB to 29 dB. Figure 4-38 shows the distribution of exceedances during this activity for residential receivers within NCA12.

The hydraulic hammers are expected to be used intermittently for around 8 months during the construction period. When not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 3 dB.

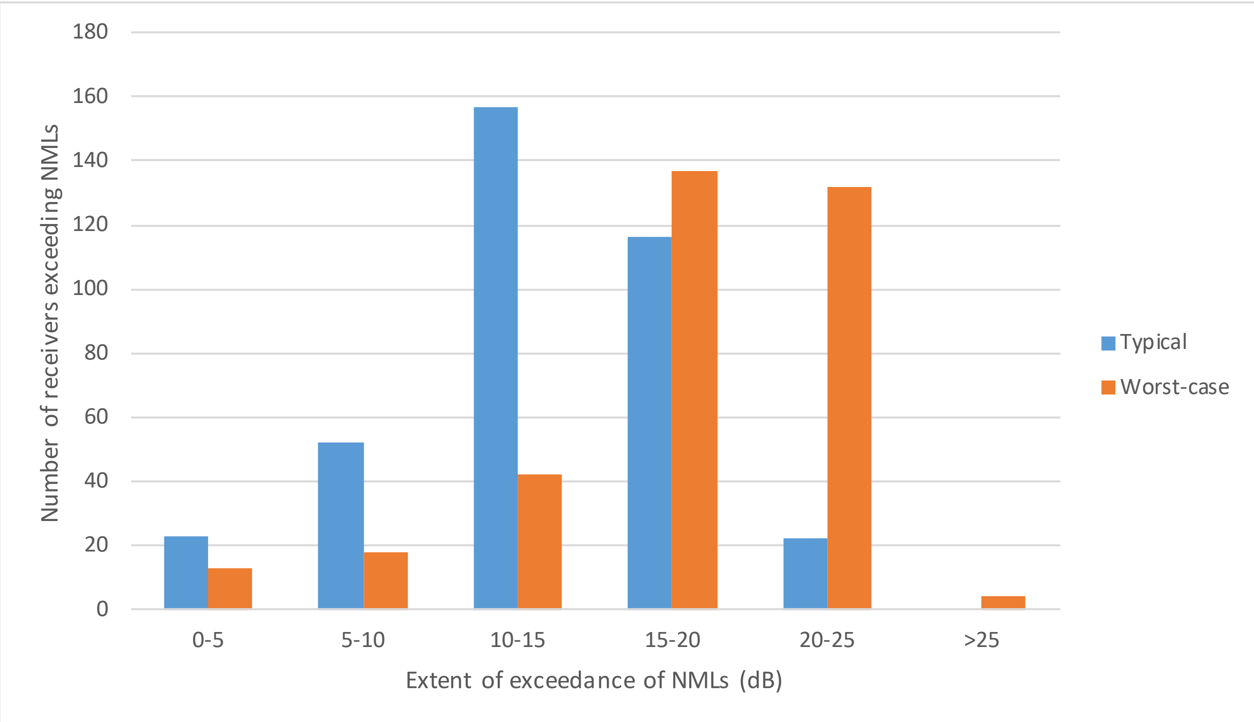


Figure 4-38 NCA12 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA12 only experiences exceedances during finishing works (Scenario 9).

Exceedances are associated with heavy vehicle movements during testing and commissioning at the Bringelly service facility and Aerotropolis Core Station, exceeding NMLs by up to 11 to 21 dB. Figure

4-39 shows the distribution of exceedances during finishing works (Scenario 9) for residential receivers within NCA12.

Exceedances of sleep disturbance and awakening screening levels are only predicted to occur during finishing works (Scenario 9) and are a result of the use of heavy vehicle movements, exceeding by up to 14 dB. The heavy vehicles are expected to be periodically used for a period of around 12 months.

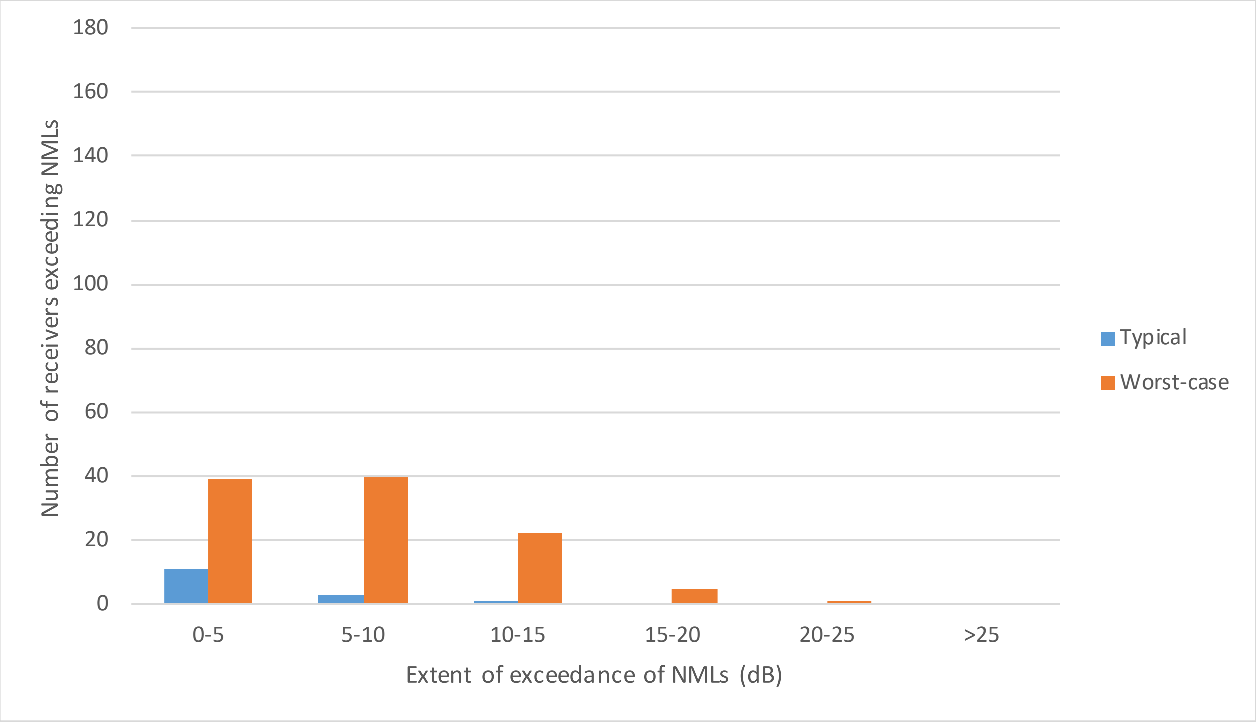


Figure 4-39 NCA12 NML exceedances – out-of-hours – finishing works

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS.

4.6 Overview of predicted noise levels (on-airport works)

Construction noise levels were predicted for all on-airport works (separately to off-airport works, which are covered in Sections 4.4 and 4.5). The predicted noise levels for each of the nine construction work scenarios (as outlined in Section4.3.4) are presented in Appendix B.3. Predicted maps showing the noise level at each receiver within the study area are presented in Appendix B.4.

No sensitive receivers (located within or in areas immediately adjacent to the airport site) are predicted to experience exceedances of the Airports Regulations specified noise limits.

Limits outlined in Airports Regulations generally align with highly noise affected NMLs (applicable during standard hours) as outlined in the ICNG. The ICNG NMLs could be considered for assessment of impacts during the evening and night periods to gauge community response to on-airport construction noise during these periods. Table 4-22 outlines the outlines the highest noise level experienced at a residential receiver in each NCA for each activity based on ICNG levels for on-airport construction works. No receivers have been identified as highly noise affected (receivers that experience noise levels of greater than 75 dB during standard hours), including the Western Sydney Airport Experience Centre and construction site office.

The predicted noise levels are representative of the ‘typical’ expected noise levels. The predicted noise levels representative of the ‘worst case’ expected noise levels (as defined in Section4.3.5) are presented in brackets in Table 4-22.

The noise model includes a conservative list of plant and equipment, as it includes all of the possible construction equipment that may be used during construction, and is therefore considered to represent conservative construction noise impacts. Should the project receive approval, as detailed construction planning continues construction-related noise and vibration impacts and mitigation would be managed in accordance with the CNVS.

During standard hours, NCA10 to NCA12 are predicted to experience exceedances of NMLs during construction work scenarios, with the exception of bridge and viaduct works, and construction of ancillary facilities (Scenarios 3 and 6) in NCA12. During out-of-hours works, exceedances of NMLs and sleep disturbance and awakening screening levels are predicted to occur during tunnelling and associated works, bridge and viaduct works, rail systems fitout works, and station fitout works (Scenarios 2, 3, 7, and 8) at all NCAs, with the exception of bridge and viaduct works in NCA12.

Exceedances within each NCA are predominantly located in the following areas:

- NCA10: receivers located to the north of the airport site along Elizabeth Drive
- NCA11: receivers located to the east of the airport site along Lawson Road
- NCA12: receivers located to the south of the airport site along Badgerys Creek Road, Derwent Road and the northern end of Mersey Road.

The construction noise impacts predicted for receivers in NCA10, 11 and 12 are based on the construction works which are proposed within the airport site. They do not consider the cumulative noise impacts potentially arising from construction works occurring both on-airport and off-airport at the same time.

A limited number of receivers located in areas proximate to the airport site boundary may be potentially impacted by cumulative noise levels associated with both on-airport and off-airport construction works. In most cases the cumulative noise impact experienced at these receivers will be equivalent to the highest construction noise level in each area, or in worst case scenarios up to 3dBA higher than the highest noise level. Only a small number of receivers are likely to experience these cumulative impacts and for limited periods of time when the highest noise generating construction activities in each area are occurring simultaneously.

Table 4-22 Number of residential receivers exceeding ICNG NMLs for on-airport works – typical and (worst case)

NCA	Period	NML	Highest predicted noise level (dB)								
			SC01	SC02	SC03	SC04	SC05	SC06	SC07	SC08	SC09
NCA10 – (378 noise sensitive receivers assessed)	SH	45	54 (59)	57 (62)	54 (59)	63 (68)	53 (60)	50 (57)	50 (57)	47 (51)	58 (63)
	OOH - D	40	N/A	54 (59)	54 (59)	N/A	N/A	N/A	47 (50)	N/A	40 (49)
	OOH - E	35	N/A	54 (59)	54 (59)	N/A	N/A	N/A	47 (50)	N/A	40 (49)
	OOH - N	35	N/A	54 (59)	54 (59)	N/A	N/A	N/A	47 (50)	N/A	40 (49)
NCA11 – (68 noise sensitive receivers assessed)	SH	49	59 (62)	62 (67)	61 (66)	64 (69)	53 (60)	57 (64)	49 (55)	46 (51)	64 (67)
	OOH - D	44	N/A	61 (66)	61 (66)	N/A	N/A	N/A	48 (53)	N/A	45 (50)
	OOH - E	42	N/A	61 (66)	61 (66)	N/A	N/A	N/A	48 (53)	N/A	45 (50)
	OOH - N	35	N/A	61 (66)	61 (66)	N/A	N/A	N/A	48 (53)	N/A	45 (50)
NCA12 - (396 noise sensitive receivers assessed)	SH	48	59 (62)	56 (61)	N/A	57 (63)	51 (58)	N/A	48 (53)	45 (49)	45 (51)
	OOH - D	43	N/A	60 (64)	N/A	N/A	N/A	N/A	48 (53)	N/A	45 (50)
	OOH - E	40	N/A	60 (64)	N/A	N/A	N/A	N/A	48 (53)	N/A	45 (50)
	OOH - N	39	N/A	60 (64)	N/A	N/A	N/A	N/A	48 (53)	N/A	45 (50)

(1) ICNG standard hours includes Monday to Friday 7am to 6pm and Saturday 8 am to 1pm, Out of Hours Day any time within 1pm to 6pm Saturday and 8am to 6pm Sunday, and outside standard hours, Out of Hours – Evening any time from 6pm to 10pm & Out of Hours – Night at all other times

(2) Yellow cells indicate an exceedance of NMLs between 0 and 10 dB for typical construction works; Orange cells indicate an exceedance of NMLs between 10 and 20 dB for typical construction works; Red cells indicate an exceedance of NMLs >20dB for typical construction works;

Results in brackets indicate noise level predictions assuming full utilisation of plant (i.e. realistic worst case).

4.7 Noise catchment area assessment (on-airport works)

During construction, construction noise levels could significantly impact the closest receivers, predominantly during standard hours, with limited exceedances during out-of-hours works. These impacts include exceedance of NMLs, and potential sleep disturbance and awakening. Where exceedances have been predicted to occur during the worst case 15 minute periods (when all machinery is operating at full utilisation), these impacts are indicative of highest likely noise levels that may occur. Typical construction noise levels would be expected throughout most of the construction and would be lower than the worst case periods.

A summary of the main findings from the construction noise assessment results are provided below.

NCA10 (Luddenham, north of Elizabeth Drive)

The location of the Western Sydney International Stage 1 Construction Impact Zone relative to NCA10 is shown below in Figure 4-40.

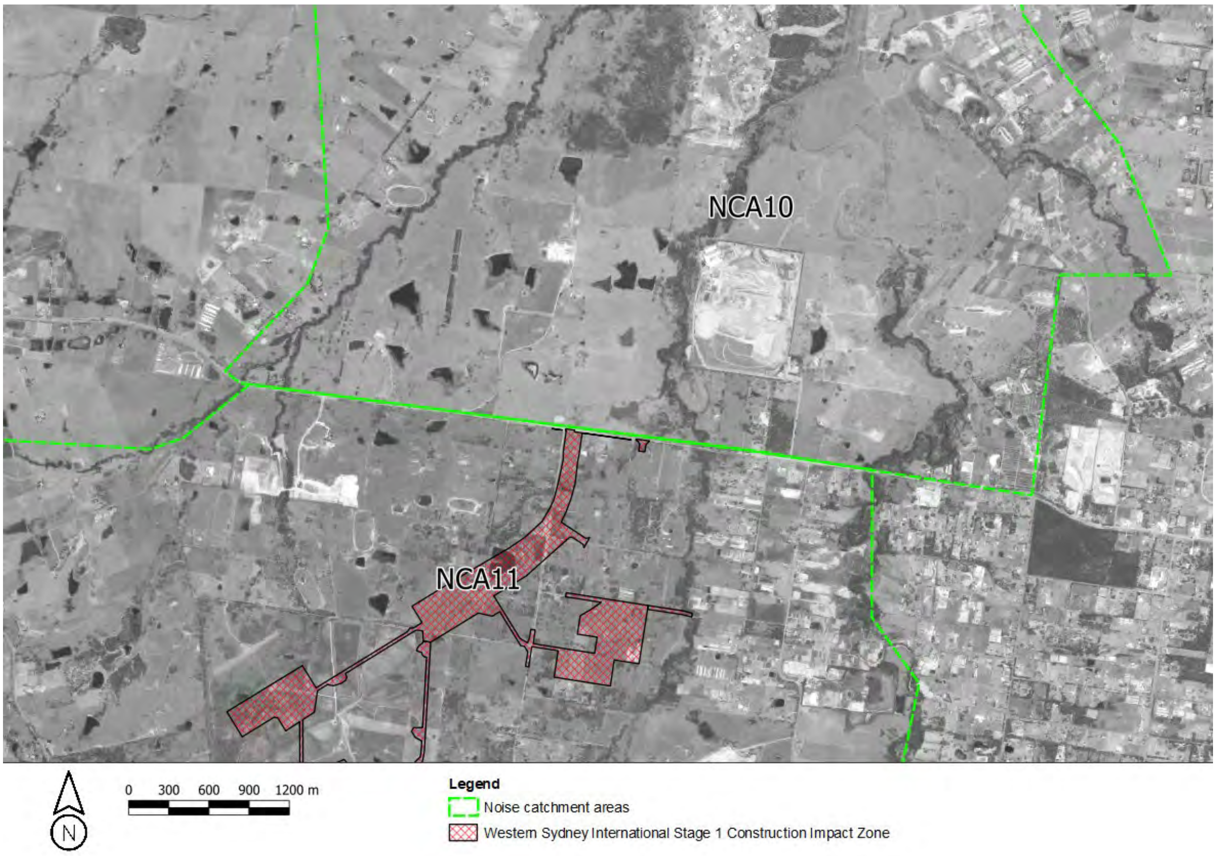


Figure 4-40 NCA10 relative to Western Sydney International Stage 1 Construction Impact Zone

A total of 378 noise sensitive receivers were assessed for NCA10 which is located to the north of the airport site. The predicted NML exceedances within NCA10 are presented in Table 4-23. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods.

Table 4-23 NCA10 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
		Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
		0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	N/A	7 (2)	0 (5)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	5	5 (0)	1 (6)	0 (0)	3 (3)	2 (3)	0 (0)	3 (2)	3 (2)	0 (2)	3 (2)	3 (2)	0 (2)
SC03 - Bridge and viaduct construction	4	3 (1)	0 (2)	0 (0)	1 (3)	2 (2)	0 (0)	3 (2)	2 (1)	0 (2)	3 (2)	2 (1)	0 (2)
SC04 - Earthworks and excavation	N/A	2 (2)	5 (4)	0 (2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	N/A	4 (1)	0 (4)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	N/A	2 (1)	0 (2)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	4	6 (4)	0 (3)	0 (0)	4 (4)	0 (0)	0 (0)	3 (2)	1 (2)	0 (0)	3 (2)	1 (2)	0 (0)
SC08 - Station fitout, precinct and transport integration works	N/A	1 (4)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	5	5 (0)	2 (7)	0 (0)	0 (7)	0 (0)	0 (0)	4 (2)	0 (5)	0 (0)	4 (2)	0 (5)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Elizabeth Drive. Some of the highest impact works occur during:

- Tunnelling and associated works (Scenario 2) - predicted noise levels are most influenced by the use of multiple concrete vibrators
- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers and excavators
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of excavators during rail embankment works along the on-airport construction corridor, and hydraulic hammers at the Business Park, exceeding NMLs by up to 18 dB to 23 dB. Figure 4-41 shows the distribution of NML exceedances during this activity for residential receivers within NCA10.

The excavators may be used over a period of around 12 months, and hydraulic hammers may be used intermittently over a period of around 6 months. When the hydraulic hammers are not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 3 dB.

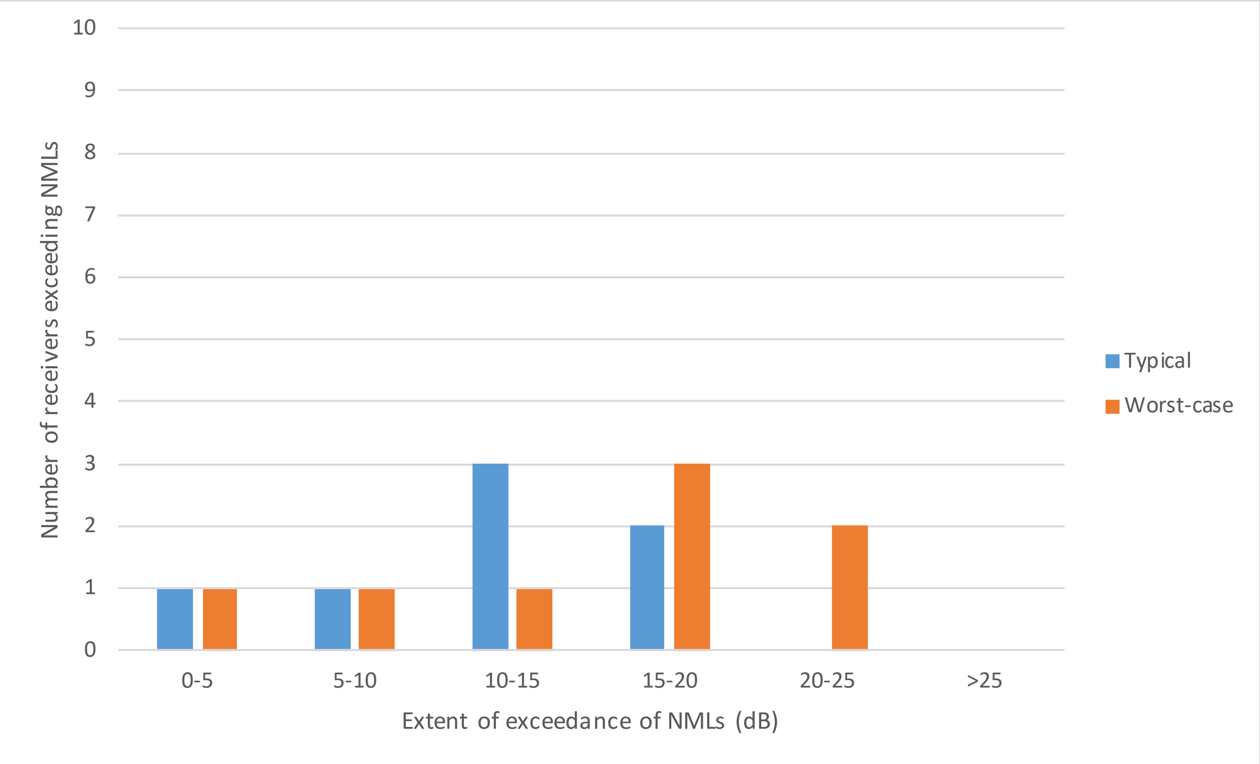


Figure 4-41 NCA10 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA10 experiences exceedances of NMLs and sleep disturbance and awakening screening levels during tunnelling and associated works, bridge and viaduct construction, rail fitout works, and finishing works (Scenarios 2, 3, 7 and 9).

Residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of concrete vibrators during tunnel segment casting at Airport construction site, exceeding NMLs by up to 19 to 24 dB. Figure 4-42 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA10.

The concrete vibrators are expected to be in use for a period of around 18 months.

The worst case exceedances of the sleep disturbance and awakening screening levels occur during tunnel segment casting as part of tunnelling and associated works (Scenario 2), and are as a result of use of the concrete batch plant, exceeding by up to 7 dB.

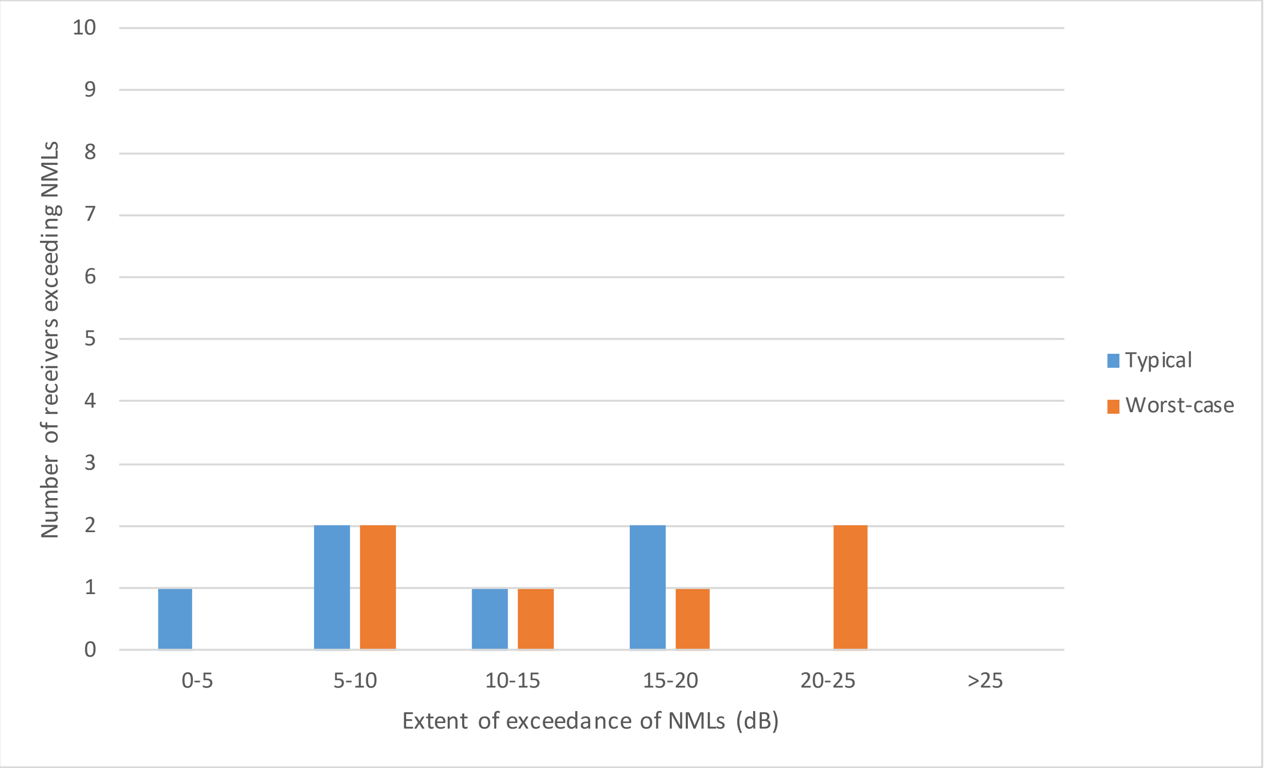


Figure 4-42 NCA10 NML exceedances – out-of-hours – tunnelling and associated works

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which mat reduce the number of exceedances of NMLs by around 30 to 50%.

NCA11 (Luddenham and Badgerys Creek, south of Elizabeth Drive)

The location of the Western Sydney International Stage 1 Construction Impact Zone within NCA11 is shown below in Figure 4-43.

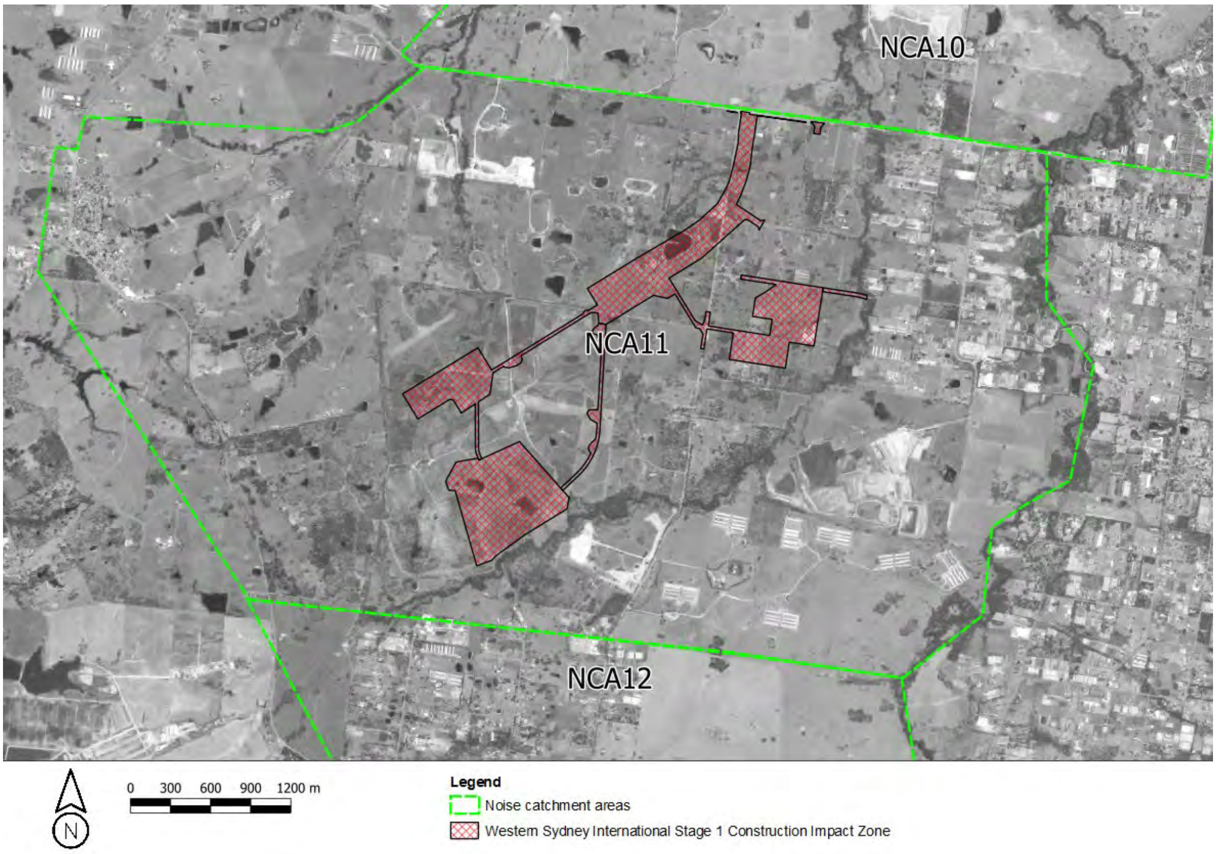


Figure 4-43 NCA11 relative to Western Sydney International Stage 1 Construction Impact Zone

A total of 68 noise sensitive receivers were assessed for NCA11 which includes the airport site and areas immediately to the east and west of the airport site. The predicted NML exceedances within NCA11 are presented in Table 4-24. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods.

Table 4-24 NCA11 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
		Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
		0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	N/A	25 (40)	0 (3)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	60	43 (28)	7 (30)	0 (0)	28 (8)	30 (47)	0 (4)	16 (7)	42 (41)	0 (11)	5 (6)	31 (7)	25 (47)
SC03 - Bridge and viaduct construction	46	38 (24)	4 (23)	0 (0)	25 (5)	22 (38)	0 (4)	13 (5)	34 (32)	0 (10)	1 (2)	25 (5)	21 (38)
SC04 - Earthworks and excavation	N/A	42 (23)	12 (34)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	N/A	15 (34)	0 (3)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	N/A	32 (30)	0 (14)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	38	1 (28)	0 (0)	0 (0)	9 (17)	0 (0)	0 (0)	15 (24)	0 (1)	0 (0)	30 (20)	4 (15)	0 (0)
SC08 - Station fitout, precinct and transport integration works	N/A	0 (4)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	3	30 (14)	17 (34)	0 (0)	1 (20)	0 (0)	0 (0)	1 (28)	0 (0)	0 (0)	12 (42)	1 (14)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located along Lawson Road. Some of the highest impact works occur during:

- Tunnelling and associated works and bridge and viaduct works (Scenarios 2 and 3) - predicted noise levels are most influenced by the use of multiple concrete vibrators
- Excavation and earthworks (Scenario 4) – predicted noise levels are most influenced by the use of hydraulic hammers and excavators
- Finishing works (Scenario 9) – predicted noise levels are most influenced by the use of hydraulic hammers

Most residential receivers are predicted to be affected during excavation and earthworks (Scenario 4). The highest construction noise during this scenario is a result of the use of excavators during rail embankment works along the on-airport construction corridor, and hydraulic hammers at the Airport business Ppark, exceeding NMLs by up to 16 dB to 20 dB. Figure 4-44 shows the distribution of NML exceedances during this activity for residential receivers within NCA11.

The excavators may be used over a period of around 12 months, and hydraulic hammers may be used intermittently over a period of around 6 months. When the hydraulic hammers are not in use, the predicted noise levels and corresponding NML exceedances are predicted to reduce by around 3 dB.

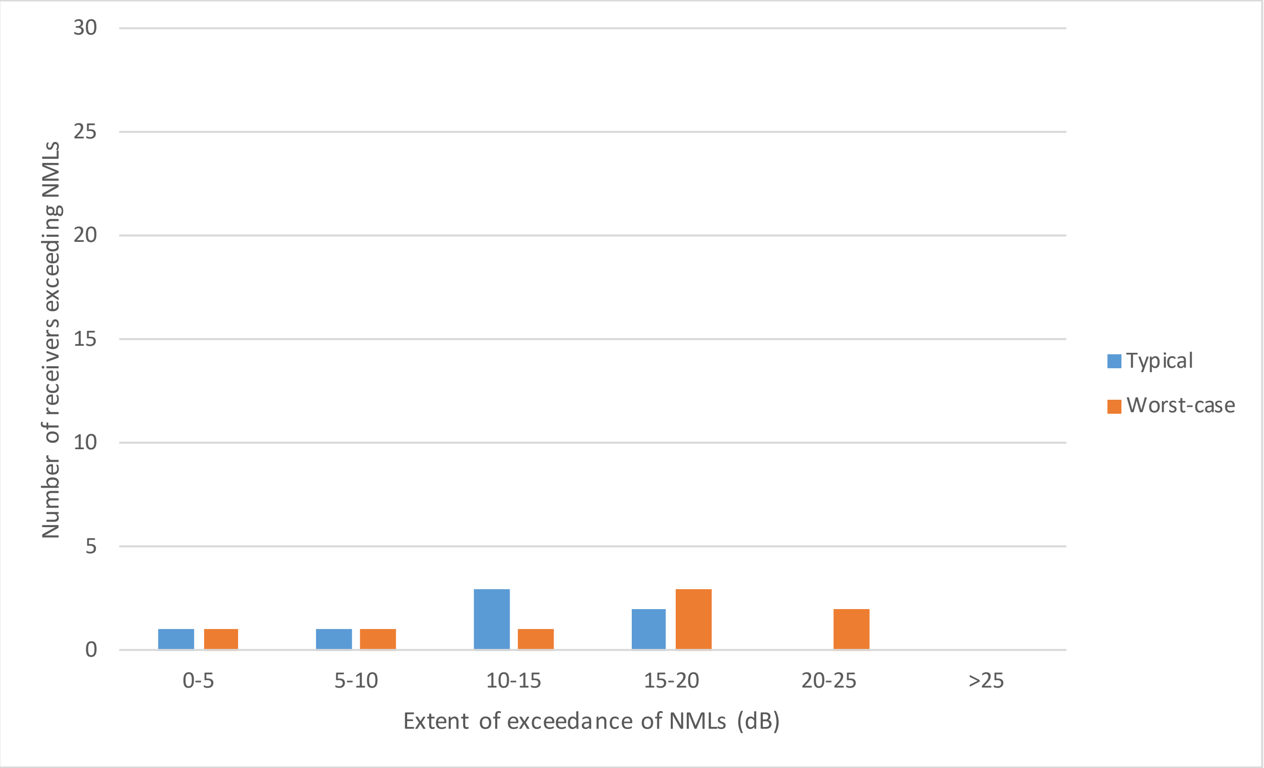


Figure 4-44 NCA11 NML exceedances – standard hours – excavation and earthworks

Summary of out-of-hours construction results

During out-of-hours construction works, NCA11 experiences exceedances of NMLs and sleep disturbance and awakening screening levels during tunnelling and associated works, bridge and viaduct construction, rail fitout works, and finishing works (Scenarios 2, 3, 7 and 9).

Residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of concrete vibrators during tunnel segment casting at the Airport construction site, exceeding NMLs by up to 25 to 30 dB.

Figure 4-45 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA11.

The concrete vibrators are expected to be in use for a period of around 18 months.

The worst case exceedances of the sleep disturbance and awakening screening levels occur during tunnel segment casting as part of tunnelling and associated works (Scenario 2), and are as a result of use of the concrete batch plant, exceeding by up to 14 dB.

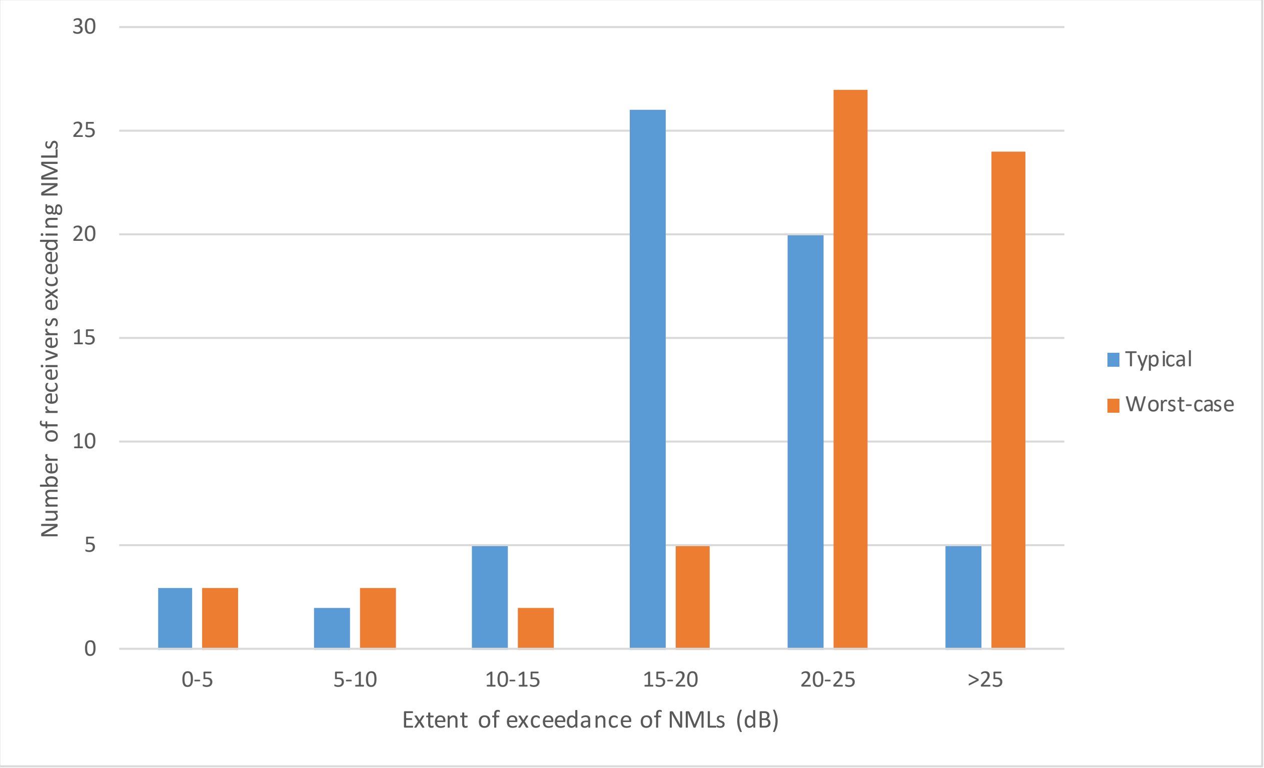


Figure 4-45 NCA11 NML exceedances – out-of-hours – tunnelling and associated works

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which mat reduce the number of exceedances of NMLs by around 30 to 50%.

NCA12 (Bringelly)

The location of the Western Sydney International Stage 1 Construction Impact Zone relative to NCA12 is shown below in Figure 4-46.

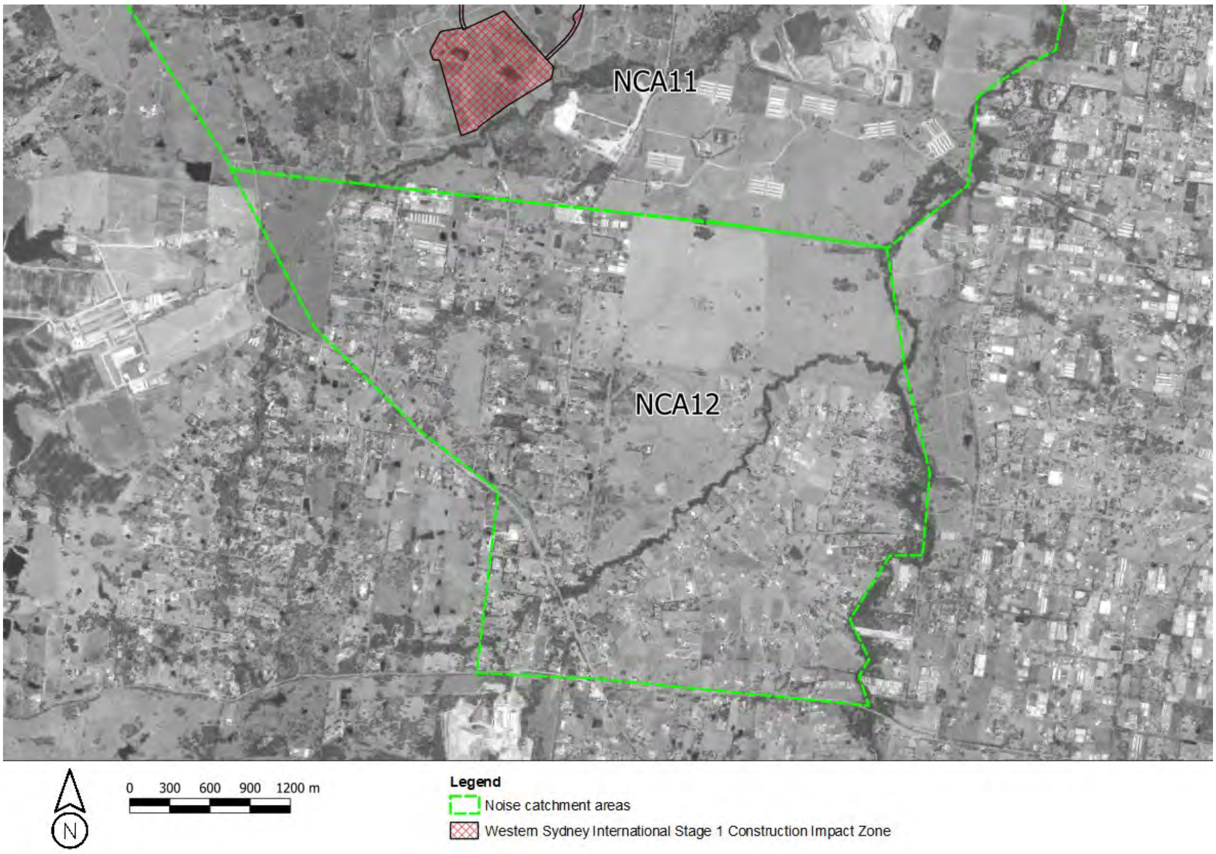


Figure 4-46 NCA12 relative to Western Sydney International Stage 1 Construction Impact Zone

A total of 396 noise sensitive receivers were assessed for NCA12 which is predominantly located to the south of the airport site. The predicted NML exceedances within NCA12 are presented in Table 4-25. The number of receivers exceeding NMLs have been separated into bands grouping the magnitude of predicted exceedances across day, evening, and night periods.

Table 4-25 NCA12 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep disturbance and awakening screening levels	Number of receivers exceeding NML – typical and (worst case)											
		Standard hours			Out-of-hours - day			Out-of-hours - evening			Out-of-hours - night		
		0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+	0-10	10-20	20+
SC01 - Enabling works	N/A	60 (59)	2 (15)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC02 - Tunnelling and associated works	69	13 (14)	0 (7)	0 (0)	53 (44)	25 (36)	0 (0)	33 (28)	51 (59)	0 (0)	27 (26)	59 (61)	0 (1)
SC03 - Bridge and viaduct construction	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
SC04 - Earthworks and excavation	N/A	14 (13)	0 (10)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC05 - Station construction	N/A	7 (14)	0 (1)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC06 - Construction of stabling and maintenance and other ancillary facilities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC07 - Rail systems fitout	6	0 (15)	0 (0)	0 (0)	12 (52)	0 (0)	0 (0)	23 (56)	0 (10)	0 (0)	30 (58)	0 (13)	0 (0)
SC08 - Station fitout, precinct and transport integration works	N/A	0 (3)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SC09 - Finishing works	0	0 (11)	0 (0)	0 (0)	6 (36)	0 (0)	0 (0)	17 (57)	0 (1)	0 (0)	26 (58)	0 (5)	0 (0)

(1) Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10dB) during typical scenarios over worst-case, this is because predicted worst case impacts are higher than the typical impacts at a receiver, and therefore some number of receivers may move up into the higher exceedance ranges.

Summary of standard construction hours results

The most affected receivers are predicted to be located to the north of Derwent Road and Mersey Road. The highest impact works occur during enabling works as a result of dozers during site establishment at the permanent spoil area, exceeding NMLs by up to 11 dB to 24 dB. Figure 4-47 shows the distribution of NML exceedances during this activity for residential receivers within NCA12.

The dozers may be used over a period of around 18 months.

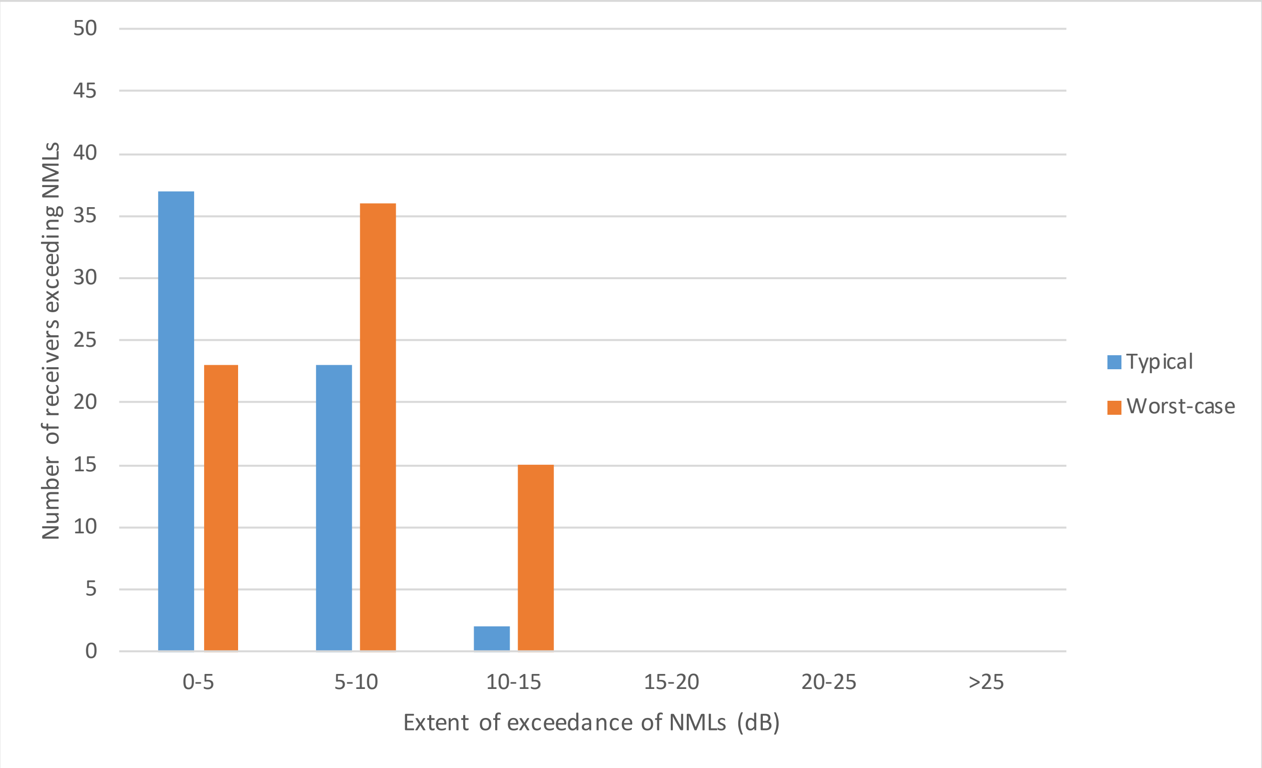


Figure 4-47 NCA12 NML exceedances – standard hours – site establishment

Summary of out-of-hours construction results

During out-of-hours construction works, NCA12 experiences exceedances of NMLs and sleep disturbance and awakening screening levels during tunnelling and associated works, rail fitout works, and finishing works (Scenarios 2, 7 and 9).

Residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2). The exceedances of NMLs are as a result of the use of dozers at the permanent spoil area, exceeding NMLs by up to 20 to 21 dB. Figure 4-48 shows the distribution of NML exceedances during tunnelling and associated works (Scenario 2) for residential receivers within NCA12.

These dozers may be used over a period of around 18 months.

The worst case exceedances of the sleep disturbance and awakening screening levels occur as part of tunnelling and associated works (Scenario 2), and are as a result of use of dozers at the permanent spoil area, exceeding by up to 3 dB.

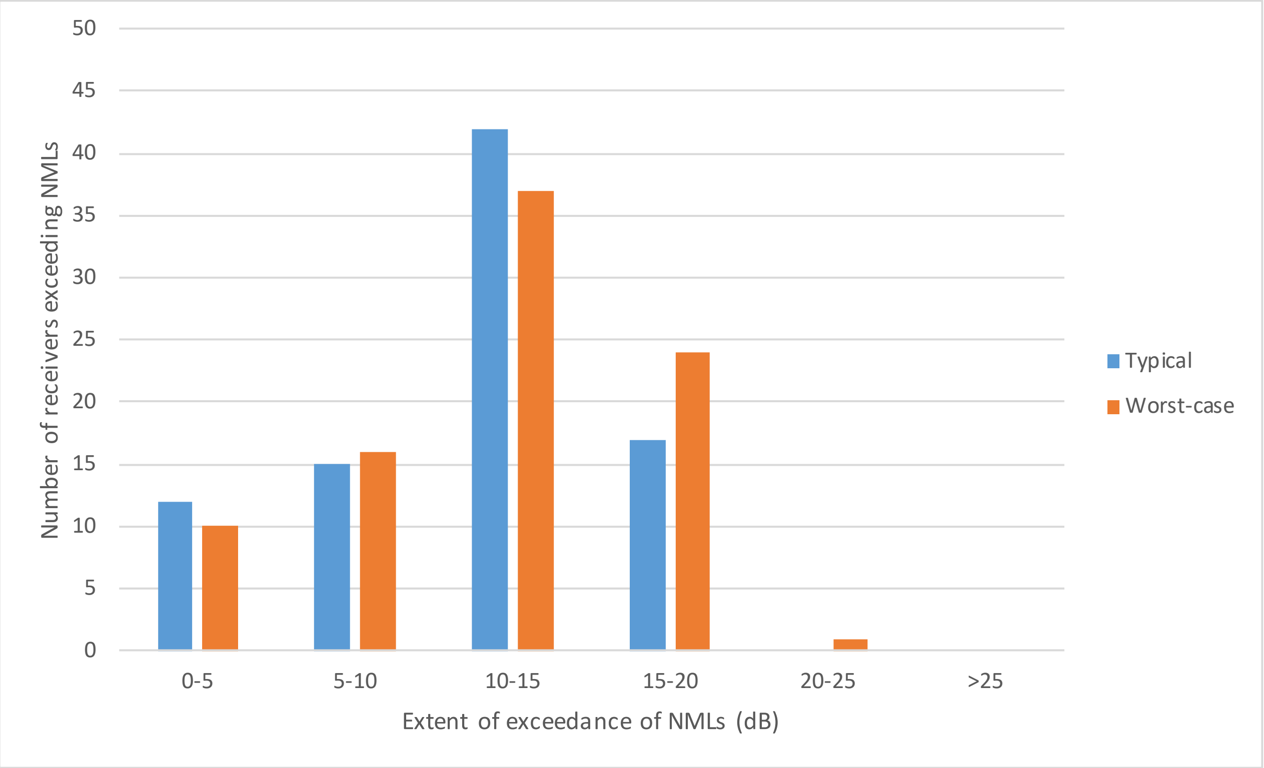


Figure 4-48 NCA12 NML exceedances – out-of-hours – tunnelling and associated works

Mitigation and management

These exceedances will be managed through the standard mitigation as outlined in the CNVS. Project specific mitigation would include consideration of acoustic sheds with suitable noise attenuation, which mat reduce the number of exceedances of NMLs by around 30 to 50%.

4.8 Construction ground-borne noise and vibration assessment methodology

Construction activities generally generate a certain amount of ground-borne noise and vibration. These impacts are not readily perceived for surface works with acceptable offset distances. However, underground construction activities generally have a tendency to cause perceivable ground-borne noise and vibration at nearby receivers, and are discussed further in this section.

Ground-borne noise and vibration levels from tunnelling works have been calculated based on source vibration levels from typical tunnel boring equipment used in similar ground types. Theoretical predictions of noise and vibration propagation through the ground, and coupling losses into buildings, were calculated from soil properties based on geotechnical investigations for the Project and empirical data provided by the RIVAS project in Europe (2013) and Transportation Noise Reference Book, Nelson (1987).

Assessment of ground-borne noise and vibration due to tunnelling and other construction works on the Western Sydney International has not been undertaken as part of this assessment, since there is not anticipated to be any noise or vibration sensitive receivers located on the airport site.

4.8.1 Construction ground-borne noise and vibration scenario descriptions

Tunnelling works proposed for the project are the most critical activities for the generation of ground-borne noise and vibration during construction. The activities considered for this assessment include:

- tunnelling activities from TBM and roadheaders
- underground rock-breaking using hydraulic hammers.

4.9 Construction ground-borne noise and vibration assessment

This section provides the modelling inputs, prediction curves and assessment of impacts for ground-borne noise and vibration from tunnelling works.

4.9.1 Modelling inputs and parameters

The equipment details used for the assessment are provided in Table 4-26.

Given the limited geotechnical information available for this technical paper, a sensitivity study on the TBM travel rate is discussed based on a range from 10 m/day to 25 m/day; the design average rate of travel is 100 m/week or 14.3 m/day.

Rock breakers or roadheaders may be used to excavate cross-passages between the twin tunnels. The cross-passages would be spaced at around 240 metre intervals. Specific cross-passage locations would be determined during design development and construction planning and general prediction curves that demonstrate the ground-borne noise and vibration at varying distances are provided for this assessment.

Roadheaders may be used to excavate tunnel stubs and non-standard tunnel sections, and general prediction curves are also provided for a typical roadheader for assessment of impacts.

Ground-borne noise levels have been predicted from vibration levels using industry-standard conversion factors for typical residential building structures. More information regarding the modelling inputs are provided in Appendix C.1.

Table 4-26 Tunnelling equipment details

Equipment	Size and details	Dominant frequency range (Hz)	Crest factor assumption
TBM	7m diameter; travel rate 100 m/week.	30 - 60	2
Rock breaker	1 tonne hammer with 21 tonne excavator	15 - 30	2
Roadheader	100 tonnes with transversal cutter head	30 - 60	2

4.9.2 Predicted ground-borne noise and vibration levels (off-airport)

Typical ground-borne noise and vibration levels are predicted for varying distances from the tunnels and are provided in Figure 4-49 and Figure 4-50.

Figure 4-49 and Figure 4-50 shows that ground-borne noise and vibration levels generated by rock breakers are higher compared to TBMs and roadheaders. However, at distances beyond 100 metres, these levels are comparable. This is due to the differences in the equipment, operating patterns and vibration generation (frequency) characteristics. Roadheaders are predicted to have a marginally higher impact compared to TBMs at shorter distances (less than 60m), but marginally lower impact at greater distances.

Based on the vibration targets, the following can be summarised with respect to working distances between tunnelling equipment and sensitive receivers:

- residential targets can be achieved beyond 24 metres for TBM, 28 metres for roadheader, and 31 metres for rock-breaking activities
- commercial targets can be achieved beyond 15 metres for TBM, 19 metres for roadheader, and 22 metres for rock-breaking activities.

Based on the ground-borne noise targets, the following can be summarised with respect to working distances between tunnelling equipment and sensitive receivers:

- residential night-time targets can be achieved beyond 32 metres for TBM, 35 metres for roadheader, and 40 metres for rock-breaking activities
- residential day time targets can be achieved beyond 22 metres for TBM, 25 metres for roadheader, and 29 metres for rock-breaking activities
- commercial targets can be achieved beyond 17 metres for TBM, 20 metres for roadheader, and 24 metres for rock-breaking activities.

It is noted that all of the distances provided above refer to the direct distance to the closest point of the tunnel, considering both the vertical and horizontal separation distances.

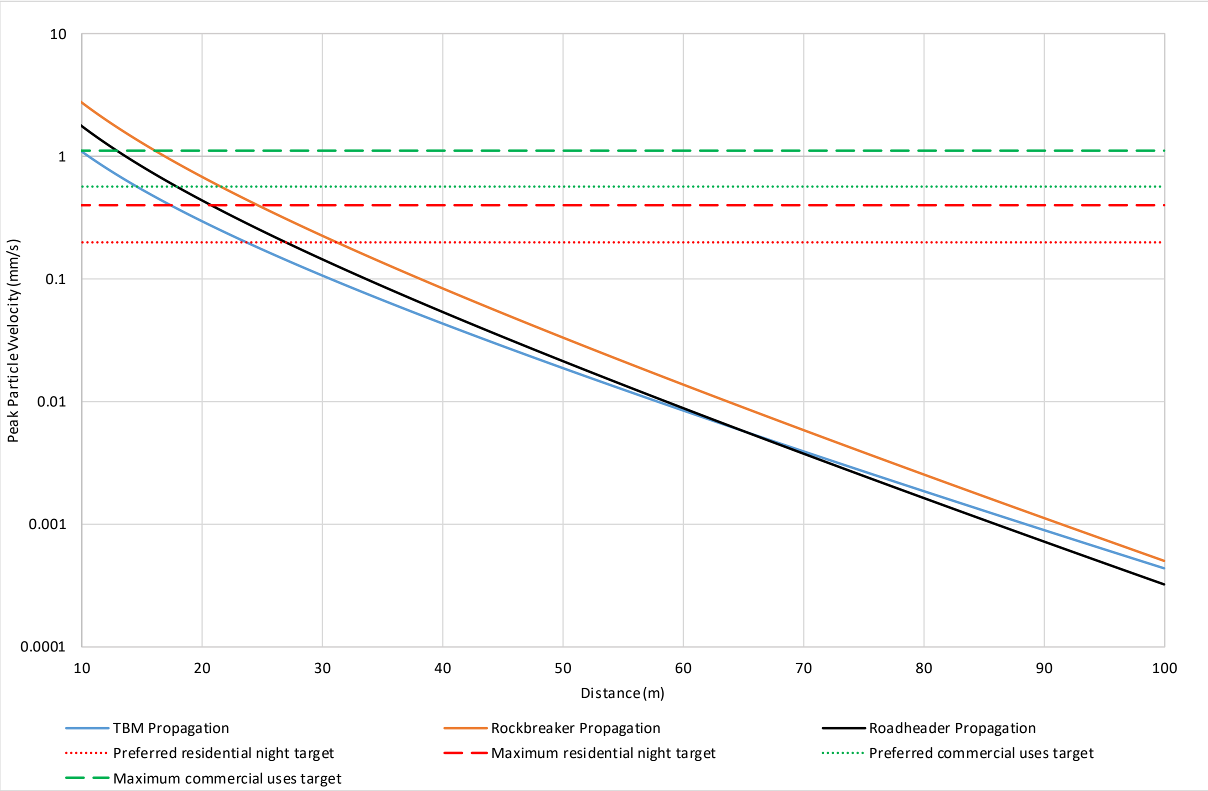


Figure 4-49 Ground-borne vibration prediction curves

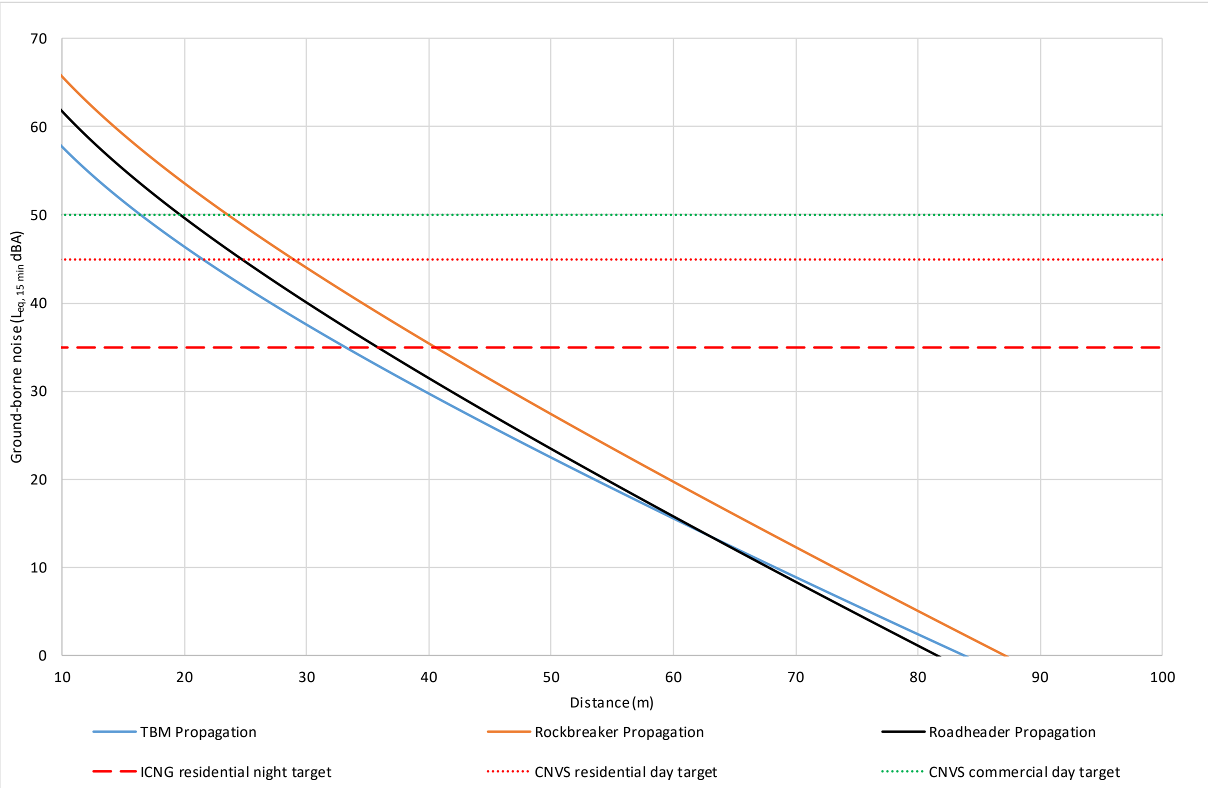


Figure 4-50 Ground-borne noise prediction curves

4.9.3 Assessment against construction ground-borne noise and vibration guidelines (off-airport)

Vibration assessment (tunnelling works)

The vibration levels are predicted for each sensitive receiver and are presented in Figure 4-51 and Figure 4-52 for the St Marys to Orchard Hills and Western Sydney International to Bringelly tunnels respectively. The preferred and maximum vibration targets are also shown in the figures to identify exceedances.

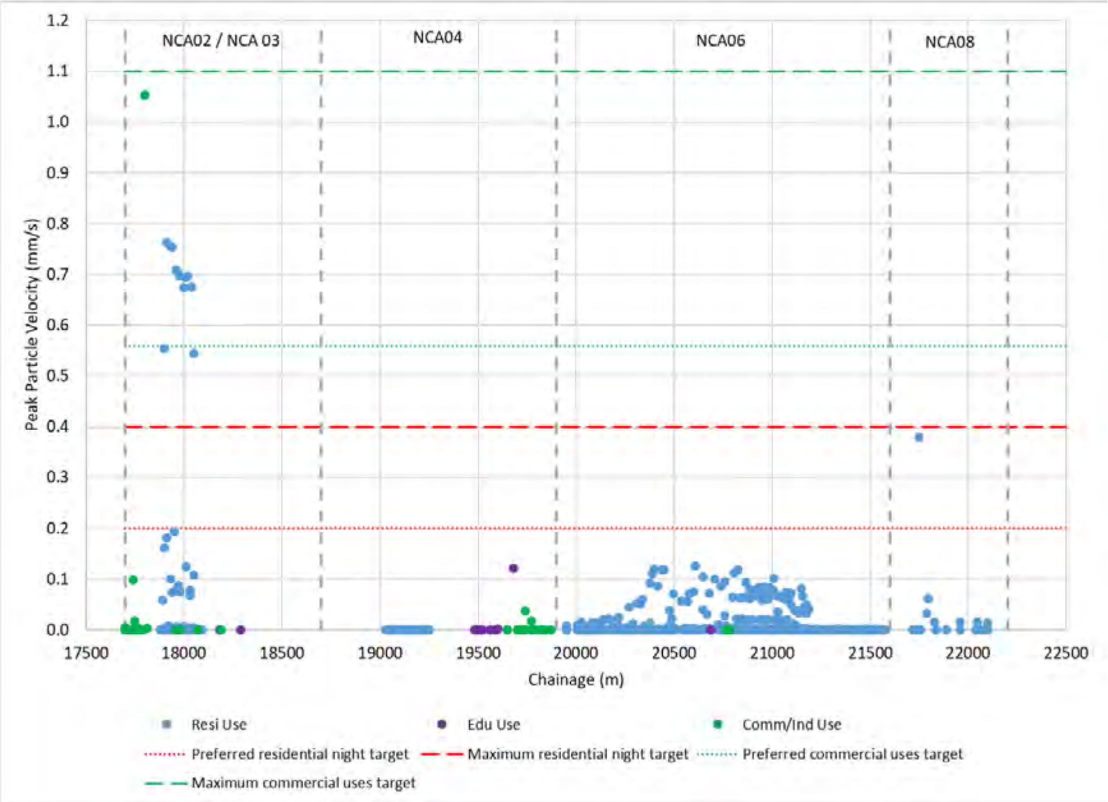


Figure 4-51 Ground-borne vibration predictions from TBM - St Marys to Orchard Hills tunnel

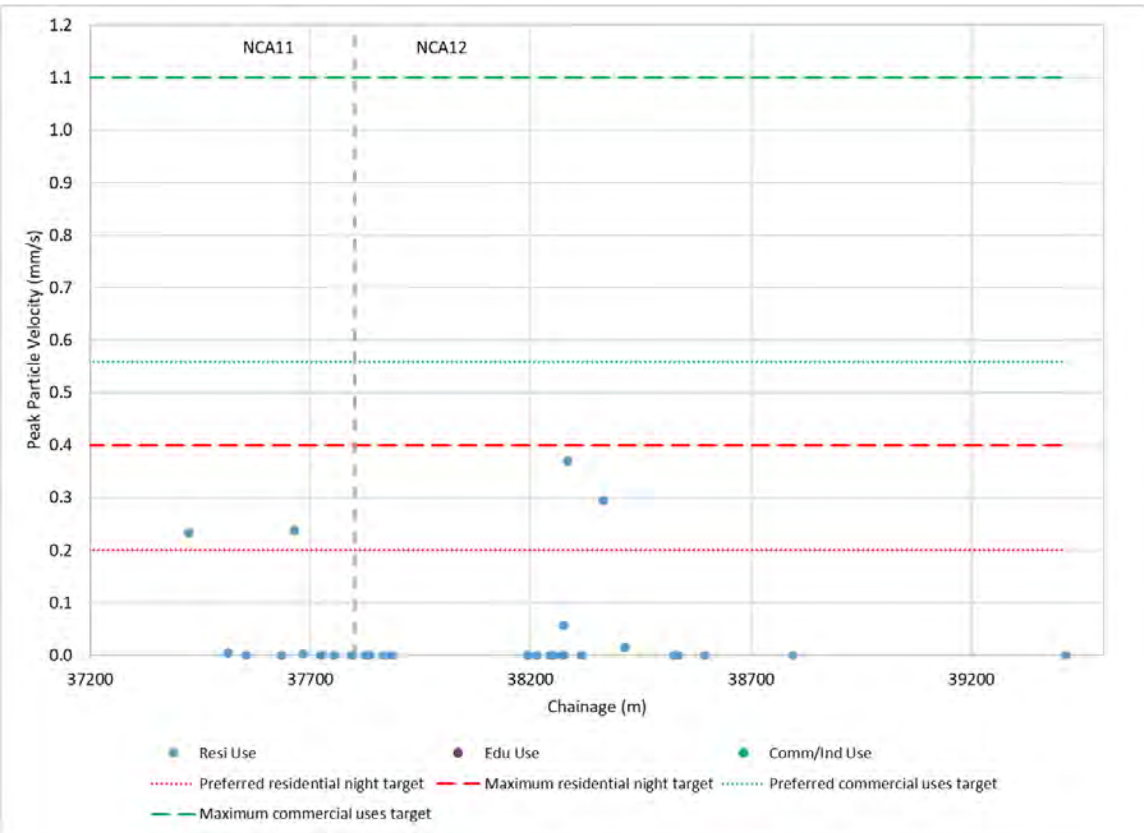


Figure 4-52 Ground-borne vibration predictions from TBM - Western Sydney International to Bringelly tunnel

The results demonstrate compliance with the preferred vibration level targets for most receivers.

Ten residential receivers located above the St Marys to Orchard Hills tunnel (at chainages between 17800 metres and 18200 metres) are predicted to exceed the maximum vibration level targets.

Six residential receivers, predominantly above the Western Sydney International to Bringelly tunnel, are predicted to experience vibration levels between the preferred and maximum management targets. These exceedances are short-term, and the impacts are not anticipated to extend beyond 3-4 nights at any particular receiver, as discussed in the following sections.

While there are some exceedances of ground-borne vibration criteria from a human comfort perspective, it is noted that ground-borne noise levels determine the mitigation approach as the ground-borne noise targets are more stringent (ground-borne noise is related to the ground vibration). Therefore, mitigation measures developed for ground-borne noise will assist in managing potential vibration related issues.

There are state heritage-listed buildings, and potential local heritage buildings near the existing St Marys Station which would be near tunnelling works. The predicted vibration levels for these buildings are provided in Table 4-27.

Table 4-27 Predicted ground-borne vibration levels from tunnelling activities for St Marys heritage buildings

Heritage building	Distance to tunnel edge (m)	Predicted PPV from TBM (mm/s)	Predicted PPV from Rockbreaker (mm/s)
St Marys platform 3-4 building	19	0.8	1.4
St Marys goods shed	9	2.1	4.1
St Marys jib crane (likely to be relocated)	9	2.1	4.1

Heritage building	Distance to tunnel edge (m)	Predicted PPV from TBM (mm/s)	Predicted PPV from Rockbreaker (mm/s)
Post-War Commercial Building, 1-7 Queen Street, St Marys[1]	15.5	1.3	2.1
Munitions Workers Housing St Marys[1]	16	1.2	2.0

(1) These items are currently classified as potential heritage items with local significance – refer to Technical Paper 4 (Non-Aboriginal heritage) for more information.

Note that the CNVS recommends a screening criterion of 10 mm/s for framed / reinforced structures, and 5 mm/s for light unframed structures. However, if the buildings are categorised as structurally unsound, then a more stringent criterion of 2.5 mm/s is recommended. If the structure is unsound, careful detailed predictions, active monitoring and management would be required.

There are no predicted exceedances of the building structural damage criteria at any other location due to TBM and rock-breaker activities from tunnelling. Potential adverse impacts to buried services would be required to be determined once details and locations of buried services are obtained, however, no major impacts are anticipated.

Ground-borne noise assessment (tunnelling works)

Ground-borne noise predictions for all noise sensitive receivers adjacent to the tunnel alignment are presented in Figure 4-53 and Figure 4-54 for the St Marys to Orchard Hills and Western Sydney International to Bringelly tunnels respectively. The predicted ground-borne noise levels are presented as maps in Appendix C.2 to assist with identification of receivers likely to experience highest impacts.

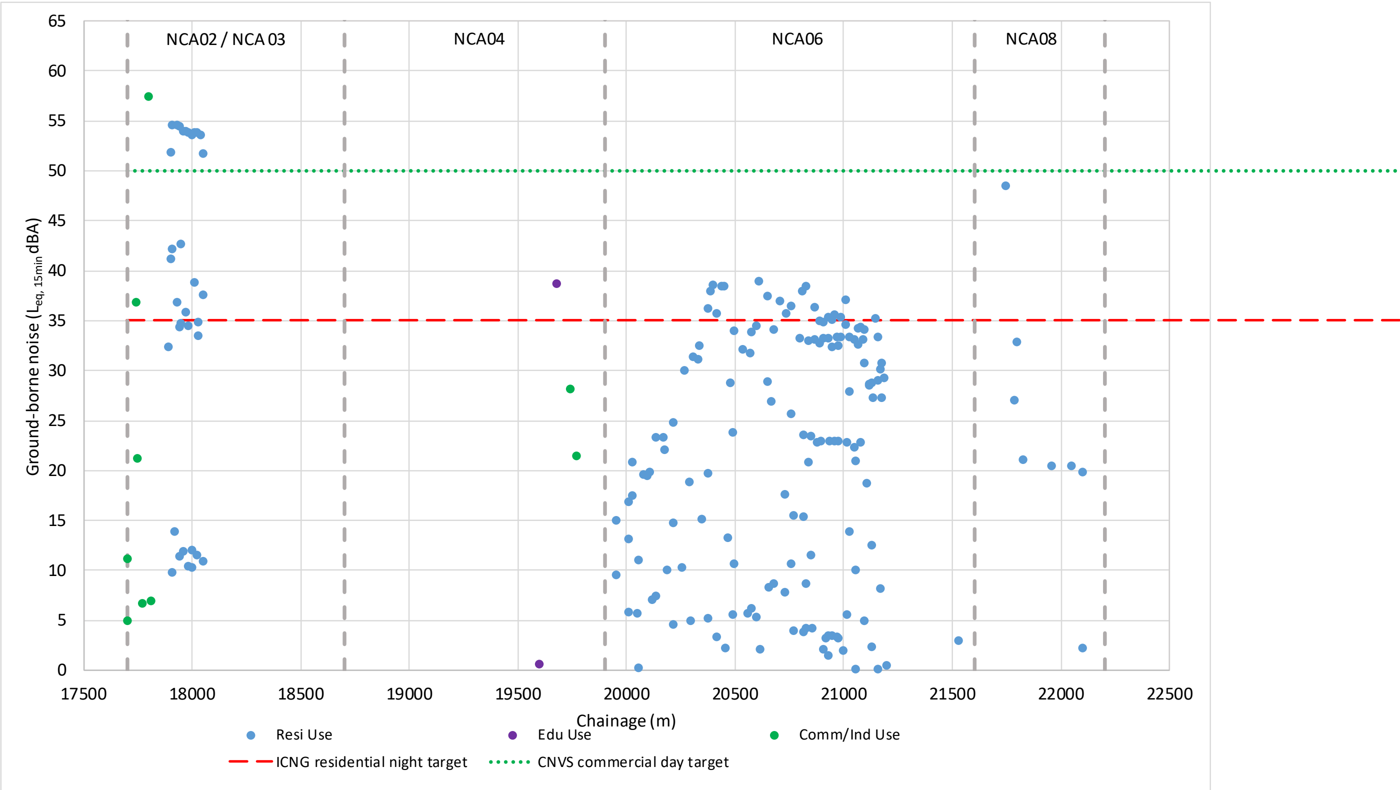


Figure 4-53 Ground-borne noise predictions from TBM - St Marys to Orchard Hills tunnel

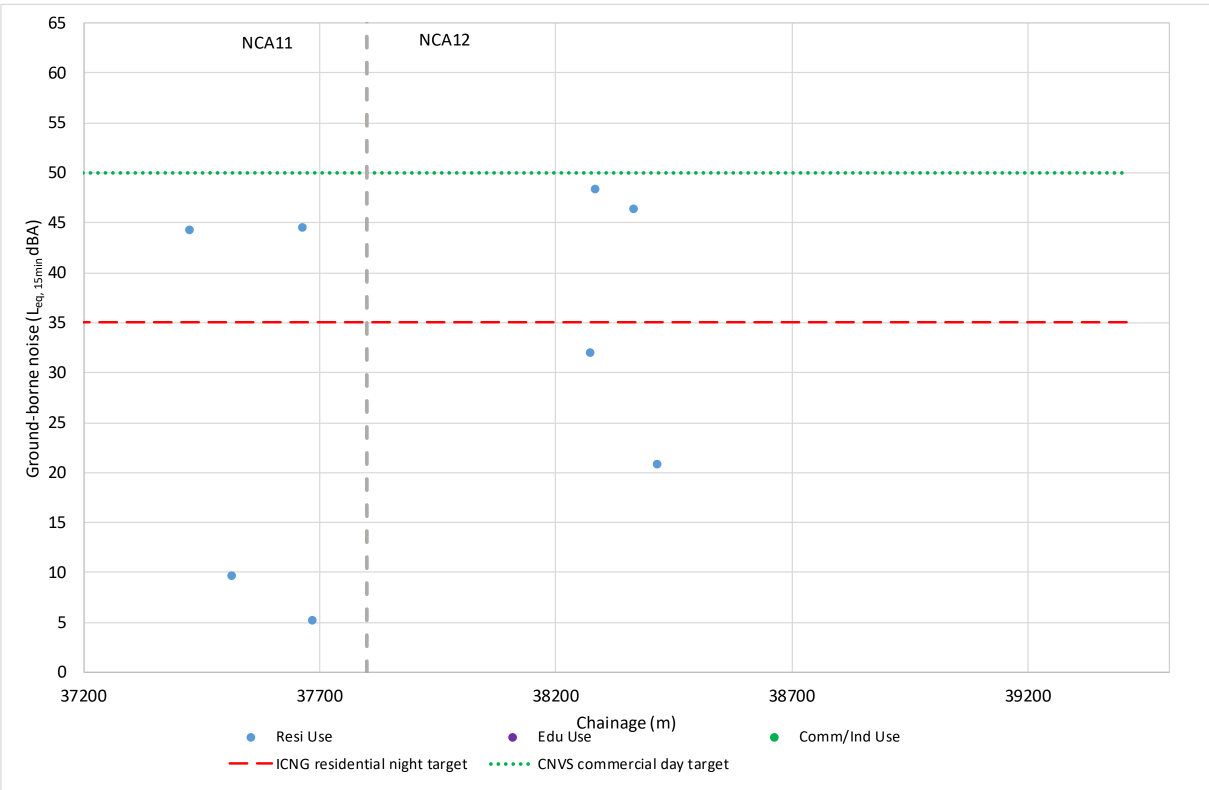


Figure 4-54 Ground-borne noise predictions from TBM - Western Sydney International to Bringelly tunnel

The ground-borne noise results provided in Figure 4-53 and Figure 4-54 indicate that for a large number of noise sensitive receivers along the tunnel alignment, the ground-borne noise levels may exceed management targets. The exceedances of the ground-borne noise targets would be for a relatively short duration, as discussed in the following section. It is predicted that up to 38 receivers may exceed the ICNG residential night target for the St Marys to Orchard Hills tunnel, and up to four receivers for the Western Sydney International to Bringelly tunnel. It should be noted that the ground-borne noise levels presented are for the worst case 15 minute interval which is likely to be experienced when the TBM is closest to these receivers.

Duration of impacts

The duration of exposure to ground-borne noise and vibration for sensitive receivers located along the alignment will be different depending on its horizontal and vertical offset from the alignment and the rate of TBM travel. The duration of exposure also depends on the time that the cutting heads of the TBM is operational. It is anticipated that TBMs may not operate continuously, but may operate for a few hours, and then stop for the installation of tunnel segments or TBM maintenance.

The duration of exposure to ground-borne noise from TBM operations has been predicted for varying rates of progression and horizontal sideline distances, assuming a depth of 15 metres between the top of the tunnel and ground surface (typical worst case tunnel depth). Day 0 in these figures represent a point where the TBM is closest to the sensitive receivers; days in negative represent the approach of the TBM, and days in positive represent the departure of the TBM from the site:

- directly above the alignment (see Figure 4-55)
- 15 metres horizontally offset from the alignment (see Figure 4-56)
- 25 metres horizontally offset from the alignment (see Figure 4-57).

The potential duration of exposure for noise sensitive receivers, for the case where the TBM rate of progression is 100 m/week (14.3 m/day) are summarised in Table 4-28.

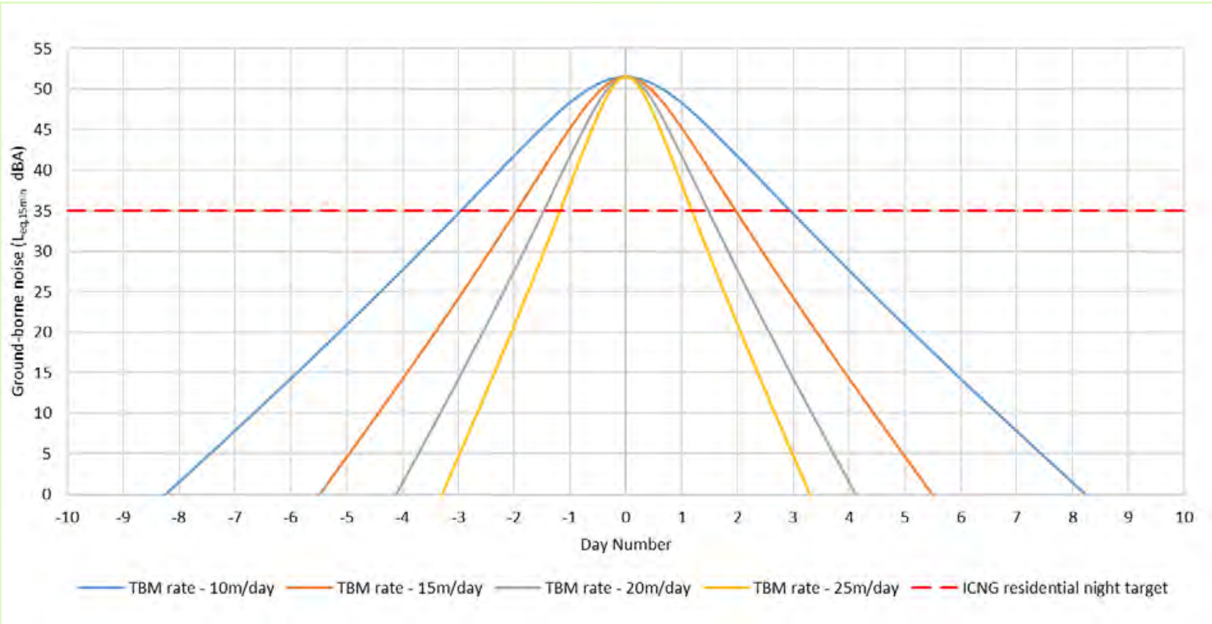


Figure 4-55 **TBM ground-borne noise exposure - buildings directly above tunnel**

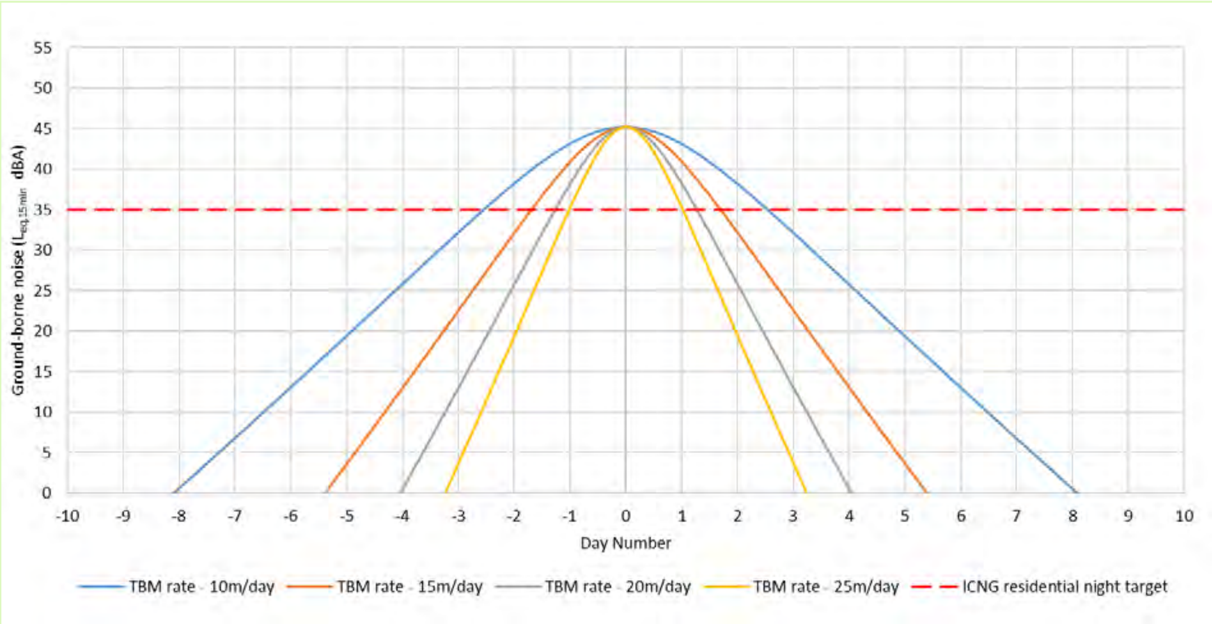


Figure 4-56 TBM ground-borne noise exposure - buildings with 15m horizontal offset

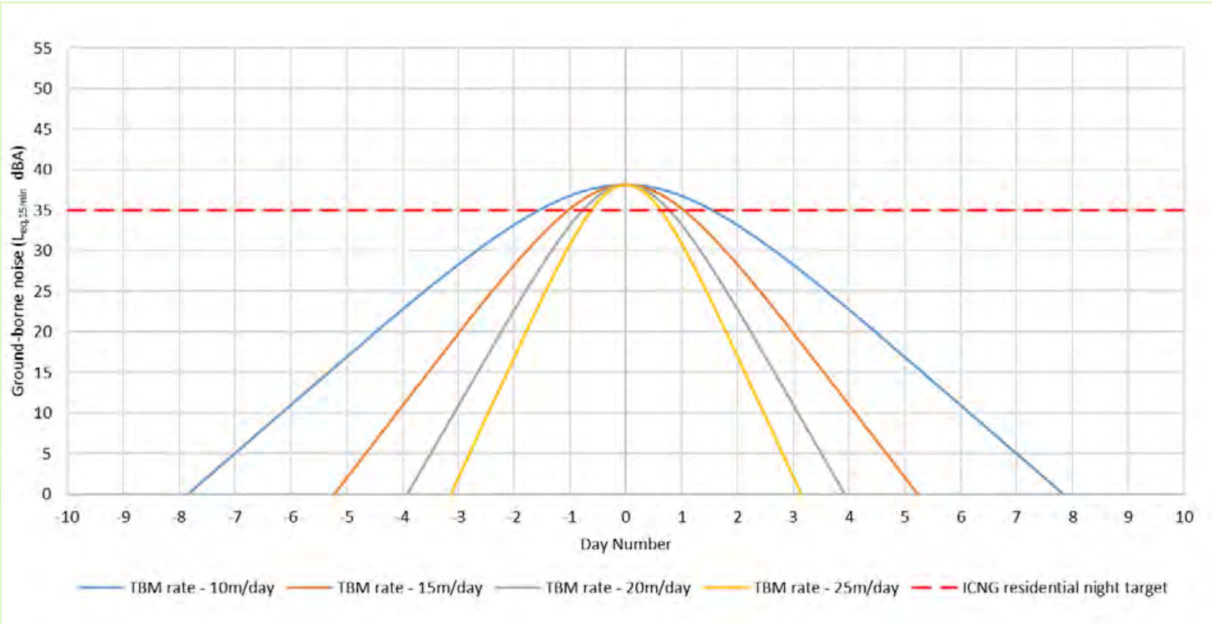


Figure 4-57 TBM ground-borne noise exposure - buildings with 25m horizontal offset

Table 4-28 Estimated duration of impacts from TBM

Horizontal offset of buildings from tunnel (metres) based on 15 m tunnel depth	Estimated duration of exposure above ground-borne noise targets
0 – 15	3 – 4 nights
15 – 25	2 – 3 nights
25 – 35	1 – 2 nights
35 - 40	0 – 1 night
> 40	Low probability of adverse impacts

Mitigation and management

The exceedances of ground-borne noise and vibration targets resulting from construction activities would be will be managed through standard mitigation as outlined in the CNVS.

Assessment of surface vibration

Certain construction activities require the use of vibration intensive equipment that may adversely impact the nearest sensitive receivers.

Minimum working distances to sensitive receivers and for human response have been identified for vibration intensive equipment. Where equipment is operating closer to a sensitive receiver, vibration from construction works may exceed the vibration guidelines provided in Section 4.1. The minimum working distances are indicative and results may vary depending on the activity, equipment, local ground, and receiver conditions.

Table 4-29 presents the vibration intensive equipment and the associated minimum working distances. Vibration information used to derive the nominated minimum working distances was sourced from data provided in the CNVS and internal databases where information was not readily available elsewhere.

Figure 4-58 presents the number of receivers within the minimum working distance within the construction footprint at each construction site. It should be noted that vibration intensive works are mostly expected to take place set back from the construction footprint boundary, and therefore the number of receivers assessed to be located within minimum working distances is considered to be a conservative assessment.

Table 4-29 Recommended minimum working distances for vibration intensive equipment

Equipment item	Minimum working distance (metres)		
	Cosmetic damage (heritage structures)	Cosmetic damage	Human response
Excavator (approx. 3 tonne)	4	3	-[1]
Excavator (approx. 6 tonne)	4	3	-[1]
Excavator (approx. 10 tonne)	4	3	-[1]
Small Hydraulic Hammer (300 kg - 5 to 12t excavator)	4	3	-[1]
Excavator (approximately 20 tonnes)	4	3	-[1]
Medium Hydraulic Hammer (900 kg - 12 to 18t excavator)	15	10	-[1]
Excavator (approximately 30 tonnes)	4	3	-[1]
Excavator (approximately 40 tonnes)	4	3	-[1]
Large Hydraulic Hammer (1600 kg - 18 to 34t excavator)	45	30	-[1]

Equipment item	Minimum working distance (metres)		
	Cosmetic damage (heritage structures)	Cosmetic damage	Human response
Vibratory Ripper (20-40t excavator)	-[1]	-[1]	-[1]
Scraper (38m3 capacity)	3	2	n/a
Dozer (equiv. CAT D10)	7	5	-[1]
Dozer (equiv. CAT D11)	7	5	-[1]
Pile Boring Rig > 800 mm diameter	4	3	20
Pile Boring Rig < 800 mm diameter	4	3	20
Vibratory Pile Driver	40	27	20
Impact Piling Rig	30	20	50
Jack hammer Hand held	2	2	n/a
Vibratory roller (Typically 2-4 tonnes)	12	8	20
Vibratory roller (Typically 4-6 tonnes)	25	16	40
Vibratory roller (Typically 7-13 tonnes)	30	20	100
Vibratory roller (Typically 13-18 tones)	40	27	100
Vibratory roller (> 18 tonnes)	50	35	100

(1) Data to allow the calculation of a minimum working distance is not available. Specific investigation of these plant items should be undertaken when used

It is noted that the majority of the non-residential receivers south of the M4 Western Motorway are sheds or other secondary structures associated with rural residential properties.

The St Marys Railway Station (including the goods shed, jib crane, and station building) and McGarvie Farm (central cluster of buildings) heritage receivers, as identified in Section 3.1.2, are located within the construction footprint, and are therefore within the minimum working distances. The jib crane is likely to be removed and stored elsewhere as part of the construction works. The Queen Street, Post-War Commercial Building is adjacent to the construction footprint, and is within the minimum working distances. It is noted that two buildings of high significance in the western cluster of buildings on McGarvie Farm would not be adversely impacted by vibration due to construction of the project. The St Marys Munitions Workers Housing heritage receivers are located adjacent to the construction footprint, and are also within the minimum working distances.

The construction type and structural integrity of the heritage buildings would be confirmed subject to design development. Applicable vibration criteria and associated impacts would be verified at this stage to inform any potential reasonable and feasible mitigation options.

Viaduct support structures would be constructed approximately 5 metres from the pipelines. Construction of these support structures would involve the use of a pile boring rig and excavators. Pile boring rigs and excavators have a minimum working distance of 4 metres, to achieve the required vibration limits. Specific mitigation as required by Guidelines for Development Adjacent to the Upper Canal and Warragamba Pipelines would be undertaken, and include confirming vibration velocity from construction activities and the impact the works will have on the pipelines, and undertaking vibration monitoring to manage construction activities including the use of pile boring rigs and excavators.

Where works occur within minimum working distances reasonable and feasible mitigation, including dilapidation surveys and vibration monitoring, would be considered in line with the CNVS, as outlined in Chapter 7.

Sydney Metro – Western Sydney Airport

Construction surface vibration - buildings within minimum working distances

Figure 4-58a

Sydney Metro – Western Sydney Airport

Construction surface vibration - buildings within minimum working distances

Figure 4-58b

Sydney Metro – Western Sydney Airport

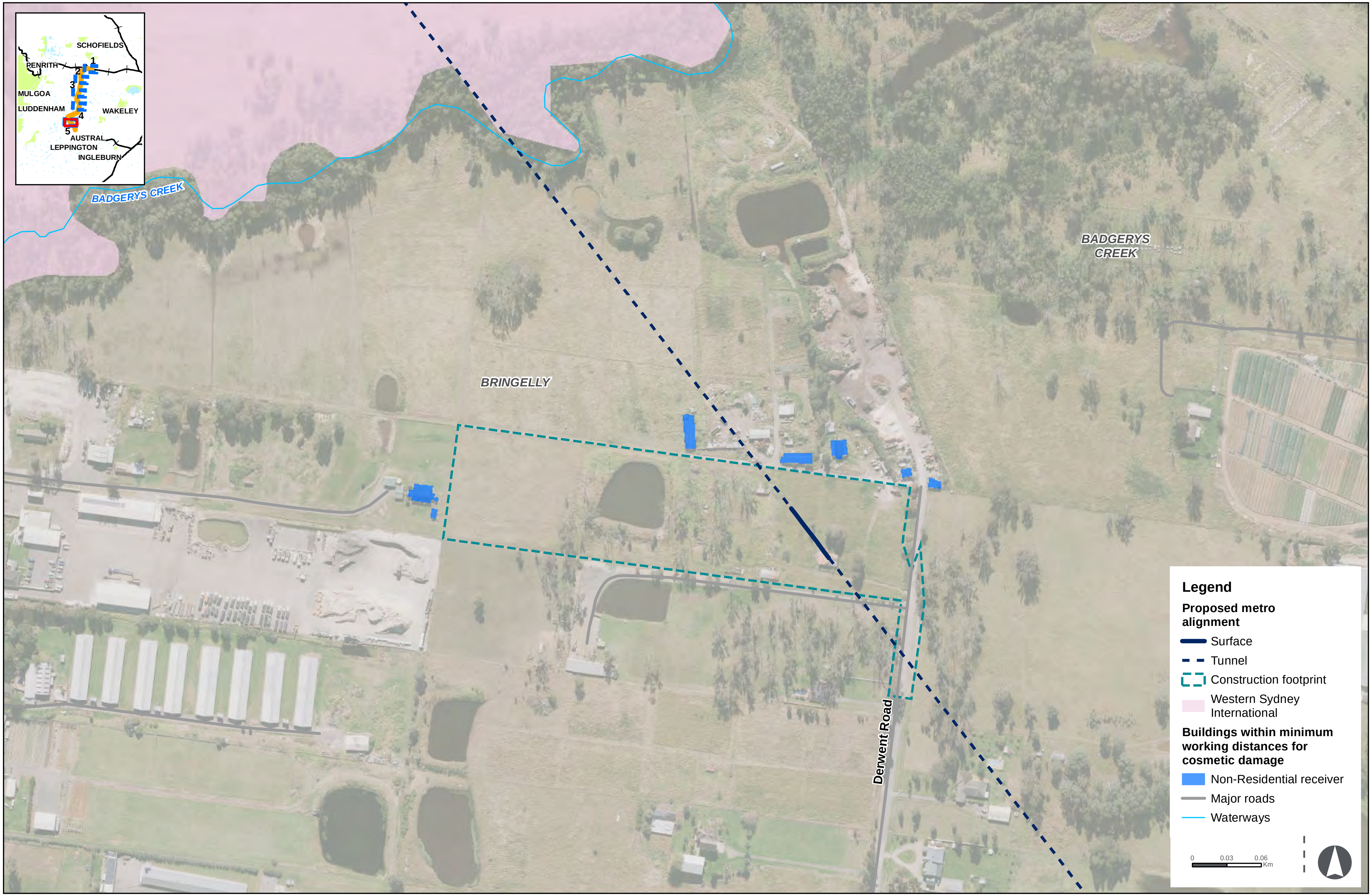
Construction surface vibration - buildings within minimum working distances

Figure 4-58c

Sydney Metro – Western Sydney Airport

Construction surface vibration - buildings within minimum working distances

Figure 4-58d



Sydney Metro – Western Sydney Airport

Construction surface vibration - buildings within minimum working distances

Figure 4-58e

4.9.4 Predicted ground-borne noise and vibration levels (on-airport)

Assessment of ground-borne noise and vibration due to tunnelling on Western Sydney International has been undertaken for all sensitive receivers that are located within 300 metres of the tunnel alignment. The assessment has shown that ground-borne noise from tunnelling (associated with the operation of TBMs, road headers and rock breakers) can meet the most stringent ICNG residential night time targets at a separation distance of around 40 metres from the tunnel, and vibration targets can be achieved at a separation distance of around 30 metres from the tunnel.

During construction, there are two sensitive receivers within the Western Sydney International; the Airport Experience Centre and Western Sydney Airport site offices. Both of these receivers are well removed from the tunnel alignment and will not be adversely affected by ground-borne noise and vibration. The section of the metro alignment between Elizabeth Drive and the Western Sydney International tunnel portal will be at surface level and therefore construction ground-borne noise is not an issue for this part of the alignment. Vibration targets for this surface section of the alignment can be met within 50 metres (to avoid cosmetic damage to residential building structures) and 100 metres (for human comfort), for the most vibration intensive plant anticipated during construction (large vibratory rollers). The two sensitive receivers are both located well outside these separation distances, and therefore construction vibration is also not considered to be an issue.

For construction of the Western Sydney International to Bringelly tunnel located to south east of Western Sydney International only four receivers are predicted to experience exceedances of the relevant ground-borne noise targets during the worst case night time period. Two of these receivers are located on Derwent Road over 400 metres from the airport site and the other two receivers are located immediately east of Badgerys Creek Road over 1 kilometre from the airport site. In both cases the receivers are located where the tunnel intersects those roads. The exceedances would occur for a limited duration (up to 3 to 4 days) as the TBMs progress at a rate of around 100 metres per week. These exceedances are associated with tunnelling works occurring in the immediate vicinity of these receivers and outside of the Western Sydney International site.

Therefore, no impacts on sensitive receivers are anticipated from ground-borne noise and vibration associated with tunnelling within the Western Sydney International site.

4.10 Construction road traffic noise assessment

Construction related vehicle movements have the potential to generate noise impacts at the nearest sensitive receivers over the duration of the construction program. Roads potentially impacted by such movements during construction of the project are classified as sub-arterial and arterial roads, as defined by the RNP and discussed in Section 4.1.4.

A high-level assessment of construction road traffic noise impacts has been conducted for this assessment. The following assumptions were made:

- Construction traffic on public roads, including staff vehicle and truck movements associated with haulage, has been modelled.

To support the day shift:

- 50 percent of staff arriving before 7am (during the night shift) and 50 percent arriving after (during the day shift)
- all staff leaving before 10pm (during the day shift)
- 25 percent of staff movements throughout the day (for lunch, meetings, etc).

To support the night shift:

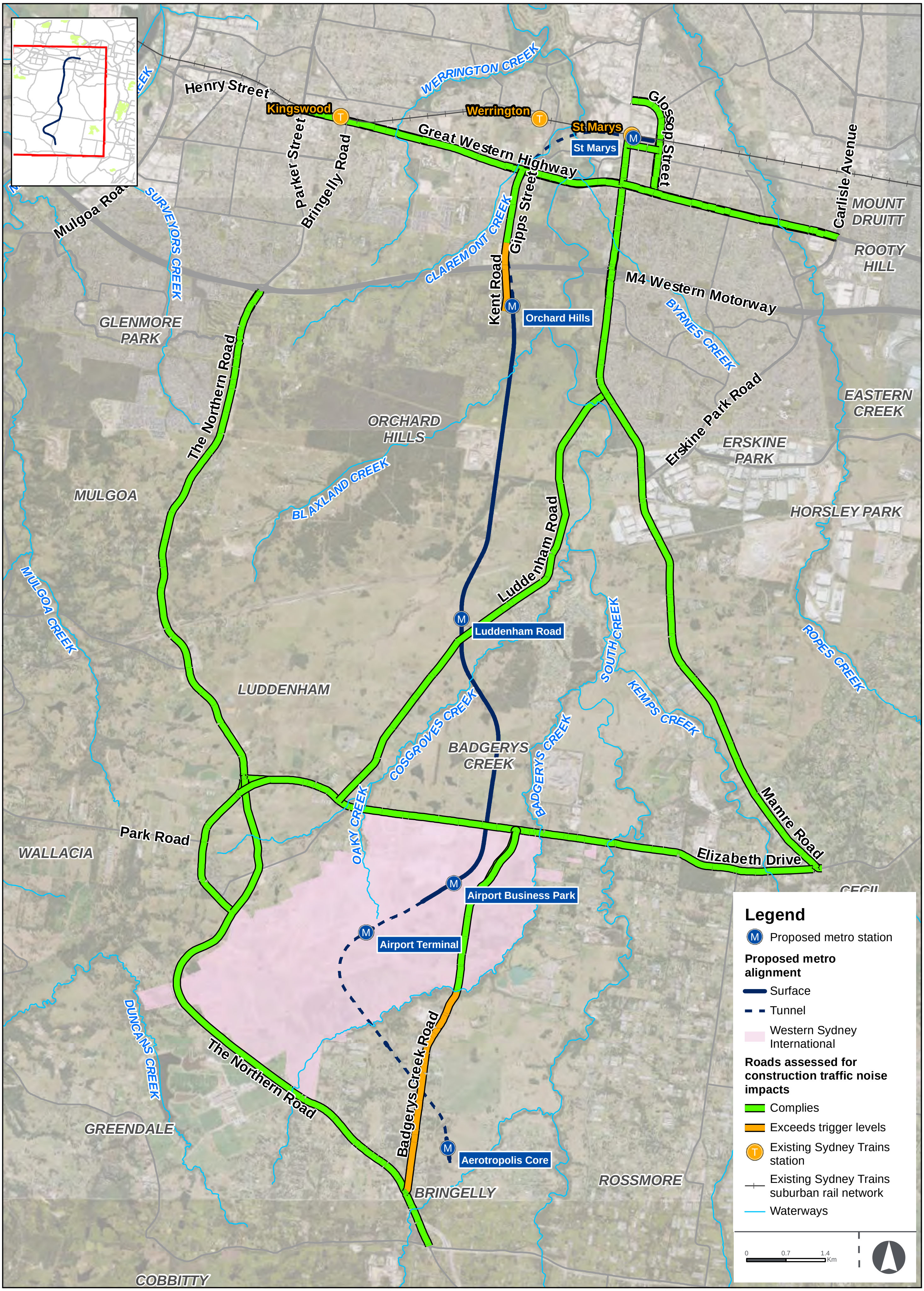
- 100 percent of staff arriving before 10pm (during the day shift)
- all staff finishing on-site and leaving before 7am (during the night shift)
- 10 percent of staff movements throughout the night (for meals, meetings, etc).

4.10.1 Predicted noise levels

Table 4-30 summarises the forecast base and construction traffic volumes for the project over the peak construction year (2023/2024). These volumes have been compared to limiting noise criteria for each period and used to predict the relative noise increase on affected roads as a result of construction traffic volumes, with respect to the nearest identified receiver.

The predicted construction traffic noise levels, based on the forecasted base and construction traffic volumes, are presented in Table 4-31. These levels are assessed at the most affected representative residential receiver

The roads considered for the construction traffic noise assessment are shown in Figure 4-59.



Sydney Metro – Western Sydney Airport

Modelled construction routes

Figure 4-59

Indicative only, subject to design development

Table 4-30 Summary of traffic volumes – base (2023/2024) traffic volumes and base traffic volumes with construction traffic

Road	2023/2024 Base				2023/2024 Base + Construction			
	Day (7am to 10pm)		Night (10pm to 7am)		Day (7am to 10pm)		Night (10pm to 7am)	
	Total vehicles	HV%	Total vehicles	HV%	Total vehicles	HV%	Total vehicles	HV%
Glossop Street (north of the Great Western Highway)	18556	18%	3275	7%	19607	18%	4039	8%
Great Western Highway (east of Queen Street)	37576	9%	6631	5%	38297	9%	7169	5%
Great Western Highway (west of Queen Street)	29510	7%	5208	5%	30108	7%	5655	5%
Queen Street (north of Great Western Highway)	9925	3%	1103	3%	9925	3%	1103	3%
Great Western Highway (east of Gipps Street)	44708	3%	7278	2%	44992	3%	7490	2%
Great Western Highway (west of Gipps Street)	43257	3%	7042	2%	43550	4%	7262	2%
Kent Road (north of the M4)	21629	6%	3817	3%	22186	6%	4233	3%
Kent Road (south of the M4)	7421	4%	1310	3%	8916	9%	2263	11%
Mamre Road (south of the Great Western Highway)	21600	12%	4114	6%	21969	12%	4365	6%
Mamre Road (north of Luddenham Road)	37120	10%	7603	6%	37671	10%	7883	6%
Luddenham Road (west of Mamre Road)	10307	4%	1963	3%	11035	7%	2314	8%
Luddenham Road (north of Elizabeth Drive)	10817	4%	2060	3%	11900	7%	2614	8%
Elizabeth Drive (west of Badgerys Creek Road)	8696	12%	1781	5%	9753	15%	2325	9%
Elizabeth Drive (east of Badgerys Creek Road)	11668	14%	2390	7%	12878	17%	2981	12%
Badgerys Creek Road (between The Northern Road and the Western Sydney International)	5578	10%	1308	5%	9318	14%	3325	11%
The Northern Road (west of Badgerys Creek Road)	21053	13%	3715	4%	21628	15%	3969	8%
The Northern Road (east of Badgerys Creek Road)	28730	12%	5070	5%	32136	12%	6939	6%
Derwent Road (north of The Northern Road)	340	0%	60	0%	582	19%	178	23%
Phillip Street (peak 1hr volumes for local road)	573	5%	811	4%	586	7%	823	5%
Station Street (peak 1hr volumes for local road)	555	8%	776	7%	281	2%	388	2%

Table 4-31 Construction road traffic noise assessment

Location	Distance to closest representative residential receiver (metres)	RNP classification	RNP criteria[1]		Predicted noise level of base traffic[1]		Predicted noise level of base traffic with construction traffic[1]		Increase in noise level generated by construction traffic[1]		Complies?[1]	
			Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day	Night	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$
Glossop Street (north of the Great Western Highway)	15	Sub-arterial	60	55	66	60	68	61	1.6	0.9	YES	YES
Great Western Highway (east of Queen Street)	25	Arterial	60	55	65	60	65	60	0.1	0.4	YES	YES
Great Western Highway (west of Queen Street)	50	Arterial	60	55	60	55	60	55	0.1	0.3	YES	YES
Queen Street (north of Great Western Highway)	90	Sub-arterial	60	55	50	43	50	43	0.0	0.0	YES	YES
Great Western Highway (east of Gipps Street)	200	Arterial	60	55	55	50	55	50	0.0	0.2	YES	YES
Great Western Highway (west of Gipps Street)	25	Arterial	60	55	67	61	67	61	0.0	0.1	YES	YES
Kent Road (north of the M4)	10	Sub-arterial	60	55	68	63	69	63	0.2	0.5	YES	YES
Kent Road (south of the M4)	20	Sub-arterial	60	55	60	54	61	58	1.9	3.8	YES	NO
Mamre Road (south of the Great Western Highway)	20	Sub-arterial	60	55	65	59	65	59	0.1	0.4	YES	YES
Mamre Road (north of Luddenham Road)	20	Sub-arterial	60	55	68	63	68	63	0.1	0.4	YES	YES
Luddenham Road (west of Mamre Road)	25	Sub-arterial	60	55	61	56	62	58	0.8	1.7	YES	YES
Luddenham Road (north of Elizabeth Drive)	45	Sub-arterial	60	55	58	53	59	55	0.9	1.9	YES	YES
Elizabeth Drive (west of Badgerys Creek Road)	30	Sub-arterial	60	55	61	55	61	57	0.8	1.8	YES	YES
Elizabeth Drive (east of Badgerys Creek Road)	50	Sub-arterial	60	55	59	54	60	56	0.8	1.7	YES	YES
Badgerys Creek Road (between The Northern Road and the Western Sydney International)	15	Sub-arterial	60	55	62	57	64	62	2.7	4.6	NO	NO
The Northern Road (west of Badgerys Creek Road)	40	Arterial	60	55	63	56	63	57	0.4	0.9	YES	YES
The Northern Road (east of Badgerys Creek Road)	30	Arterial	60	55	65	59	66	61	0.6	1.6	YES	YES

Location	Distance to closest representative residential receiver (metres)	RNP classification	RNP criteria[1]		Predicted noise level of base traffic[1]		Predicted noise level of base traffic with construction traffic[1]		Increase in noise level generated by construction traffic[1]		Complies?[1]	
			Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day	Night	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$
Derwent Road (north of The Northern Road)	25	Arterial	60	55	46	41	51	49	5.4	8.1	YES	YES
Phillip Street (peak 1hr volumes for local road)	10	Local	55 (1hr)	50 (1hr)	63 (1hr)	64 (1hr)	63 (1hr)	64 (1hr)	0.6	0.5	YES	YES
Station Street (peak 1hr volumes for local road)	10	Local	55 (1hr)	50 (1hr)	63 (1hr)	64 (1hr)	59 (1hr)	60 (1hr)	-4.4	-4.2	YES	YES

(1) Day = 7am to 10pm, Night = 10pm to 7am

(2) Green cells indicate compliance with RNP criteria

(3) Orange cells indicate an exceedance of RNP criteria

The results presented in Table 4-31 indicate that construction road traffic noise levels are predicted to comply with relevant RNP noise criteria at the majority of project affected roads. Therefore, no additional noise mitigation or management measures are required at these locations.

Exceedances of relevant RNP criteria and relative increase criteria have been identified at the closest representative receiver on Kent Road (south of M4 Western Motorway) and Badgerys Creek Road (between The Northern Road and the Western Sydney International). At Kent Road, noise levels of up to 58 dBA are predicted during the night period (10pm to 7am), exceeding the RNP criterion by 3 dBA, and resulting in a relative increase of 3.8 dBA, exceeding the relative increase criteria of 2 dBA. Exceedances are expected to occur at all residential receivers located within 40m of Kent Road, resulting in 5 residential properties exceeding mitigation levels.

Noise levels up to 64 dBA and 62 dBA during the day and night periods respectively are predicted at the nearest receiver on Badgerys Creek Road, south of the Western Sydney International. These levels exceed relevant RNP criteria by up to 4 dBA and 7 dBA during the day and night-time periods, and present increases of 3 dBA and 5 dBA respectively. Exceedances are expected to occur at all residential receivers located within 60m of Badgerys Creek Road, resulting in 31 residential properties exceeding mitigation levels. This is a conservative assumption for Badgerys Creek Rd based on all spoil from within the Western Sydney International being taken to external disposal locations. If the spoil placement area within Western Sydney International is used to accommodate spoil from tunnelling then spoil traffic volumes on the external roads such as Badgerys Creek Road and Elizabeth Drive would be significantly reduced.

Construction traffic noise would be reassessed during construction planning and design development to confirm results and if required mitigation options would be identified to address exceedances of RNP criteria. Mitigation would be considered, as outlined in the CNVS including planning traffic flow, parking and loading/unloading areas, to reduce construction road traffic noise impacts to meet RNP criteria where reasonable and feasible.

5 Assessment of operational impacts

5.1 Operational rail noise guidelines

5.1.1 Rail noise guidelines (off-airport)

The RING provides guidance on the assessment and management of airborne noise impacts generated by railways, providing non-mandatory airborne noise trigger levels for sensitive receivers.

The trigger levels represent external levels of noise that trigger the need for an assessment of potential noise mitigation measures to reduce noise levels from a rail infrastructure project. Where trigger levels are exceeded by a project, the consideration of mitigation should aim to reduce noise towards the relevant trigger levels where reasonable and feasible. It is not mandatory to achieve the trigger levels but the assessment should provide justification if they cannot be met.

Noise trigger levels are assessed for a height of 1.5 metres above ground, at a location one metre in front of the most affected building façade. Predicted noise levels are to include a façade correction factor of +2.5 dBA.

Triggers for residential land uses are provided in Table 5-1. Triggers for non-residential receivers are provided in Table 5-2. The alignment is considered a new rail line development for the purpose of the operational noise assessment.

Table 5-1 Airborne noise trigger levels for residential land uses

Type of development	Noise trigger level, dBA (external)	
	Day 7am-10pm	Night 10pm-7am
New rail line development	Predicted rail noise levels exceed:	
	60 $L_{eq,15hr}$ or 80 L_{Fmax}	55 $L_{eq,9hr}$ or 80 L_{Fmax}

Table 5-2 Airborne noise trigger levels for sensitive land uses other than residential

Other sensitive land uses	Noise trigger level, dBA (when in use)
	New rail line development
	Resulting rail noise levels exceed:
Schools, educational institutions and child care centres	40 $L_{eq,1hr}$ internal
Places of worship	40 $L_{eq,1hr}$ internal
Hospital wards	35 $L_{eq,1hr}$ internal
Hospitals other uses	60 $L_{eq,1hr}$ external
Open space – passive use (e.g. parkland, bush reserves)	60 $L_{eq,15hr}$ external
Open space – active use (e.g. sports field, golf course)	65 $L_{eq,15hr}$ external

The noise modelling predictions provided in this assessment relate to external noise levels. Where the noise trigger levels are provided as internal noise criteria, the assessment has converted these to equivalent external noise criteria, assuming:

- a generic building envelope noise reduction of 10 dBA
- the +2.5 dBA façade correction factor applied to external noise levels is excluded.

This is in accordance with the RING, and accounts for noise reduction across a building façade, where windows are partially open.

Commercial receivers are not considered as noise sensitive receivers within the RING and as such have not been assessed for noise from operation of the project.

5.1.2 Rail noise guidelines (on-airport)

Noise generated by operation of the project on-airport land is regulated by the Airports Regulations. These regulations specify that noise generated from rail traffic operated at an airport should not exceed:

- L_{max} 87 dBA, calculated as the average maximum A-weighted sound pressure level for a period of at least 15 minutes measurement
- $L_{eq,24\,hr}$ 60 dBA, calculated as the equivalent continuous A-weighted sound pressure level for a 24 hour period of measurement
- $L_{eq,8hr}$ 55 dBA, from 10pm on a particular day to 6am on the following day.

For commercial receptors, the same criteria apply. However, the time of day, duration, characteristics of noise, background noise level, and nature business conducted at the site should be considered when determining whether noise is excessive.

5.2 Operational rail ground-borne noise and vibration guidelines

The RING provides guidance on the assessment and management of ground-borne noise and vibration impacts generated by railways.

The RING notes that there is limited research into the impacts of ground-borne noise; however, it states that:

> *It appears reasonable to conclude that ground-borne noise at or below 30 dBA L_{max} will not result in adverse reactions, even where the source of noise is new and occurs in areas with low ambient noise levels. Levels of 35–40 dBA L_{max} are more typically applied and likely to be sufficient for most urban residential situations, even where there are large numbers of pass-by events.*

The RING provides the following trigger levels for ground-borne noise as outlined in Table 5-3.

Table 5-3 Ground-borne noise trigger levels for heavy or light rail projects

Sensitive land use	Time of day	Internal noise trigger levels dBA[1]
Residential	Day (7am-10pm)	40 L_{Smax}
	Night (10pm-7am)	35 L_{Smax}
Schools, educational institutions, places of worship	When in use	40-45 L_{Smax}

(1) LSmax refers to the maximum noise level not exceeded for 95 per cent of rail pass-by events and is measured using the 'slow' (S) response setting on a sound-level meter.

For the assessment of ground-borne vibration, the RING suggests use of Assessing vibration: a technical guideline (AVTG) (DEC 2006). It notes that train movements on a rail network generate intermittent vibration and:

> *The vibration guideline contains information on 'preferred' and 'maximum' vibration values for assessing human responses to vibration. Consider the relevant 'preferred values' to be the triggers which initiate an assessment of feasible and reasonable mitigation measures under this guideline.*

AVTG recommends the use of the vibration dose value (VDV) for assessment of intermittent vibration. The VDV can be calculated from the frequency-weighted acceleration of a single event, when the vibration comprises repeated events each of similar value and duration (as is the case for the vibration generated by train movements on the rail network). Acceptable VDV values are outlined in Table 5-4.

Table 5-4 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

(1) Daytime is 7.00am to 10.00pm and night-time is 10.00pm to 7.00am

(2) Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas

5.3 Operational rail noise assessment methodology

The RING states that noise trigger levels should be assessed for the opening year and for a design year, typically 10 years after opening of the project.

The following years have been assessed in rail noise modelling:

- 2026 – represents the opening year when the project will be connected and opened. The alignment is modelled with the proposed traffic and conditions for Year 2026
- 2036 – represents the project design year (ultimate year). The proposed alignment is modelled with the ultimate traffic and conditions for Year 2036.

5.4 Operational rail ground-borne noise and vibration assessment methodology

Noise resulting from the operation of railways, when received in buildings located on the surface above or adjacent to railway tunnels, is predominantly caused by the transmission of ground-borne vibration that is re-radiated within the building above. After entering a building, the vibration can cause the walls and floors to vibrate and radiate audible noise, which is commonly termed ‘ground-borne noise’.

If the ground-borne noise is of sufficient magnitude to be audible, the noise is characterised by low frequency, rumbling sounds, which increase and decrease in level as a train passes beneath. Where left untreated, this type of noise can be experienced in buildings adjacent to many urban underground rail systems.

For most new railway lines, the track design usually incorporates resilient rail fasteners to reduce the transmission of dynamic vibratory forces generated by the wheel-rail interface and therefore reduce vibration and regenerated noise.

The impacts of ground-borne noise levels are typically only assessed where they are higher than the airborne noise, such as when the railway is underground. The project has the rail alignment underground within the St Marys to Orchard Hills and Western Sydney International to Bringelly tunnels.

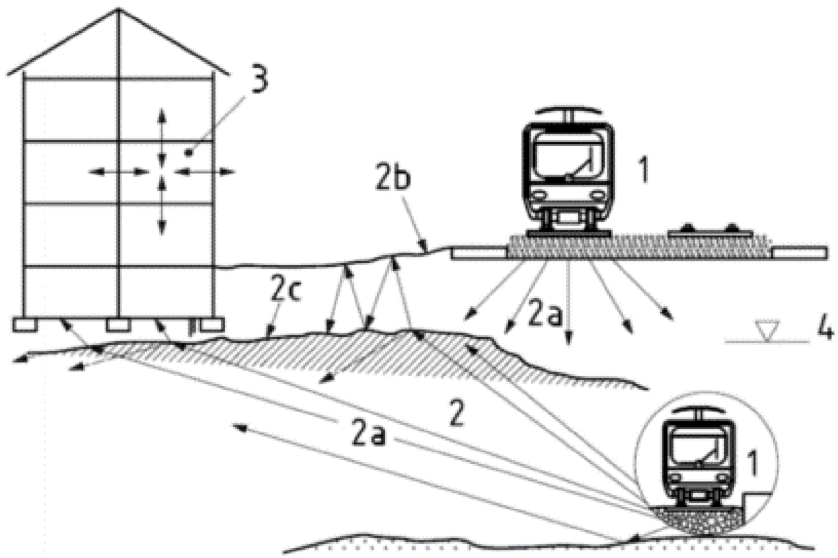
The primary noise metric used to describe railway ground-borne noise emissions in the modelling and assessment is $L_{max(slow),95\%}$. The vibration metric is assessed in the form of estimated vibration dose value. The assessment of operational ground-borne noise and vibration is undertaken in accordance with the International Standard ISO 14837-1 2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance, ground-borne noise levels are evaluated over the 20 Hz to 315 Hz frequency range.

The key parameters of the ground-borne noise and vibration modelling algorithms are as follows:

- source – route alignment, rolling stock design, rail type, track form design, tunnel design, turnouts, construction tolerances, operations and maintenance

- propagation path – ground type and vibration propagation wave types
- receivers – building construction.

The above-mentioned elements are shown schematically in Figure 5-1.



Key

1 source

2 propagation:
 2 a body waves (compression, shear)
 2 b surface waves (e.g. Rayleigh, Love)
 2 c interface waves (e.g. Stoneley)

3 receiver (vibration, re-radiated noise)

4 water table

NOTE The components of the system comprising source, propagation and receiver are interdependent.

Figure 5-1 Schematic showing the source, receiver and propagation paths (ISO 14837)

5.5 Operational rail noise assessment

5.5.1 Inputs and modelling parameters

The proposed alignment was modelled in SoundPlan V8.2 using the Nordic Rail Prediction Method (Kilde Report 130). Model parameters and correction factors are detailed in Table 5-5. Corrections shown in italics in the table below were not required to be applied in the model.

Table 5-5 Noise model parameters and correction factors

Parameter	Value
Ground effect	Hard ground between rail and receiver (ground absorption set to 0)
Curve	< 300 m: +8 dBA for L_{eq} and +17 dBA for L_{max} 300 m to 400 m: +8 dBA for L_{eq} and +16 dBA for L_{max} 400 m to 500 m: +3 dBA for L_{eq} and L_{max} > 500 m: No correction
Track	Continuous welded rail: No correction Mechanical or uneven glued jointed: +3 dBA over 10m Slab track: +2 dBA
Turnout/Crossing	Fixed nose turnout: +6 dBA over 10m
Bridges	Open transom, fabricated steel web, no side screens: +10 dBA Open transom, fabricated web forming side screens: +8 dBA Ballasted, steel box girder, no side screens: +4 dBA Ballasted, fabricated web forming side screens: +4 dBA Concrete trackbed, concrete box girder, no side screens: +3 dBA Ballasted, concrete span, no side screens: No correction Concrete trackbed, concrete box girder, concrete side screens: -2 dBA Ballasted, concrete span, concrete side screens: -5 dBA
Façade	For facade reflected measurements, the measured level is to be adjusted by +2.5 dB to account for the façade reflection effect. No correction is applied to free-field receivers
Meteorological conditions	Zero wind speed Zero degrees Celsius per 100 metre atmospheric temperature gradient 15 degrees Celsius temperature 70 per cent relative humidity

Source noise levels

At the time of undertaking the assessment, the metro train fleet in operation as part of the Sydney Metro Northwest has been active for a year and is considered to be in relatively new condition. Therefore, the train condition and associated wheel/rail noise emission levels are not considered representative of in-service track and train fleet conditions that have been running for many years.

To provide a realistic assessment of noise emissions from the metro train fleet with in-service track and fleet conditions, source noise levels for existing double-deck Sydney trains are used in this assessment. Validation measurements undertaken on Sydney Metro Northwest (provided by Sydney Metro) approximately one year after opening, show a slight decrease in L_{max} and sound exposure level (SEL) under similar conditions. Therefore, using source noise levels for existing double-deck Sydney trains is considered a reasonable assumption. This approach is consistent with Environmental Impact Statements prepared for other Sydney Metro Projects.

The reference noise levels modelled are presented in Table 5-6.

Table 5-6 Rolling stock source noise levels (3-car and 4-car Metro trains)

Train	Track form	Source mitigation	Reference conditions	$L_{max, 95\%}$, dBA	SEL, dBA
Double-deck Sydney Trains	Ballast	None	15 m, 80 km/hr	85	88
Sydney Metro 3-car Train (opening)	Ballast	None	15 m, 80 km/hr	84	84
Sydney Metro 4-car Train (ultimate)	Ballast	None	15 m, 80 km/hr	84	85

Track feature corrections

Impact noise is generated when a train passes over rail discontinuities (including turnouts, crossovers, expansion joints). This increase in wheel-rail noise is included in the model, with a correction (outlined in Table 5-5) applied to 5 metres either side of the discontinuity in the rail.

Flanging noise may increase the levels of noise emission on sections of the track with a tight curve radius. Flanging noise typically occurs over curves with a radius of less than 500 metres. As the alignment doesn't contain curves with a radius of less than 500m, no flanging noise corrections have been applied.

Bridge and viaduct noise

Structure-radiated noise from rail bridges can increase the overall noise emissions from the track. Bridges have been assumed to be constructed with a concrete trackbed and concrete box girders, incurring a +3dB correction. Viaduct parapets with a height of 1.8 metres above the bridge surface have been included in the model. Rail bridges with corrections applied are listed in Table 5-7.

Table 5-7 Modelled bridge location

Location	Approx structure length (metres)	Approx start chainage	Approx end chainage
Blaxland Creek	360	23,300	23,660
Patons Lane	830	25,060	25,890
The pipelines, Luddenham Road and Cosgrove Creek	2,465	26,780	29,250
Future M12 interchange	94	30,360	30,460
Elizabeth Drive	21	31,960	31,990

Speed profile

Operational speed profiles for the up/down tracks were not available at the time of undertaking the operational rail noise assessment. Therefore, the maximum line speed of 100 km/h has been adopted for this assessment. This approach is conservative as an increase in line speed is proportional to an increase in sound generated by the operation of the rail line.

It is noted that the maximum line speed assumed for this assessment may be revised as part of design development. Further assessment of the noise impacts resulting from changes to the operational speed profile would be undertaken during design development, where required.

Track alignment and ground terrain

A digital ground model was generated based on light detection and ranging (LiDAR) data of the existing terrain encompassing the project area. This digital ground model was modified to include the project alignment, incorporating cuttings and embankments where necessary. The LiDAR data and three-dimensional project alignment was sourced from the NSW Government Spatial Information eXchange.

Service frequency

The expected service frequency assessed as part of the project, in line with Chapter 7 (Project description - operation) of the Environmental Impact Statement, are outlined as follows:

- opening operations (day 1 initial services - 2026):
  - *peak periods* (between 6am and 9am and between 3pm and 6pm) – metro train with three cars per train, every five minutes (up to 12 trains per hour)
  - *non-peak periods* – metro train with three cars per train, every 10 minutes (up to six trains per hour)
- future (ultimate service - 2036) operations:

  - *peak periods* (between 6:00am and 9:00am and between 3pm and 6pm) – metro train with four cars per train, every two minutes (up to 20 trains per hour)
  - *non-peak periods* – metro train with four cars per train, every five minutes (up to 12 trains per hour)

The proposed indicative hours of operation for the project are:

- the first train service each day would commence from St Marys Station or the Aerotropolis Core Station from around 4:30am (Monday to Sunday)
- the last train service each day would depart from either St Marys Station or the Aerotropolis Core Station on or before midnight Sunday to Thursday and no later than 1:30am on Saturday and Sunday mornings.

Table 5-8 presents the service frequency assessed over the periods specified in the RING. It is noted that an additional two train movements have been included during the night period to account for positioning train movements to/from the stabling and maintenance facility.

Table 5-8 Modelled service frequency

Period	Number of service frequency per period per direction	
	Opening (2026)	Ultimate (2036)
Day (7am to 10pm)	120	220
Night (10pm to 7am)	50	94

5.5.2 Predicted noise levels (off-airport)

Predicted noise levels at sensitive receivers, generated by off-airport operation of the proposed rail alignment is presented in this section. The predicted noise levels have been presented for the Opening year (2026) and Ultimate year (2036) in line with the RING. Predicted noise levels at sensitive receivers are presented against chainage, which is presented in Figure 1-3.

Opening year 2026

The predicted opening year daytime $L_{eq,15hr}$, night-time $L_{eq,9hr}$, and L_{max} railway noise levels at sensitive receivers within the study area are presented in Figure 5-2, Figure 5-3, and Figure 5-4 respectively.

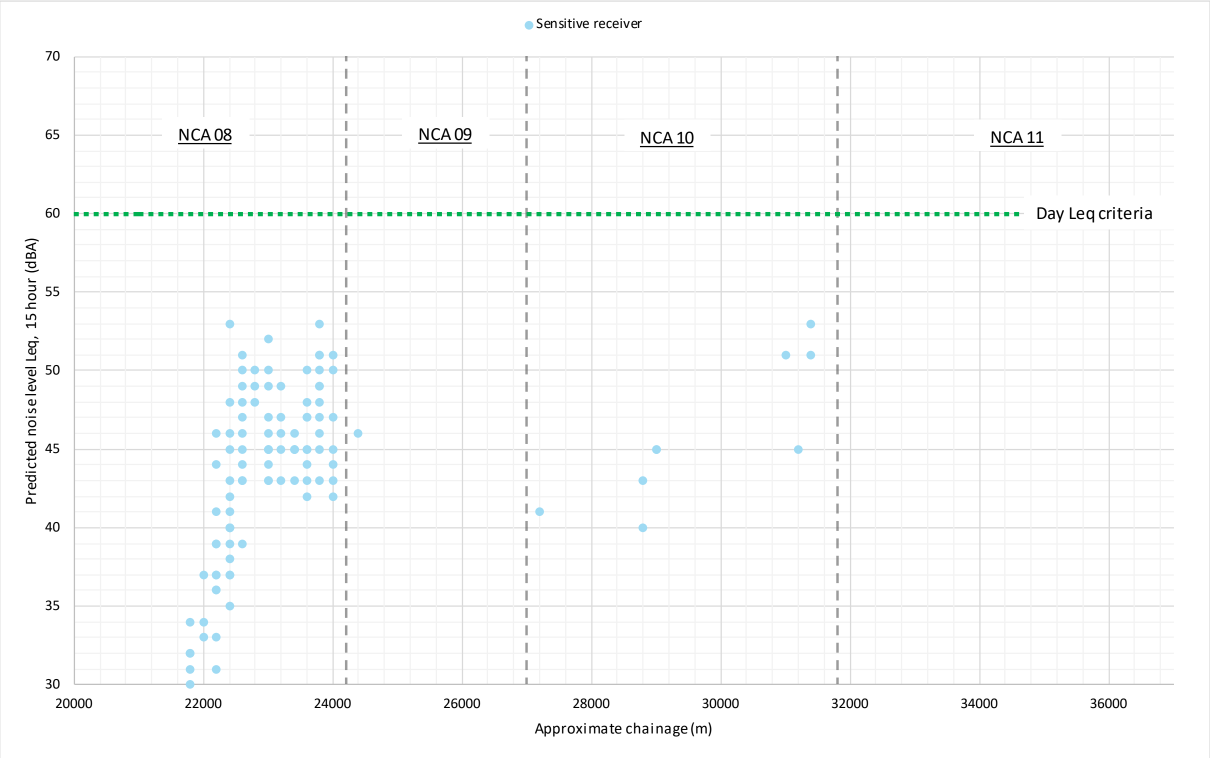


Figure 5-2 Predicted noise levels at sensitive receivers $L_{eq,15hr}$ – daytime opening year

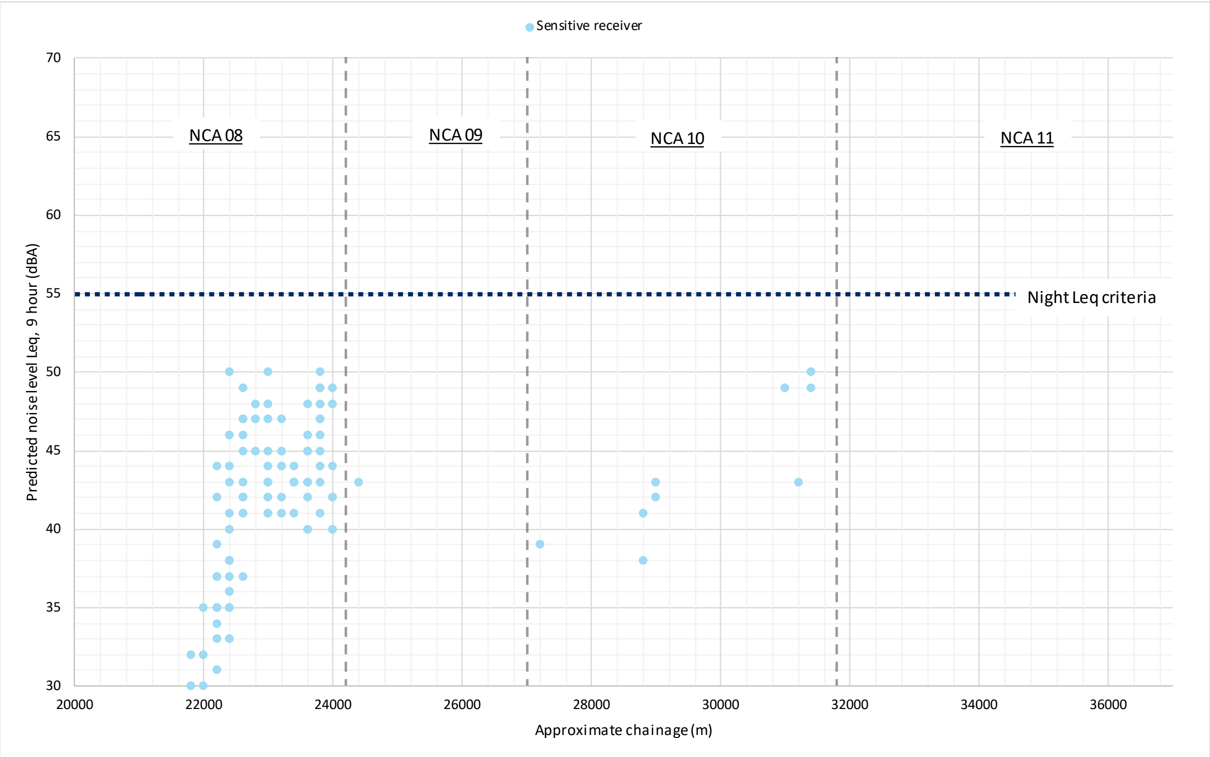


Figure 5-3 Predicted noise levels at sensitive receivers $L_{eq,9hr}$ – night-time opening year

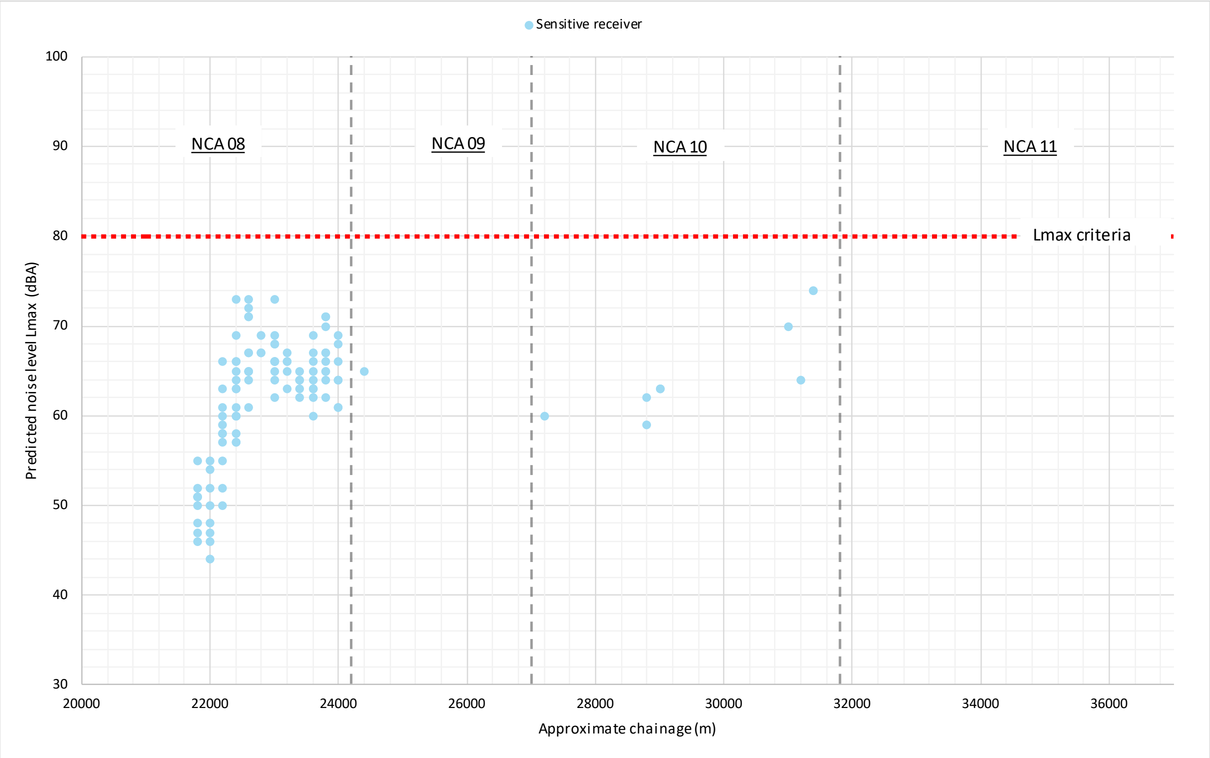


Figure 5-4 Predicted noise levels at sensitive receivers L_{max} – night-time opening year

Ultimate year 2036

The predicted ultimate year daytime $L_{eq,15hr}$, $L_{eq,9hr}$, and L_{max} railway noise levels at sensitive receivers within the study area are presented in Figure 5-5, Figure 5-6, and Figure 5-7 respectively.

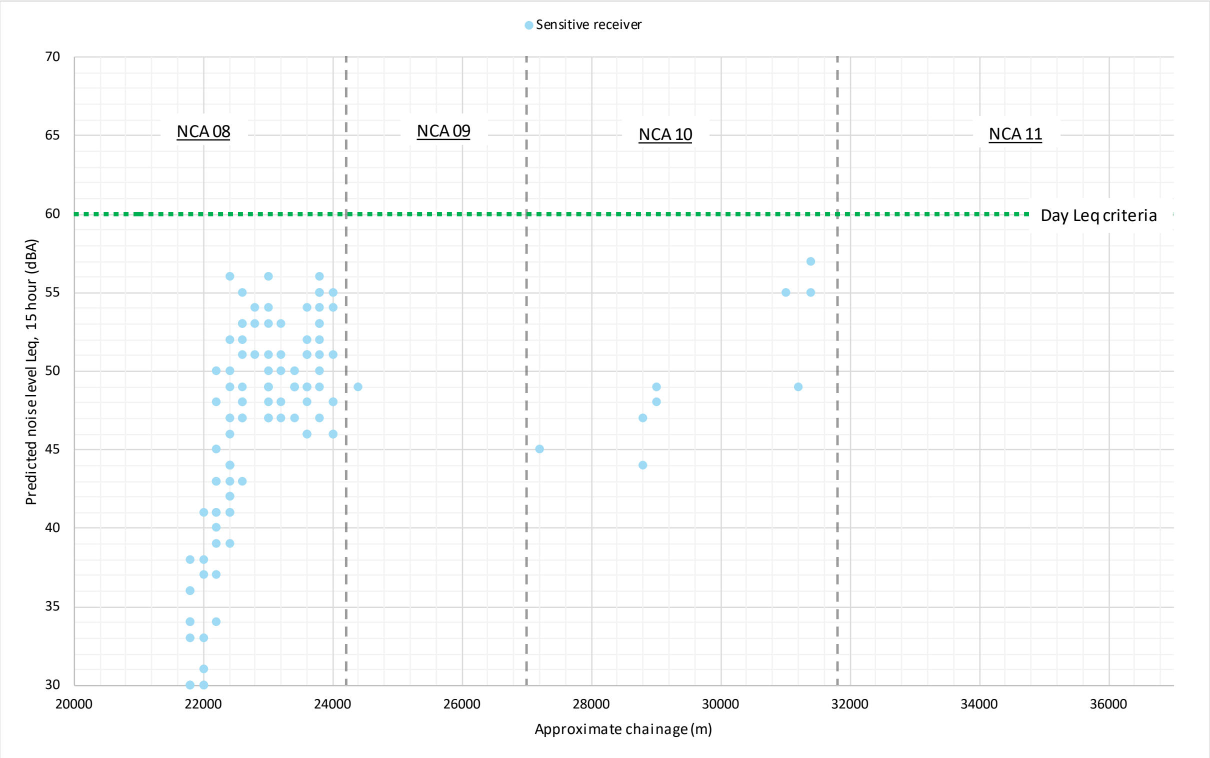


Figure 5-5 Predicted noise levels at sensitive receivers $L_{eq,15hr}$ – daytime ultimate year

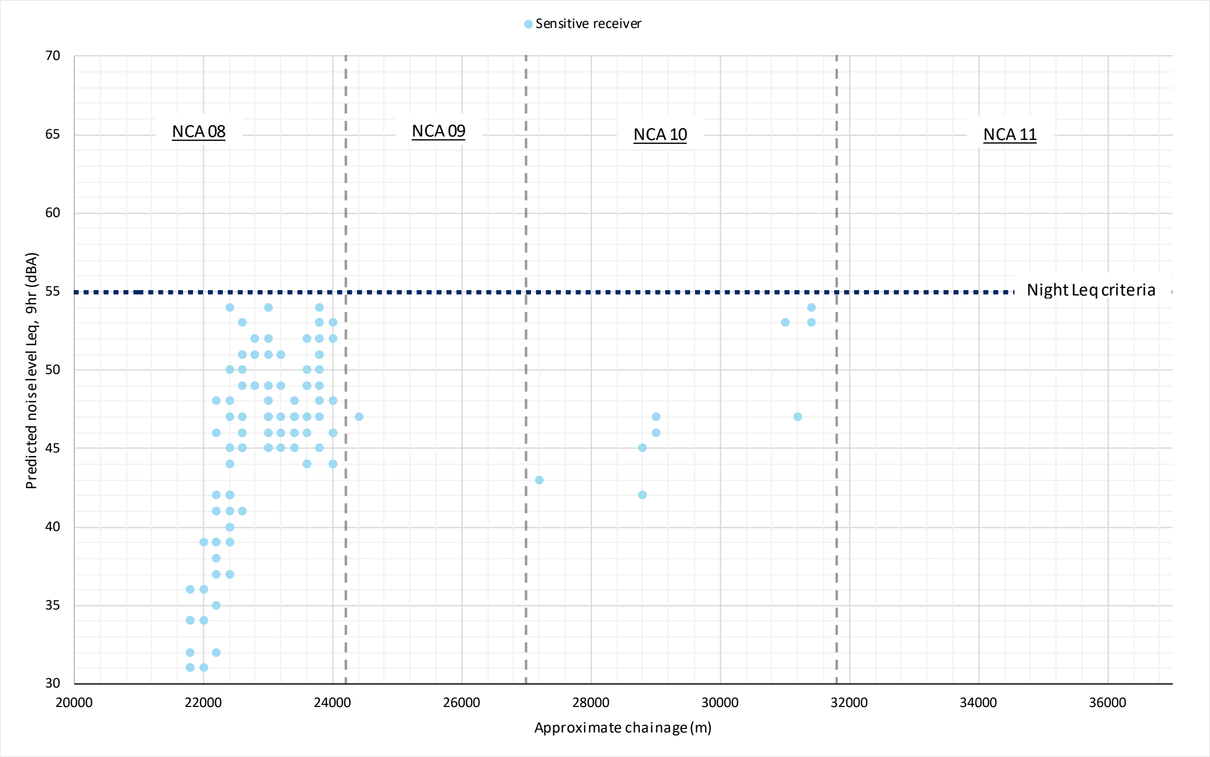


Figure 5-6 Predicted noise levels at sensitive receivers $L_{eq,9hr}$ – night-time ultimate year

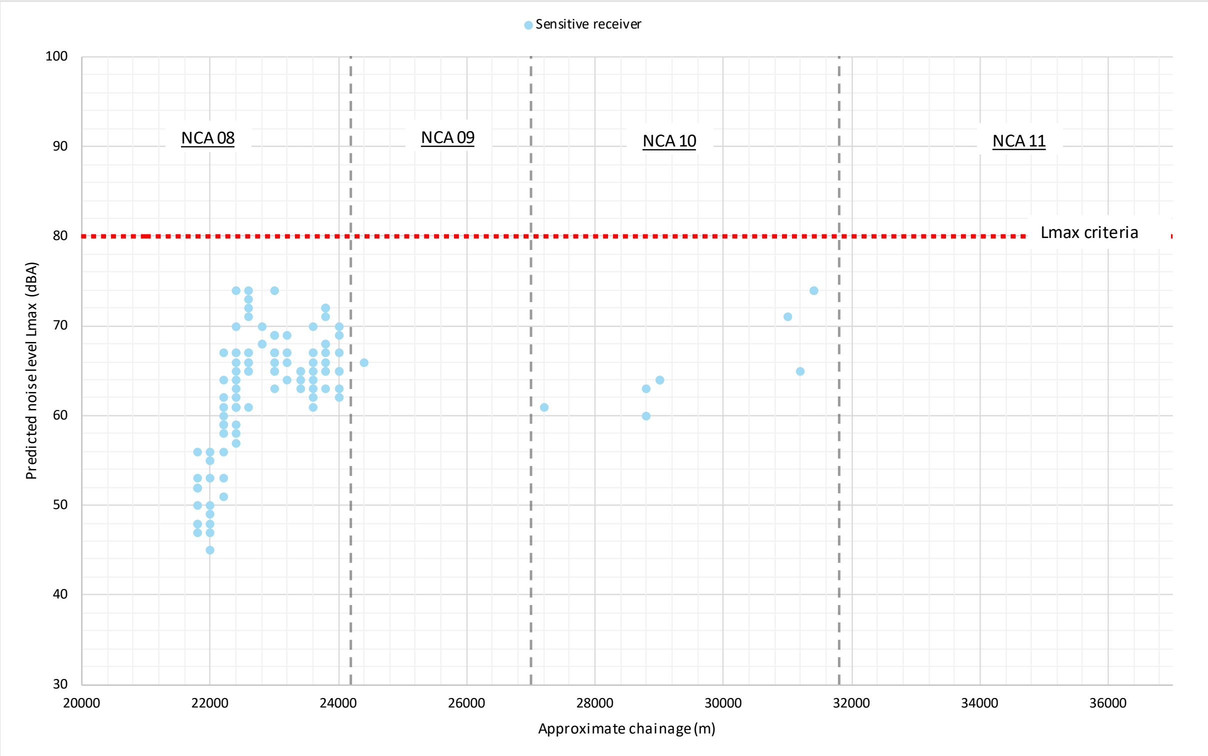


Figure 5-7 Predicted noise levels at sensitive receivers L_{max} – night-time ultimate year

5.5.3 Assessment against rail noise guidelines (off-airport)

The operational rail noise levels are predicted to comply with the relevant RING noise trigger levels at all noise sensitive receiver locations. To provide context around potential noise impacts at future-planned noise sensitive land-uses, noise contours have been provided in Appendix D.1 to indicate where exceedances of trigger levels may occur.

The worst-affected existing noise sensitive receivers as seen in Figure 5-2 to Figure 5-7, are located in NCA08 around Orchard Hills tunnel portal, and are predicted to experience a noise level of 53 dBA $L_{eq,15\ hr}$ (daytime), and a noise level of 50 dBA $L_{eq,9\ hr}$ (night-time) on opening. There is predicted to be an approximate 4 dB increase in L_{eq} noise levels, during both daytime and night-time, at the most affected sensitive receivers between opening and ultimate years.

The worst-affected receiver is predicted to experience a maximum pass-by noise level of 75 dBA L_{max} on opening. There is predicted to be an approximate 1 dB increase in maximum noise levels at the most affected sensitive receiver between opening and ultimate years; attributable to the change from a 3-car to 4-car train set.

5.5.4 Predicted noise levels (on-airport)

Predicted noise levels due to rail operations within Western Sydney International is presented in this section. As the specific location of noise sensitive receivers proposed to be developed within the business park is not yet finalised, noise contours have been provided to indicate where exceedances of criteria may occur within Western Sydney International. The predicted noise levels have been presented for the opening year (2026) and ultimate year (2036) consistent with the approach undertaken within the RING.

Opening year 2026

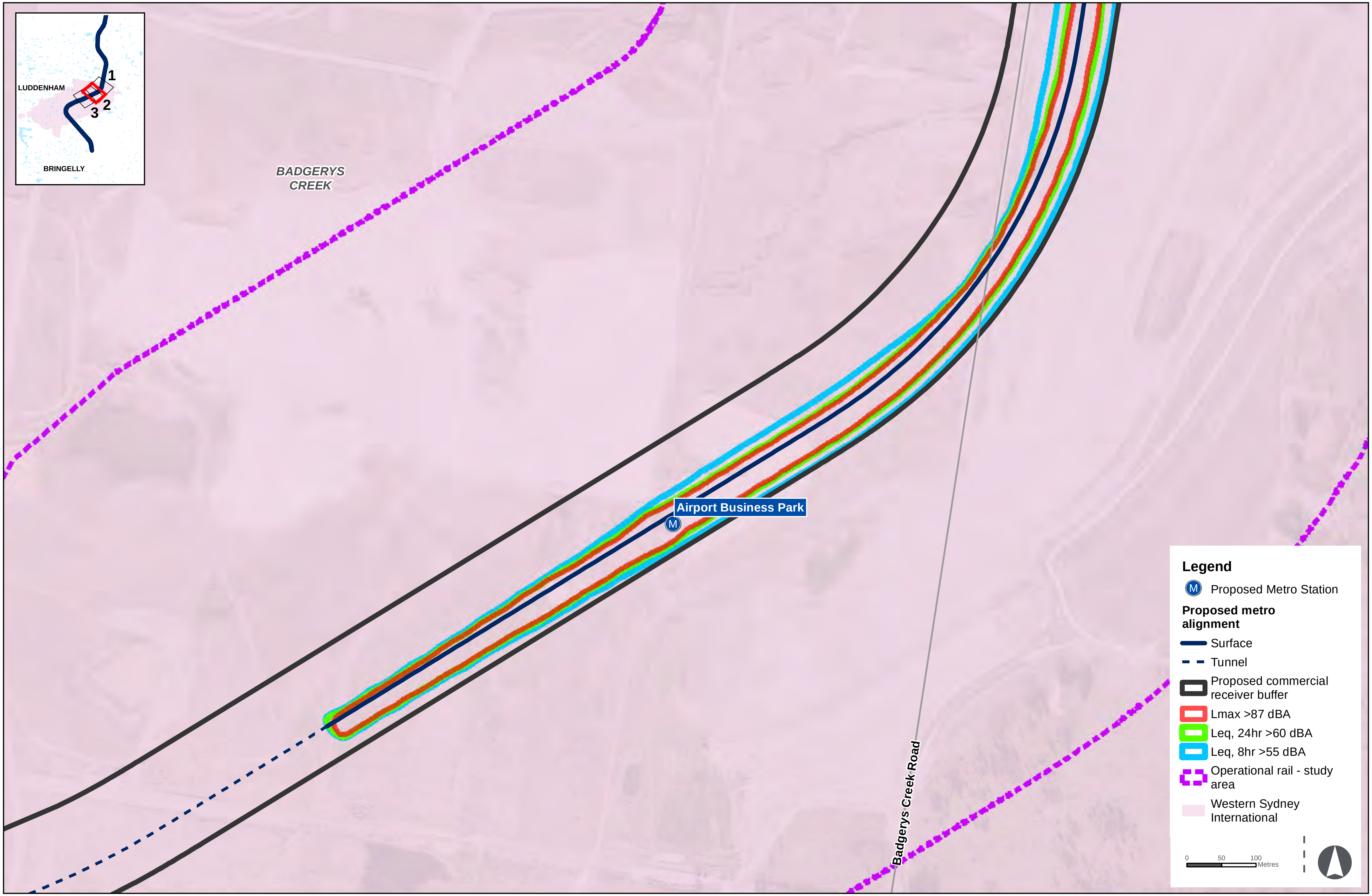
The predicted opening year $L_{eq,24hr}$, $L_{eq,8hr}$ and L_{max} railway noise contours within the study area are presented in Figure 5-8.

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Operational Rail Noise On-Airport - Opening Year - 2026

Figure 5-8a



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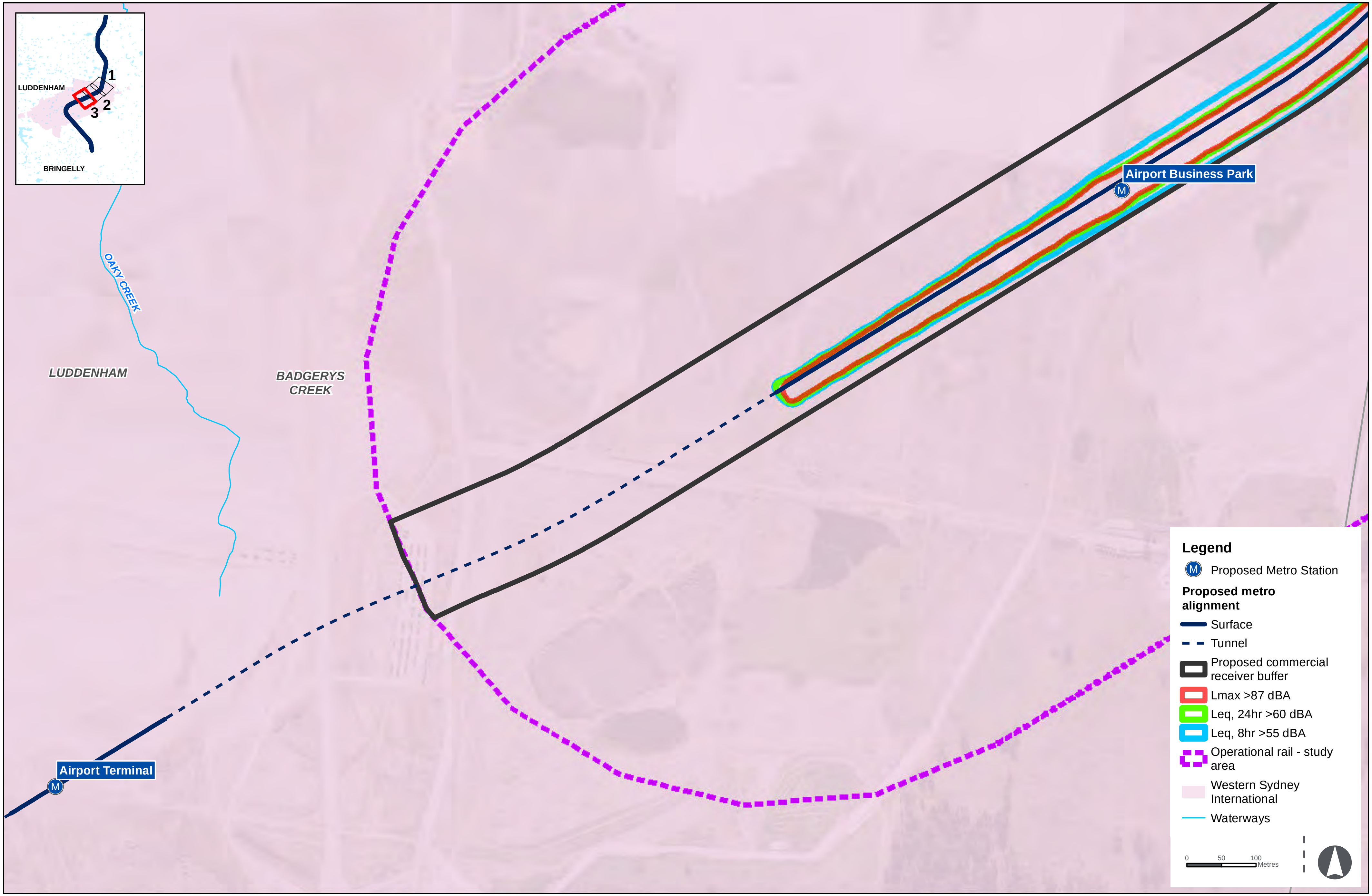
Operational Rail Noise On-Airport - Opening Year - 2026

Figure 5-8b



Sydney Metro – Western Sydney Airport

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Operational Rail Noise On-Airport - Opening Year - 2026

Figure 5-8c

Ultimate year 2036

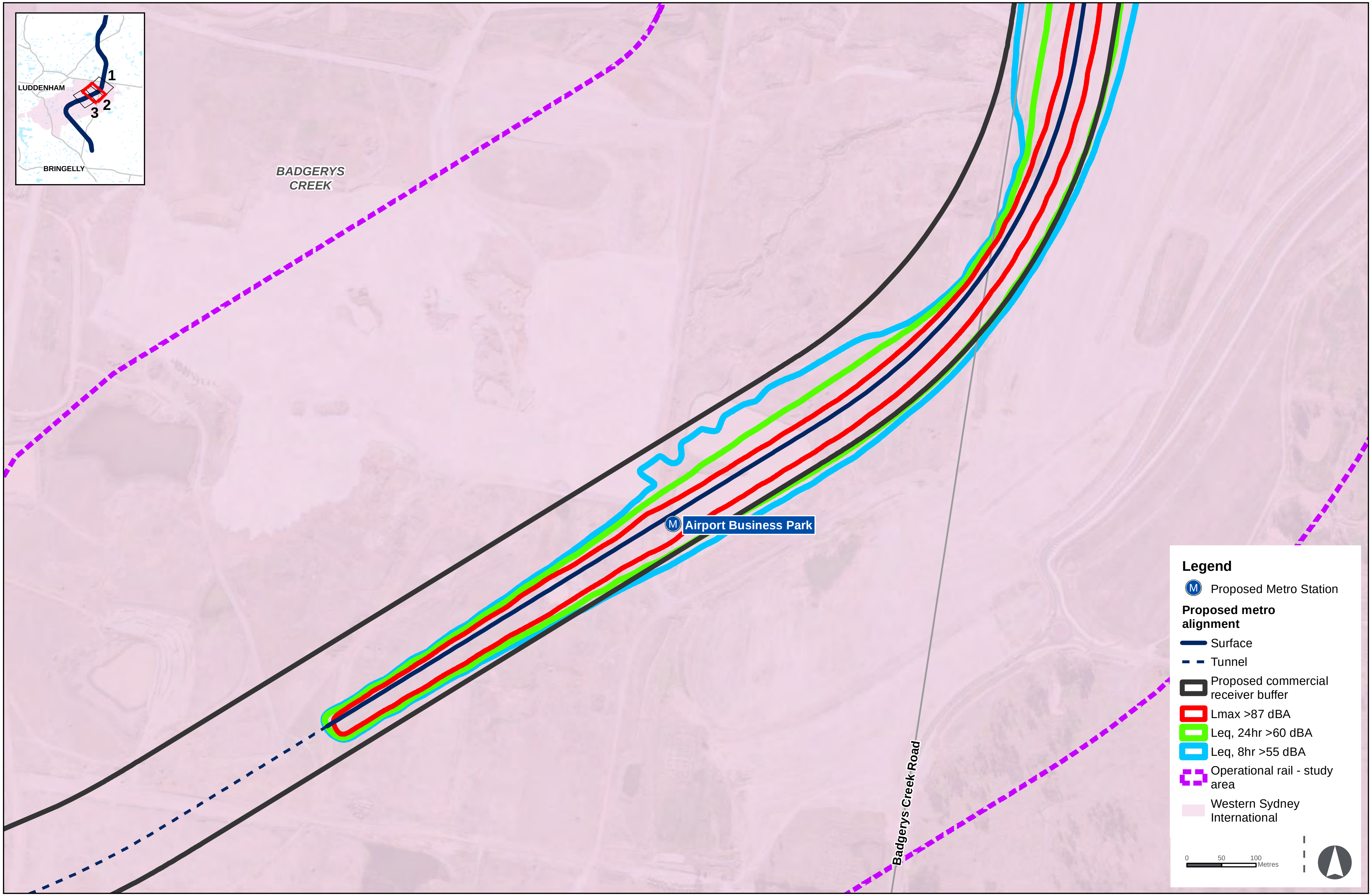
The predicted ultimate year $L_{eq,24hr}$, $L_{eq,8hr}$ and L_{max} railway noise contours within the study area are presented in Figure 5-9.

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Operational Rail Noise On-Airport - Ultimate Year - 2036

Figure 5-9a



Sydney Metro – Western Sydney Airport

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Operational Rail Noise On-Airport - Ultimate Year - 2036

Figure 5-9b

Sydney Metro – Western Sydney Airport

Indicative only, subject to design development

Operational Rail Noise On-Airport - Ultimate Year - 2036

Figure 5-9c

5.5.5 Assessment against rail noise guidelines (on-airport)

No on-airport noise sensitive receivers are predicted to exceed the Airports Regulations specified noise limits.

As outlined in the Western Sydney International airport site layout, commercial receivers are proposed on either side of the surface rail alignment at an approximate 50 metre offset from the project, as part of the Airport business park. Roads are proposed to run along both sides of the rail alignment, contributing to the setback between the commercial receivers and the rail alignment.

No exceedances of the on-airport criteria are expected at the proposed commercial receivers for the following setbacks from the rail alignment:

- $L_{eq,24hr}$ complies at >50 metres for the opening and ultimate years
- $L_{eq,8hr}$ complies at >50 metres for the opening year and >75 metres for the ultimate year
- L_{max} complies at >50 metres for the opening and ultimate years

Where potential exceedances are predicted for commercial receivers, the time of day, duration, characteristics of noise, background noise level, and nature of the of the business conducted at the site would be considered when determining whether noise is excessive in line with the Airports Regulations.

As commercial receivers are not typically expected to be occupied during the night-time period (10pm to 6am), rail noise for buildings located between 50-75 metres along the eastern side of the alignment within Western Sydney International is not expected to impact occupants.

Further to this, including where commercial receivers may be occupied during the night-time period, commercial buildings constructed within close proximity to an airport would also likely have a building envelope designed to mitigate aircraft noise, which would dominate the noise environment. It is expected that a building envelope designed to mitigate aircraft noise would render rail noise impacts negligible when assessed at an internal location within the building.

5.6 Operational rail ground-borne noise and vibration assessment

5.6.1 Inputs and modelling parameters

Detailed information in relation to the inputs and modelling parameters adopted for the operational rail ground-borne noise and vibration assessment is presented in Appendix E.

5.6.2 Prediction and assessment of ground-borne noise and vibration levels (off-airport)

Ground-borne noise and vibration levels have been predicted for all receivers within 300 metres on either side of the proposed St Marys to Orchard Hills and Western Sydney International to Bringelly tunnels. Approximately 880 buildings have been identified within this area and assessed for operational ground-borne noise and vibration. The assessment has been carried out based on reference source vibration level with standard attenuation trackform as a base case (see Appendix E).

Estimated vibration dose value predictions

Estimated vibration dose value (eVDV) predictions indicate that all buildings assessed are below the preferred VDV values shown in Table 5-4. The highest predicted eVDV is 0.087 $m/s^{1.75}$ which is lower than 0.13 $m/s^{1.75}$ preferred vibration target for residential dwellings at night.

It is important to note that the overall exposure time to operational vibration is very small (approximately 30 minutes during the day, and 12 minutes during night), and therefore the predicted eVDVs are compliant by a substantial margin for most buildings. The predicted compliance does not mean that individual events (train pass-bys) would not be perceived by receivers.

In any case, the ground-borne noise criteria are more stringent, and would drive the design for ground-borne noise and vibration mitigation.

Ground-borne noise

Ground-borne noise levels have been predicted based on standard attenuation trackform for all receivers. These results are presented in Figure 5-10 for the St Marys to Orchard Hills tunnel, and

Figure 5-11 for the Western Sydney International to Bringelly tunnel. Note that predicted ground-borne noise levels below 0 dBA are not presented in the graphs.

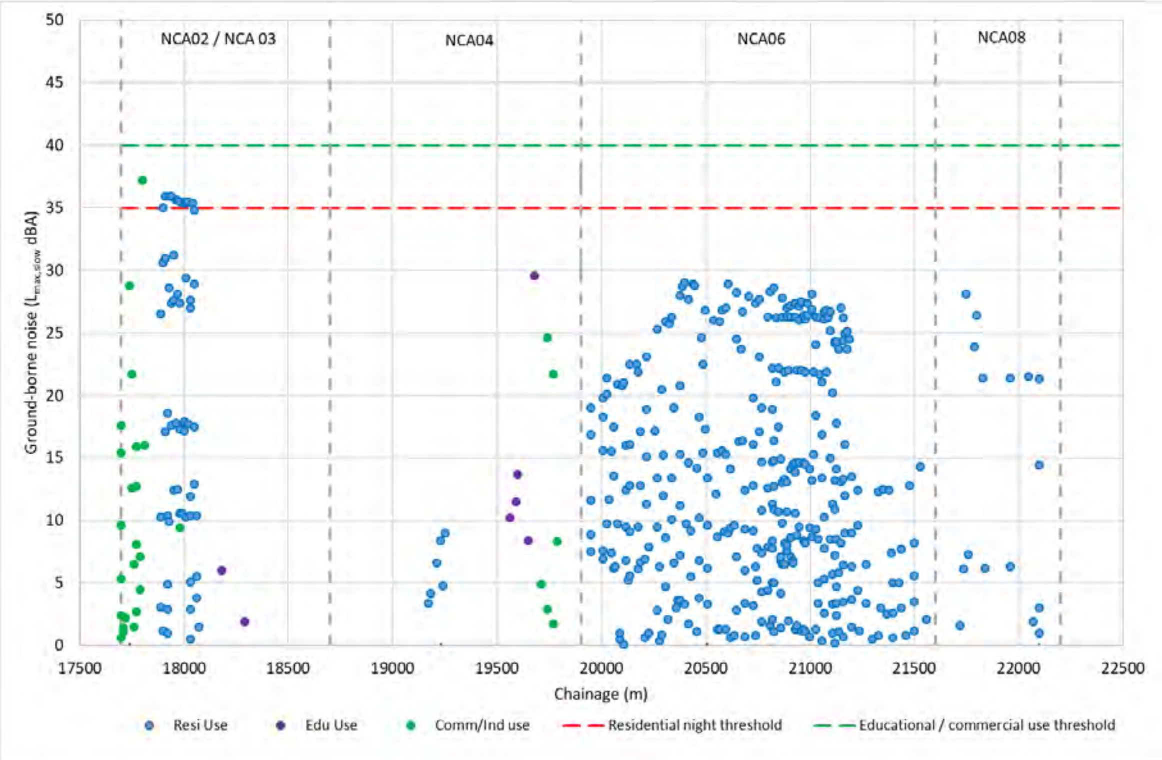


Figure 5-10 Predicted ground-borne noise levels with standard attenuation trackform - St Marys to Orchard Hills tunnel

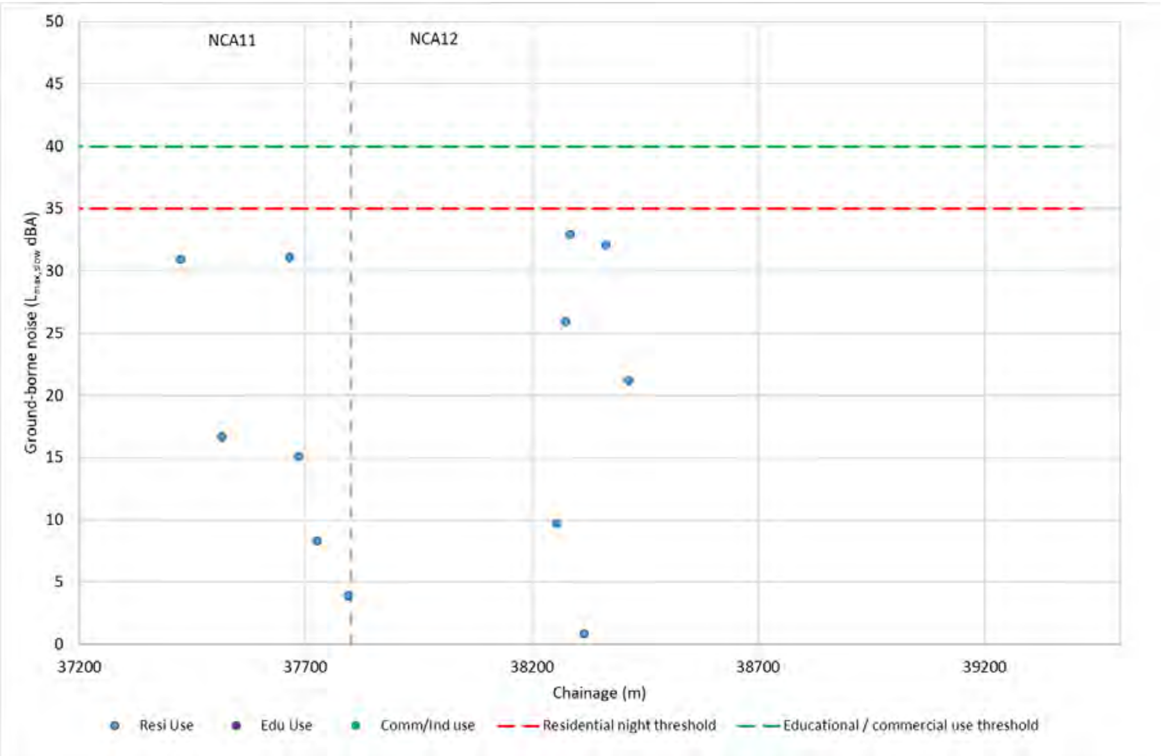


Figure 5-11 Predicted ground-borne noise levels with standard attenuation trackform - Western Sydney International to Bringelly tunnel (off-airport)

The St Marys to Orchard Hills tunnel has more noise sensitive receivers near the rail alignment (less than 50 metres) compared to the Western Sydney International to Bringelly tunnel. It can be seen from the results that a few exceedances (up to 12 residential receivers) are predicted at the start of the St Marys to Orchard Hills tunnel adjacent to St Marys Station (at chainages 17700 to 18200 metres) assuming standard attenuation trackform. This can be attributed to the proximity of buildings to the rail alignment. With the use of a high attenuation trackform adjacent to St Marys Station the ground-borne noise levels are predicted to not exceed the noise trigger levels. As part of design development measures to mitigate ground-borne noise would be developed with the objective of meeting required ground-borne noise trigger levels.

Where the alignment runs north-south between the Great Western Highway and the M4 Western Motorway along Gipps Street (between chainages 20300 and 21200 metres), the ground-borne noise levels are predicted to not exceed the noise trigger levels with a standard trackform.

At the Western Sydney International to Bringelly tunnel, the noise levels are predicted to not exceed the noise trigger levels with a standard attenuation trackform.

5.6.3 Prediction and assessment of ground borne noise and vibration levels (on-airport)

The airport site layout provides indicative locations of future noise sensitive buildings including the Air Traffic Control Tower, Airport Terminal building and commercial buildings which are to be located between the Airport Business Park and Airport Terminal stations.

The Air Traffic Control Tower is proposed to be located around 27 metres (slant distance) from the proposed rail alignment. The ground-borne noise is predicted to be 32 dBA LSmax with standard attenuation track, and the Vibration Dose Value (VDV) is predicted to be 0.02 $m/s^{1.75}$.

The Airport Terminal building is to be located over 100 metres from the underground rail alignment, with a plaza area located in between. Other noise sensitive commercial buildings that are to be located between the Airport Business Park and Airport Terminal stations are predicted to have ground-borne noise levels less than 40 dBA LSmax. The VDV values are predicted be in the range of 0.02 – 0.05 $m/s^{1.75}$.

Given there are no objective ground-borne noise criteria provided for Air Traffic Control Tower and other commercial buildings within the RING, the assessment has been based on previous experience which suggests that ground-borne noise levels of up to 40 dBA LSmax would be acceptable for the Air Traffic Control Tower, and up to 45 dBA LSmax for the Airport Terminal building and commercial buildings. As a result the standard attenuation trackform would be appropriate to meet these noise levels.

The VDV at the Air Traffic Control Tower is below the RING target of 1 $m/s^{1.75}$. For critical areas such as operating theatres and precision laboratories (see Section 5.2), the VDV at the Airport Terminal building and other commercial buildings is also below the RING target of 0.4 $m/s^{1.75}$ (for offices) for all other sensitive receivers.

5.7 Operational noise from stabling and maintenance facility

The stabling and maintenance facility would be located within Orchard Hills between Patons Lane in the south and Blaxland Creek in the north, east of the proposed track alignment. The site would consist of an area around 55 hectares, as shown on Figure 1-1.

The initial configuration of the stabling and maintenance facility would provide for up to 10 stabling roads and would allow for stabling of up to 12, 3-car train sets. The ultimate design of the stabling yard would allow for the expansion of this initial area to accommodate up to 28, 4-car train sets (as part of the operation of the current project).

The stabling and maintenance facility layout has been configured to allow for a generally at grade access/egress to the main track alignment. Vehicular access would be provided via Patons Lane. The site layout and nearest sensitive receivers are presented in Figure 5-12.

5.7.1 Assessment methodology

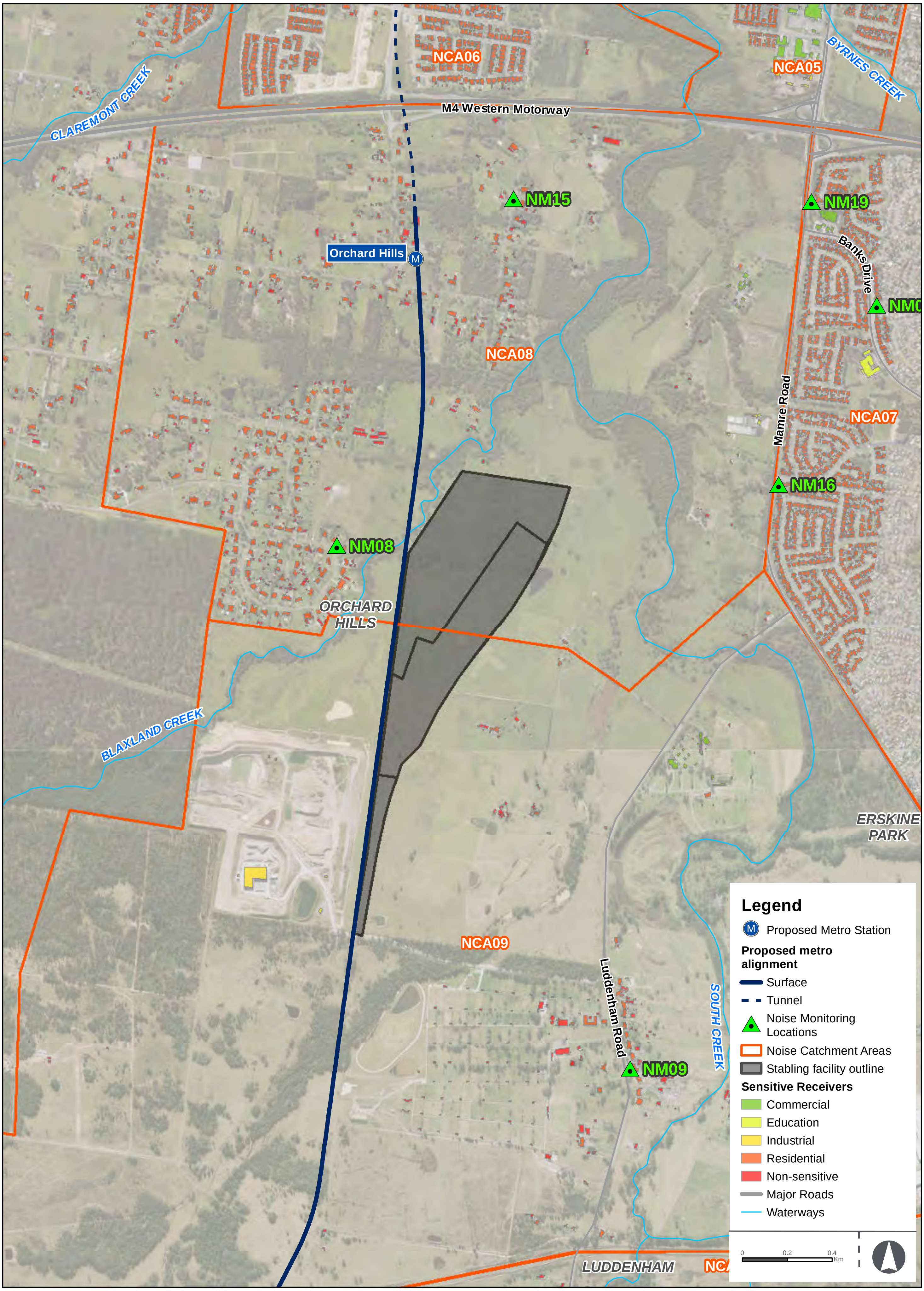
Operational noise sources associated with the stabling facilities include train movements, maintenance and testing, requiring acoustic assessment in accordance with the NPfI. Quantitative predictive noise modelling has been completed using the CONCAWE algorithm in SoundPlan V8.1.

The facility is to be designed to accommodate up to 28 trains, with additional capacity to account for future increases in demand beyond the ultimate year if required. For the purpose of this assessment, scenarios have been developed to encompass the proposed year of opening year (2026) and ultimate year (2036).

5.7.2 Sensitive receivers near stabling facilities

Noise sensitive receivers in the vicinity of the stabling facilities include residential receivers in NCA07, NCA08 and NCA09. Potentially affected receivers are generally located approximately 350 metres west in Orchard Hills (NCA08) and 1 kilometre east in St Clair (NCA07 and NCA09).

As discussed in Section 3, receivers in these NCAs are generally residential, which present the most stringent potential noise criteria.



Sydney Metro – Western Sydney Airport

Stabling Facility, Monitoring Locations and Noise Sensitive Receivers

Figure 5-12

Indicative only, subject to design development

5.7.3 Operational noise criteria for the stabling and maintenance facility

The NPfI provides the framework and process for deriving the noise limits for multiple developments, including industrial or commercial premises and maintenance/repair facilities. The assessment considers the operational impacts from the industrial noise sources associated with the stabling and maintenance facility. Further, consideration of sleep disturbance is required in terms of night time operations of noise sources.

The full procedure for the derivation of noise criteria for the stabling and maintenance facility is presented in Appendix F.

Stabling and maintenance facility noise trigger levels

In assessing the noise impact of the project on residential receivers, both intrusiveness and amenity criteria has been considered. The most stringent trigger level forms the project noise trigger level (PNTL) for the project.

To standardise the time periods for the intrusiveness and amenity noise levels, a +3dB conversion between $L_{eq,period}$ and $L_{eq,15min}$ has been applied (see Section 2.2 of the NPfI).

As required in Section 2.2 of the NPfI, all PNTL are expressed as $L_{eq,15min}$, unless otherwise noted. A summary of the PNTL applicable to the project is presented in Table 5-9.

Table 5-9 NPfI Project noise trigger levels (PNTL)

Receiver type	Noise measurement location	Time period[1,2]	Noise level dBA $L_{eq,15 min}$			Sleep disturbance trigger level, dBA	
			Intrusiveness	Amenity	PNTL[4]	Screening level, $L_{eq,15min}$[3]	Screening level, L_{Fmax}[3]
Residential (Suburban) (NCA07)	NM16	Morning shoulder	35	38	35	-	-
		Day	52	53	52	-	-
		Evening	47	43	43	-	-
		Night	35	38	35	40	52
Residential (Rural) (NCA08)	NM08	Morning shoulder	35	38	35	-	-
		Day	36	48	36	-	-
		Evening	36	43	36	-	-
		Night	35	38	35	40	52
Residential (Suburban) (NCA09)	NM09	Morning shoulder	39	38	38	-	-
		Day	45	53	45	-	-
		Evening	44	43	43	-	-
		Night	39	38	38	40	52

(1) Time periods defined as Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and public holidays; evening: the period from 6 pm to 10 pm; night: the remaining periods.

(4) Morning shoulder: 5 am to 7 am noise trigger levels derived from night time RBLs for all locations.

(5) Sleep disturbance noise trigger levels applied to night time periods.

(6) The full procedure for the derivation of PTNLs is presented in Appendix F.

Stabling and maintenance facility operational assumptions

Operational assumptions have been developed for the project in consultation with Sydney Metro as follows for this assessment.

Trains not in operation would be stored in the stabling and maintenance facility outside of peak periods, and between the last service and the first service commencing the following day.

Trains accessing the project would enter the stabling and maintenance facility at speeds around 10 km/hr and be directed towards the stabling yard via the train wash facility.

Once stationary at the stabling yard the train would vent compressed air from the braking system. Exhausting compressed air generates high noise levels of short duration, with air typically exhausted from underneath the train at the two end carriages.

Once parked, all auxiliary equipment is shut down which can occur within a few minutes. While stabled, train interiors are cleaned, and safety checks are undertaken prior to the train entering service the following morning.

Prior to the departure, auxiliary equipment, including air-conditioning, air compressors and static inverters, is turned on and would operate for up to fifteen minutes.

Train movements within the project site itself will occur at low speeds, so noise impacts will be most influenced by the operation of on-board equipment such as air conditioning and air compressor units, rather than rolling stock noise.

Train horn testing will not be required within the stabling and maintenance facility. In the event horn testing is required, appropriate testing procedures would be required to minimise the impacts of these short-term noise events at the nearest receivers. These requirements will be further evaluated further during design development and construction planning.

General maintenance activities to the trains would be undertaken within the maintenance building. Limited information is available regarding the maintenance building and façade construction; however, it is understood that buildings would be constructed using conventional steel frame methods.

5.7.4 Noise modelling assumptions

Meteorological conditions

Worst case assumptions of noise-enhancing weather conditions (temperature inversions or wind-enhancing winds) have been adopted as part of this assessment, represented by default CONCAWE inversion parameters (Meteorological Category 6).

Noise sources

Figure 5-12 presents an indicative layout for the proposed stabling and maintenance facility. The sources with the most significant potential for noise generation associated with the project include the train stabling area, maintenance shed and train wash plant.

Table 5-10 presents the sound power levels adopted for the noise sources associated with stabling and maintenance activities, which have been sourced from similar projects.

Table 5-10 Stabling and maintenance facility model – sound power levels and durations

Noise Source	Sound Power Level	Location of Noise Source
$L_{eq,15min}$		
Air compressor, including brake air release noise	87 dBA[3]	Under floor, two units per four cars, located at the ends of each four-car set
Static inverter	83 dBA[3]	Top of train[1], two units per four cars, located at the ends of each four-car set
Air conditioner	82 dBA[3]	Top of train, one unit per car, located at the centre of each car
General workshop noise	105 dBA	Inside maintenance building (assumes R_W 25 construction)
Train wash facility	84 (75)[2] dBA	Train wash facility facades
Track monitor	75 dBA	Track monitoring location
Wheel lathe	75 dBA	Lathe facility openings (each)
Traction power substation	90 dBA	Traction power substation

Noise Source	Sound Power Level	Location of Noise Source
Building air conditioning units	82 dBA	Roof of OCC, Administration building, Maintenance Facility
Car park activities	65 dBA	Four cars travelling in any period in both car parks at 40 km/h
L_{max}		
Brake air release noise	105 dBA	At end of train underneath
Car park activities	90 dBA	Car park - door slam and engine starts

(1) May be located in the vehicle underframe rather than at the top of the train. Modelled location is assumed worst case.

(2) Sound Power Level in brackets represents the noise emissions through each wall due to the noise sources inside the building. Sound Power Level of 84 dBA represents the noise emission through each end opening of the building.

(3) Noise source modelled along length of train.

It is assumed that trains are generally stabled at the identified roads, closest in proximity to western most receivers, to provide a conservative estimate of potential impact. In the event stabled trains are located on roads further from residences or shielded by other trains, noise levels would be lower than those predicted.

Openings to the maintenance facility building have the potential to emit high levels of noise; the following assumptions regarding maintenance building openings (at the southern end of the building) are included in the assessment:

- daytime period: doors open.
- evening period: doors closed
- night time/morning shoulder period: doors closed.

Other noise sources

The majority of train maintenance activities would be undertaken within the maintenance building. Other noise sources with the potential to result in noise impacts around the stabling facility are summarised in Table 5-11.

Table 5-11 Other noise sources considered in assessment

Noise Source	Details
Infrastructure maintenance	Not included Potential noise impacts activities such as rail grinding and other major maintenance activities would generally occur infrequently and will be investigated in greater detail in the Operational Noise and Vibration Management Plan (ONVMP) for the project when more detail on proposed activities is available.
Wheel lathe	Included. The wheel lathe is proposed within a separate building (open at the ends), allowing for train wheels to be periodically machined using an underfloor wheel lathe. The train would enter the facility, pass over the lathe and stop at designated locations during operations. It is expected that the design of the building and enclosure materials would be undertaken to ensure compliance with relevant noise criteria at the nearest residences, incorporating noise mitigations on mechanical equipment as required. While this noise source is not anticipated to be operational over the full assessment period, it has been included for conservativeness.

Noise Source	Details
Alarm systems	Not included. It is anticipated that a visible and audible warning system will be designed in and around the maintenance building to alert staff of train movements. It is recommended that audible alarm systems are designed and selected to be non-tonal. Further, the design of the maintenance facility hard stand areas and turning spaces should ensure that the requirement for reversing beepers is minimised where possible. Considering the buffer distance between the facility and nearby residences, noise impacts are expected to be minimal.
Train Cleaning	Not included. Train cleaning activities will occur within the train itself and will not generate significant noise emissions to surrounding receivers, and has not been included in this assessment. However, for the purpose of train cleaning it has been assumed that air conditioners and static inverters would remain in operation and this has been included in the assessment.
Car park and vehicle movements	Not included. Noise levels from staff arrivals and departures from the project have not been assessed in detail. Generic assumptions have been adopted in this assessment, however noise impacts from this component will be revised as part of subsequent stages of the project when more detailed information regarding anticipated vehicle movements is available.
Public address system	Not included. A Public address system will be installed at the stabling facility; these systems are typically designed to minimise noise impact using measures such as speaker selection, placement and design in accordance with measured ambient noise levels. It is expected that with appropriate design measures in place, the contribution of the public address system to the overall ambient L_{eq} noise level at the nearest receivers would be minimal. Public address design would be finalised as part of future design development.

5.7.5 Assessment scenarios

Table 5-12 summarises the modelling scenarios considered in this assessment. The scenarios have been determined for the opening year (2026) and ultimate year (2036), and include the train, maintenance and other noise sources.

Table 5-12 Stabling and maintenance facility – assessment scenarios

Scenario	Name	Assessment parameter	Assumed noise sources	Assessed time period
1	Start service (AM)	$L_{eq,15min}$	Three trains undergoing preparation concurrently with air compressors, air conditioners, and static inverters operating Five trains departing the facility over 50 minutes. Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Modelled trains are on stabling roads.	Morning shoulder (opening year)
2	End service (PM)	$L_{eq,15min}$	Five trains arriving at the facility over 50 minutes Three trains undergoing shut-down concurrently (total estimated time ~30 minutes) with pneumatic air release, air conditioners, and static inverters operating (whilst internal train cleaning activities take place). Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Modelled trains are on stabling roads.	Night (opening year)

Scenario	Name	Assessment parameter	Assumed noise sources	Assessed time period
3	Worst case day (AM)	$L_{eq,15min}$	Four trains undergoing preparation with air compressors, air conditioners, and static inverters operating Four trains departing the facility Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Modelled trains are on stabling roads; one train in preparation outside maintenance facility	Day (peak) (opening year)
4	Worst case eve (PM)	$L_{eq,15min}$	Four trains arriving at the facility Four trains undergoing shut-down with pneumatic air release, air conditioners, and static inverters operating (whilst internal train cleaning activities take place) Substation, train wash facility, biowash/ graffiti removal, wheel lathe, maintenance facility Modelled trains are on stabling roads; one train in preparation outside maintenance facility	Evening (peak) (opening year)
5	Worst case night (PM)	$L_{eq,15min}$	Four trains arriving at the facility Four trains undergoing shut-down with pneumatic air release, air conditioners, and static inverters operating (whilst internal train cleaning activities take place) Substation, train wash facility, biowash/ graffiti removal, wheel lathe, maintenance facility Modelled trains are on stabling roads; one train in preparation outside maintenance facility	Night (peak) (opening year)
6	Start service (AM)	$L_{eq,15min}$	Five trains undergoing preparation concurrently with air compressors, air conditioners, and static inverters operating Eight trains departing the facility over 60 minutes Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility	Morning shoulder (ultimate year)
7	End service (PM)	$L_{eq,15min}$	Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Eight trains arriving at the facility (over 60 minutes) Five trains undergoing shut-down concurrently (total estimated time ~30 minutes) with pneumatic air release, air conditioners, and static inverters operating (whilst internal train cleaning activities take place)	Night (ultimate year)
8	Typical day (AM)	$L_{eq,15min}$	Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Seven trains undergoing preparation with air compressors, air conditioners, and static inverters operating Seven trains departing the facility Modelled trains are on stabling roads; one train in preparation outside maintenance facility	Day (peak) (ultimate year)

Scenario	Name	Assessment parameter	Assumed noise sources	Assessed time period
9	Typical eve (PM)	$L_{eq,15min}$	Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Seven trains arriving at the facility Seven trains undergoing shut-down with pneumatic air release, air conditioners, and static inverters operating (whilst internal train cleaning activities take place) Modelled trains are on stabling roads; one train in preparation outside maintenance facility	Evening (peak) (ultimate year)
10	Typical night (PM)	$L_{eq,15min}$	Substation, train wash facility, biowash/graffiti removal, wheel lathe, maintenance facility Seven trains arriving at the facility Seven trains undergoing shut-down with pneumatic air release, air conditioners, and static inverters operating (whilst internal train cleaning activities take place) Modelled trains are on stabling roads; one train in preparation outside maintenance facility	Night (peak) (ultimate year)
11	Brake Air Release and car door slam	L_{max}	Brake Air Release Car door slam	All periods, but potential impacts most significant during night-time period

5.7.6 Predicted noise levels

The predicted noise levels for each scenario have been summarised for simplicity based on the identified NCAs. A summary of maximum noise levels for each operational scenario by NCA are presented in Table 5-13, and are compared to relevant noise criteria for each period.

Modelled noise levels are conservative as they assume continuous operation of all equipment over a 15 minute assessment period adopting the scenarios outlined in Table 5-13. The summary of predicted impacts is limited to residential receivers, being subject to the most stringent trigger levels and therefore determining the noise mitigation requirements.

Noise level predictions are calculated to buildings within each NCA and presented graphically in Appendix F, for predicted worst case $L_{eq,15min}$ and L_{max} noise contours under adverse meteorological conditions. These results include all receiver types in the affected area.

Table 5-13 Stabling and maintenance facility – maximum noise levels per operational scenario per NCA

NCA		Scenario/time period										
		1	2	3	4	5	6	7	8	9	10	11
		Morning shoulder	Night	Day	Eve	Night	Morning shoulder	Night	Day	Eve	Night	Sleep disturbance
NCA07	Applicable criteria	35	35	52	43	35	35	35	52	43	35	52
	Maximum noise level, dBA	31	31	31	31	31	31	31	32	32	32	32
	Exceedance	-	-	-	-	-	-	-	-	-	-	
NCA08	Applicable criteria	35	35	36	36	35	35	35	36	36	35	52
	Maximum noise level, dBA	42	42	42	42	43	43	43	43	43	43	43
	Exceedance	7	7	6	6	8	8	8	7	7	8	
NCA09	Applicable criteria	38	38	45	43	38	38	38	45	43	38	52
	Maximum noise level, dBA	37	36	37	37	36	37	36	37	37	37	42
	Exceedance	-	-	-	-	-	-	-	-	-	-	-

(1) Grey cells indicate the PNTLs, green cells indicate compliance with the PNTLs, orange cells indicate an exceedance of the PNTLs.

Assessment of predicted noise levels

The results in Table 5-13 present the maximum L_{eq} noise levels that are expected under adverse meteorological conditions at the closest receivers in each NCA for each operational scenario. As such, noise the results present the worst case noise levels within each NCA.

Based on the results in Table 5-13, noise levels in NCA08 are generally predicted to exceed the applicable trigger levels for all scenarios at the residences closest to the stabling and maintenance facility by between 6 dBA and 8 dBA. As a result, operations at the stabling and maintenance facility would require mitigation to manage noise impacts at the nearest receivers in NCA08.

Noise levels at further distant receivers within NCA07 and NCA09 are predicted to comply with NPfI trigger levels for all scenarios.

- The assessed noise levels from the unmitigated operation of the stabling and maintenance facility for NCA08 are summarised as follows:
- Scenarios 1 and 6 - Morning shoulder (5am to 7am). Operational noise levels are predicted to exceed relevant trigger levels by up to 7 dBA at the nearest receivers at opening year, increasing to 8 dBA at under ultimate year conditions.
- Scenarios 2 and 7 - Daytime period (7am to 6pm). Predicted noise levels exceed trigger levels by up to 6 dBA at the nearest receivers at opening year, increasing to 7 dBA during ultimate year operations.
- Scenarios 4 and 9 - Evening period (6pm to 10pm). Opening year predicted noise levels exceed trigger levels by up to 6 dBA, increasing to 7 dBA under ultimate year conditions.
- Scenarios 5 and 10 – Night time period (10pm to 5am). Predicted noise levels exceed trigger levels by up to 8 dBA at opening and ultimate years.
- Noise sources found to contribute to the noise impact at these receivers are those associated with train stabling activities, being the air compressors, air conditioning and static inverters, which are located approximately 280 metres when stabling in the closest road to these receivers.
- Noise levels are predicted to be up to 43 dBA at the closest receivers in NCA08 during 2036 operations. These levels equate to exceedances up to 7 dBA during the day period and 8 dBA during the morning shoulder / night period, affecting up to 45 receivers in Orchard Hills. These noise levels are quite moderate for operational noise impacts and exceedances are attributable to the stringent project noise trigger levels; noise impacts are within 3 dBA of Project intrusiveness criteria (Table 5-9).
- The noise levels predicted for the most sensitive periods (morning shoulder /night) have been assessed under worst case meteorological conditions. It is recommended that detailed investigations into prevailing meteorological conditions be conducted at subsequent stages of the design to identify the likelihood of occurrence of these conditions.
- Due to the constant nature of the noise sources associated with the predicted exceedances within NCA08, the most effective method for managing noise impacts at receivers would be to mitigate the noise sources in question (i.e. rolling stock auxiliary noise sources). Other measures such as introduction of shielding through site reconfiguration or construction of a noise barrier would be required to block line of site from source to receiver. These measures are discussed in Chapter 7.

Figure 5.13 presents the locations of the residences predicted to experience noise levels above the trigger levels in NCA08 for the most stringent night time period during the ultimate year of operations.

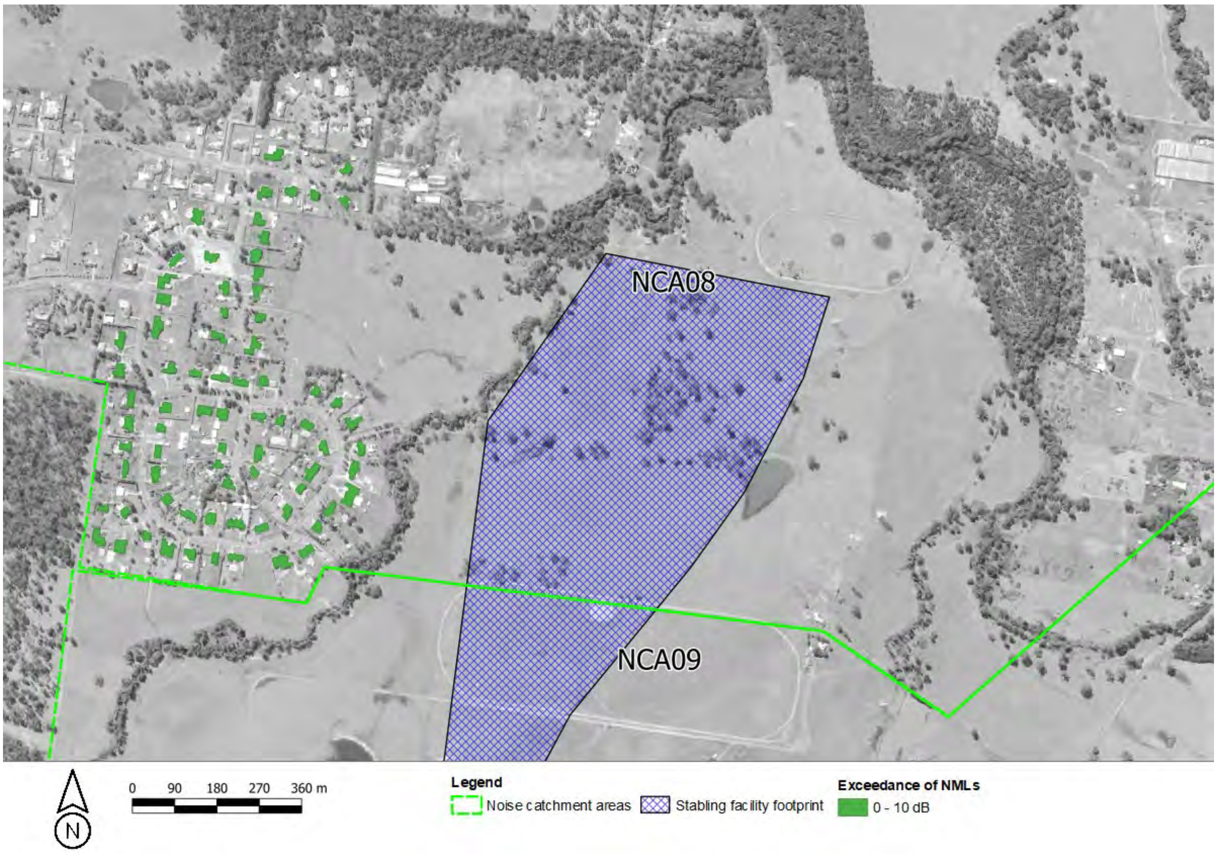


Figure 5.13 NCA08 locations of PTNL exceedances –– Night time operations, Ultimate Year

Mitigation measures to ensure compliance with relevant criteria during operation would be further investigated during design development. Noise modelling indicates that exceedances of the PTNL could be mitigated through provision of a noise barrier to the west of the facility, and/or reconfiguration of the stabling yard layout to utilise on site buildings to provide screening. Further, investigation of the occurrence of adverse meteorological conditions would be completed, and ambient background noise levels would be confirmed, taking into account the effect of future development of the area on background noise levels when determining feasible and reasonable mitigation.

Potential sleep disturbance impacts have been assessed in relation to noise generated by the train's brake system air release during typical activities, as well as car door slams within the employee car park. This assessment has assumed that based on up to five trains entering or leaving the facility during any hour, typically one event would occur in any one minute assessment period. Consideration has been made to the instantaneous (L_{max}) night time noise impact as well as the $L_{eq,15minute}$ impact level for a worst case night time period.

The noise associated with these events is predicted not to exceed relevant sleep disturbance screening levels at the nearest residential receivers within NCAs 07, 08 and 09. When considered over a worst case night time period, noise levels may be up to 2 dB above other operational noise sources at the nearest receivers in NCA08. Consideration of the exact number of brake release activities would be further investigated during design development and construction planning, considering the location of testing and frequency, however at this stage no further mitigation is warranted.

5.8 Operational noise from stations and ancillary facilities

The installation of new mechanical plant and equipment associated with the various stations and ancillary facilities of the project have the potential to generate operational noise impacts at nearby sensitive receivers. Operational noise emissions generated by new plant and equipment are assessed against the NPfI.

Noise sources to be assessed include stations, substations, mechanical plant, draught relief vents and other ancillary facilities such as water treatment plants and ventilation systems.

Noise from underground stations is generally limited to ventilation shafts, whereas above ground stations will generate noise from electrical and mechanical services. It is noted that off-airport stations considered (St Marys, Aerotropolis) are generally underground, and Orchard Hills and Luddenham are above ground.

In the absence of specifications, general noise impacts have been assessed adopting representative noise levels to estimate noise impacts at the sensitive receivers in the vicinity of each station to provide an indication of compliance with relevant noise criteria. Traction substation impacts have been assessed as part of the maintenance facility assessment.

While general standards indicate that noise levels associated with ancillary facilities are to be assessed with respect to measured background noise levels, for the purpose of this assessment, a high-level assessment of quantitative impacts has been completed.

5.8.1 Sensitive receivers near stations and ancillary facilities

The sensitive receivers affected by the operations of the stations are identified in Section 3.1.1, and the existing ambient noise environment at the various stations and ancillary facilities, was measured as reported in Chapter 3.

5.8.2 Operational noise criteria for stations and ancillary facilities

The NPfI provides the framework for the derivation of project noise trigger levels that are used to assess the potential impacts of noise from industry and indicate the noise level at which feasible and reasonable noise management measures should be considered. It also provides a process for predicting noise levels and determining achievable statutory noise limits and operational requirements for licences, consents and other statutory instruments.. The assessment considers the operational impacts from the industrial noise sources associated with the ancillary facilities. Further, consideration of sleep disturbance is required in terms of night time operations of noise sources.

The procedure for the derivation of noise criteria for the ancillary facilities is presented in Appendix E.

Some areas near the project are approved for changes in land use, specifically in relation to the redevelopment of land adjacent the Claremont Meadows services facility. These changes in land use will increase the noise levels in the surrounding environment. The NPfI states that in these instances, to account for changes in land uses, the assessment should be completed in consideration to the acceptable noise level associated with the modified future land use.

Public address system design would be finalised subject to design development for the project. The design would consider the outcomes of the environmental assessment and system design which was not available for consideration in this assessment. The resultant noise impacts associated with the public address system are not anticipated to be audible at the nearest sensitive receivers and have not been considered as part of this assessment.

5.8.3 Project noise trigger levels – stations and ancillary facilities

Noise impacts associated with mechanical plant and electrical equipment such as substations and other utilities are generally of a continuous nature and not subject to temporal fluctuations over the course of a typical 24-hour period.

As the industrial noise contribution is generally considered constant over any 24-hour period, it is reasonable to assume that the night time intrusive noise criterion would be the limiting criterion for residential receivers, while relevant amenity noise criteria are applicable to non-residential receivers when they are in use.

The relevant operational noise sources associated with ancillary facilities at each station and service facility are summarised are summarised in Table 5-14, along with relevant limiting criteria and offsets to nearest sensitive receivers.

Table 5-14 Project noise sources and criteria for stations, service facilities and ancillary facilities

Station	Element	NCA (NM)[2]	Nearest receiver type	Nearest receiver address	Distance to nearest facade (metres)	Limiting criterion dBA[1]
St Marys	Station, including electrical substation	NCA03 (NM03)	Residential	3 Station Street	35	36
		NCA03 (NM03)	Commercial	Coles, 15 Station St, St Marys	35	65
		NCA03 (NM03)	Industrial	22 Harris Street	55	70
	Ventilation system	NCA03 (NM03)	Residential	3 Station Street	35	36
	Water treatment plant	NCA03 (NM03)	Residential	Coles, 15 Station Street, St Marys	35	36
Orchard Hills	Station, including electrical substation	NCA08 (NM08)	Residential	Kent Road Orchard Hills	145	35
		NCA08 (NM08)	Hotel/ Residential	Vines holiday cottages	350	35
Luddenham Road	Station, including electrical substation	NCA10 (NM10)	Residential	611 Luddenham Road	700	35
Airport Business Park	Station, including electrical substation	NCA11 (NM20)	Residential	1 Pitt Street	230	35
		NCA11 (NM20)	Residential	120 Winston Court	120	35
		NCA11 (NM20)	Commercial	Future business park	20	65
Airport Terminal	Station, including electrical substation	NCA11 (NM11)	Commercial	Future airport	20	65
Aerotropolis Core	Station, including electrical substation	NCA13 (NM13)	Residential	175 Badgerys Creek Road	255	39
		NCA13 (NM13)	Commercial	RAAF Telecommunication Unit	30	65
Claremont Meadows services facility	Ventilation system	NCA07 (NM07)	Residential	9 Dolphin Close	55	41
		NCA07 (NM07)	Residential	Future development (Claremont Creek)	50	41
Bringelly services facility	Ventilation system	NCA11 (NM13)	Industrial	145 Mersey Road	320	70

(1) Night-time intrusive criteria adopted as most stringent criteria over a 24 hour period. Intrusiveness criteria apply to residential receivers only. Criteria for non-residential receiver are applicable when in use.

(2) Reference to noise monitoring locations per Section 3.

5.8.4 Proposal noise trigger levels – draught relief shafts

The potential for operational noise impacts associated with train passby noise emitted from draught relief shafts (at underground stations) has been assessed at residential and commercial receivers.

The L_{max} noise level refers to the 95th percentile train passby event (i.e. 95% of train passby events should not exceed these levels). The absolute maximum event is not used for assessment purposes, as it cannot be precisely defined and would occur infrequently.

These noise criteria are comparable with the design criteria adopted for the Sydney Metro Northwest, Epping to Chatswood Rail Line (ECRL) and Sydney Airport Rail Line.

To account for the short-term exposure of these events, train passby noise events have been compared against the L_{max} criteria as presented in Table 5-15.

Table 5-15 Noise criteria for draught relief shafts

Receiver Type	Time period	Short term exposure Criteria, dBA L_{max}[1]
Residential	Day	55
Commercial	Evening	65

(1) The noise level refers to the 95th percentile L_{Fmax} train passby event.

5.8.5 Operational noise criteria for road traffic on public roads

New or upgraded public roads are proposed near the station precincts St Marys to provide access to car parking, bus, taxi, and kiss and ride facilities.

Noise impacts associated with these roads have been assessed with regard to the RNP. Station access roads are assumed to be local roads for the purpose of this assessment, while other project affected roads are classified as sub-arterial or arterial. Applicable noise criteria for each road type are presented in Table 5-16. Where the criteria are exceeded, the RNP states that 'feasible and reasonable mitigation measures would be investigated in the following order of priority:

- road design and traffic management
- quieter pavement surfaces
- in-corridor noise barriers/mounds
- at-property treatments or localised barriers/mounds'

Table 5-16 Road traffic noise criteria for residential receivers

Road type	Road Traffic Noise Criteria	
	Day (7am to 10pm)	Night (10pm to 7am)
Arterial/Sub-arterial/Collector	60 dBA $L_{eq,15hr}$	55 dBA $L_{eq,9hr}$
Local Roads	55 dBA $L_{eq,1hr}$	50 dBA $L_{eq,1hr}$

The RNP states that where land use developments have the potential to generate additional traffic on existing roads, an assessment of the increase in total traffic noise level is required. The RNP states that following the consideration of feasible and reasonable mitigation, 'any increase in the total traffic noise level as a result of the development should be limited to 2 dBA above that of the noise level without the development'. This applies for both day and night periods, and for the purpose of local roads is assumed to apply to the one-hour peak period.

5.8.6 Predicted noise levels – stations and ancillary facilities

An assessment of operational noise impact has been completed based on available architectural drawings for each station. Assessments have considered above ground mechanical plant and services, and ventilation equipment.

Methodology

Modelling of mechanical and other ancillary facilities has been completed based on available services and infrastructure information. Assumptions for equipment specifications have been adopted based on similar publicly available documentation for the purpose of assessment with noise criteria at each location.

Mechanical plant and sources

Operational plant are anticipated to constitute noise sources of relatively consistent and constant noise composition, with no annoying (tonal, intermittent, low frequency) components, and as a result do not necessitate the application of modifying factors as defined in the NPfI.

Noise from underground stations is generally limited to ventilation shafts, whereas above ground stations will generate noise from electrical and mechanical services. It is noted that off-airport stations considered (St Marys, Aerotropolis Core) are cut-and-cover, and Orchard Hills is an in-cutting station and Luddenham Road is a viaduct (elevated) station. On-airport stations are located at significant distances to noise sensitive receivers and have therefore been assessed in terms of maximum allowable sound power to achieve compliance later in this section.

Table 5-17 presents a summary of the noise source considerations for this assessment.

Table 5-17 Mechanical noise sources and description

Element	Locations	Description
Substations	St Marys, Orchard Hills, Luddenham Road, Aerotropolis Core, Airport Terminal , Airport Business Park stations and stabling and maintenance facility	Substations would be enclosed, with facades of masonry construction with acoustic louvres as required. Acoustically significant plant associated with the substations include transformers. Based on similar projects a SWL 81 dBA would be expected. A traction substation and bulk power supply point would also be established within the stabling and maintenance facility at Orchard Hills East
Water treatment plants	St Marys Station, Bringelly services facility	Acoustically significant plant include chemical treatment tanks, water storage tanks, and filters. Sound power levels of such plant would be SWL 86 dBA.
Ventilation systems	Underground stations and tunnelled sections	Tunnel ventilation is typically required where the distance between stations (or stations and a tunnel portal) exceeds around three kilometres. During normal operations, tunnel ventilation would be provided by train movements and the operation of fans at the underground stations to remove air from the tunnels. Heat removal would typically occur via the tunnel exhaust; however, ventilation fans could also be operated to provide additional heat removal particularly in peak summer conditions. Separate mechanical ventilation system would be provided at St Marys Station (proposed underground station) for heat removal and to provide fresh air.
	Claremont Meadows and Bringelly services facilities	For emergency access and egress purposes only. No surface mechanical plant or tunnel ventilation would be required at these sites. No noise impacts are therefore predicted during operations at these sites.

Indicative sources and sound power levels are presented in Table 5-18.

Table 5-18 Adopted mechanical and electrical plant noise – off-airport stations and ancillary facilities

Element[1]	Sound Power Level, dBA	Description /source
Above ground stations		
Fans	85	Internal database
Station – AC (all)	76	Internal database
Lift motors	85	Internal database
Condenser units	78	Internal database
Generator	97	Internal database
Ventilation fan	75	Internal database
Total Mechanical	*89*	Internal database
Substation	81	ECRL
Ventilation system	85	Sydney Metro Northwest, Chatswood to Sydenham
Overall fixed facility	**93**	
Car engine, parking + door slam	85	Car engine in Kiss and Ride Assumes car movement would take 1 minute, assuming peak hour movements
Underground stations		
Ventilation system	80	Sydney Metro Northwest, Chatswood to Sydenham

Assessment of mechanical and electrical plant (off-airport stations and service facilities)

The assessment of mechanical and electrical plant has been completed using typical fixed facility noise levels summarised in Table 5-18 at each off-airport station and assessed with limiting trigger level (night time period) at the nearest sensitive receivers. The predicted noise levels represent the noise levels from all site-related operational non-rail noise sources at the identified receivers. Results are presented in Table 5-19.

Table 5-19 Estimated fixed facilities noise levels and project noise trigger levels for stations fixed facilities

Station	Nearest receiver type	Nearest receiver address	PNTL dBA[1]	Predicted Noise Levels, dBA
St Marys	Residential	3 Station St	36	**38**
Orchard Hills	Residential	Kent Road Orchard Hills	35	18
Luddenham Road	Residential	611 Luddenham Road	35	26
Aerotropolis Core	Residential	175 Badgerys Creek Rd	39	30

(1) Limiting PNTL for night time period adopted due to continuous nature of mechanical operations.

Noise levels for fixed facilities at the off-airport stations are predicted to comply with relevant noise criteria at the nearest receivers to all stations except St Marys. Minor exceedances of the limiting criterion are predicted at the nearest receivers to St Marys underground ventilation shafts. Mitigation measures to ensure compliance with relevant criteria are presented in Section 7.

The assessment of mechanical and electrical plant at the services facilities has been completed with reference to operational noise sources identified in Table 5-17, whereby surface mechanical plant or tunnel ventilation components are not required. To comply with relevant noise criteria at the nearest sensitive receivers, the sound power levels (SWLs) in Table 5-20 present the maximum allowable sound power levels from remaining noise sources, at the identified receivers.

Table 5-20 Maximum allowable mechanical and electrical plant noise –service facilities

Services facility	Element[1]	Sound Power Level, dBA
Claremont Meadows services facility	Miscellaneous plant (if required)	85
Bringelly services facility	Water treatment plant	85

(1) Services below ground not assumed to contribute to above ground noise levels at sensitive receivers. Public Address systems and communications not assumed to contribute to noise levels at sensitive receivers.

The design of mechanical and electrical plant has not been finalised at this stage of the assessment and is subject to change. However, the maximum allowable SWLs in Table 5-20 are below the typical SWLs for similar equipment identified for off-airport stations.

Assessment of mechanical and electrical plant (on-airport stations)

The assessment of mechanical and electrical plant has been determined at each on-airport location to comply with relevant noise criteria at the nearest sensitive receivers. The sound power levels (SWLs) represent the maximum allowable sound power levels from all site-related operation from all non-rail noise sources at the identified receivers. Results are presented in Table 5-21.

Table 5-21 Maximum allowable mechanical and electrical plant noise – on-airport stations

Station	Element[1]	Sound Power Level, dBA
Airport Business Park Station	Station, including substation	86
Airport Terminal Station	Station, including substation	99

(1) Services below ground not assumed to contribute to above ground noise levels at sensitive receivers. Public Address systems and communications not assumed to contribute to noise levels at sensitive receivers.

The design of mechanical and electrical plant has not been finalised at this stage of the assessment and is subject to change. However, the maximum allowable SWLs in Table 5-21 are below the typical SWLs for similar equipment identified for off-airport stations.

Noise breakout through draught relief shafts

The St Marys to Orchard Hills and the Western Sydney International to Bringelly tunnels would be located underground, and noise generated via train pass-by has the potential to break out through draught relief shafts. In-tunnel maximum reverberant noise levels have been sourced from the NWRL noise assessment to allow determination of noise emissions; these values were measured in the ECRL tunnels at a speed of 80 km/h.

Table 5-22 In-tunnel reverberant noise levels

Octave Band Centre Frequency (Hz)	Maximum Noise Levels, L_{Fmax} (dB)									
	31.5	63	125	250	500	1000	2000	4000	8000	Overall
In-tunnel Noise Levels	89	83	81	88	96	92	87	85	78	102

(1) Consistent with the NWRL assessment, a 5 dB noise reduction has been applied to the above levels to account for speeds below 80 km/h near the draught relief shafts.

Draught relief shafts are typically designed with a 20 m^2 cross section located at each end of the station box. They are generally concrete, therefore noise reduction losses during propagation to the surface are anticipated to be negligible.

Consistent with similar projects, the ventilation system design is assumed to include a sound attenuator in each shaft. The insertion loss provided would decrease the train noise (L_{max}) to approximately 55 dBA at 10 metres from the surface discharge location.

As a result, it is considered that noise breakout from the ventilation shafts would not exceed relevant noise criteria (55 dBA L_{max} for residential receivers) at any existing or future residential receivers near the Claremont Meadows services facility and Bringelly services facility, assuming incorporation of appropriate attenuator design.

5.8.7 On-airport operational noise from stations and ancillary facilities

Noise generated by the operation of plant or machinery, fixed audible alarms, and warning systems on-airport land is regulated by the Airports Regulations. These regulations specify that noise generated by these items at an airport should not exceed the background noise level at a sensitive receptor site:

- between the hours of 7am and 10pm — by more than 5 dBA
- between 10pm of a day and 7am of the next day — by more than 3 dBA.

For commercial receptors, the same criteria apply. However, the time of day, duration, characteristics of noise, background noise level, and nature of the business conducted at the site should be considered when determining whether noise is excessive.

The operation of Western Sydney International is expected dominate the background noise environment. As the airport is currently under construction, background noise levels which include the noise generated by the operation of the airport cannot be measured. Hence, criteria cannot be accurately determined at this stage.

However, as commercial receivers to be constructed at the airport are anticipated to have sufficient building envelope design to mitigate aircraft flyover noise, it is expected that noise generated by plant or machinery, fixed audible alarms and warning systems would not have an adverse impact on the occupants of these buildings.

5.9 Operational road traffic noise assessment

Project related vehicle movements have the potential to generate noise impacts at the nearest sensitive receivers once stations and associated infrastructure are operational. Roads potentially impacted by such movements of the project are classified as local, sub-arterial and arterial roads, as defined by the RNP and discussed in Section 4.1.4.

It is assumed that additional vehicle movements on public roads may occur during both day (7am to 10pm) and night (10pm to 7am) periods. This assessment has assessed operational road noise impacts associated with all off-airport stations. On-airport traffic would be subject to assessment as part of the Western Sydney International assessment process.

Table 5-23 summarises the existing and additional project traffic volumes for opening (2026) and ultimate (2036) years. These traffic volumes have been used to predict the relative noise increase on affected roads from project related traffic, with respect to the nearest identified receivers.

5.9.1 Description of proposed works

A description of the proposed works relating to off-airport stations and impacts on associated road network are presented in Chapter 7 of the Environmental Impact Statement. Predicted Noise Levels

A summary of predicted road noise levels from operational road traffic noise from the project on sub arterial and arterial roads for ultimate years is presented in Table 5-24 and Figure 5.14. Results for local roads is presented in Table 5-25 and Figure 5.14.

Where compliance is demonstrated for the ultimate year traffic volumes, compliance can be inferred for the opening year traffic volumes. Road traffic noise impacts are summarised in the following sections by metro station, and assessed at the most affected representative residential receiver.

Table 5-23 Summary of operational traffic volumes on project roads – opening year (2026) and ultimate year (2036)

Road	Base				Base + Project			
	Day (7am to 10pm)		Night (10pm to 7am)		Day (7am to 10pm)		Night (10pm to 7am)	
	Total vehicles	HV	Total vehicles	HV	Total vehicles	HV	Total vehicles	HV
Opening Year 2026								
Glossop Street (north of the Great Western Highway)	19258	17%	3398	9%	21114	15%	4095	7%
Great Western Highway (east of Queen Street)	40061	9%	7070	6%	45008	9%	8717	5%
Great Western Highway (west of Queen Street)	31531	8%	5564	6%	32462	8%	6822	5%
Queen Street (north of Great Western Highway)	10292	3%	1144	3%	13694	4%	1729	2%
Great Western Highway (east of Gipps Street)	53587	3%	8723	2%	53587	3%	8268	2%
Great Western Highway (west of Gipps Street)	51858	3%	8442	2%	51858	3%	8043	2%
Kent Road (north of the M4)	23103	5%	4077	3%	23429	5%	4664	2%
Kent Road (south of the M4)	9119	3%	1609	2%	10679	4%	1667	2%
Mamre Road (south of the Great Western Highway)	21962	13%	4183	6%	21962	13%	5611	5%
Mamre Road (north of Luddenham Road)	45268	9%	9272	6%	45617	9%	8637	6%
Luddenham Road (west of Mamre Road)	13390	5%	2550	3%	13860	5%	3088	2%
Luddenham Road (north of Elizabeth Drive)	13213	4%	2517	3%	13726	5%	2677	3%
Elizabeth Drive (west of Badgerys Creek Road)	8947	11%	1833	5%	9371	11%	2227	4%
Elizabeth Drive (east of Badgerys Creek Road)	12541	11%	2569	7%	13305	11%	2785	6%
Badgerys Creek Road (north of The Northern Road)	6302	7%	1478	4%	7258	8%	2037	3%
The Northern Road (west of Badgerys Creek Road)	23690	10%	4181	5%	24276	10%	4345	4%
The Northern Road (east of Badgerys Creek Road)	32513	9%	5738	4%	33099	9%	6125	4%
Derwent Street (St Marys)	510	0%	90	0%	510	0%	90	0%
Phillip Street (Badgerys Creek)	574	5%	816	4%	576	5%	816	4%
Station St (St Marys)	560	8%	788	7%	20	100%	20	100%
Ultimate Year 2036								
Glossop Street (north of the Great Western Highway)	24990	17%	4435	12%	26683	16%	4435	12%
Great Western Highway (east of Queen Street)	52862	11%	10519	6%	60078	10%	11644	5%

Road	Base				Base + Project			
	Day (7am to 10pm)		Night (10pm to 7am)		Day (7am to 10pm)		Night (10pm to 7am)	
	Total vehicles	HV	Total vehicles	HV	Total vehicles	HV	Total vehicles	HV
Great Western Highway (west of Queen Street)	48412	11%	9752	6%	49266	11%	9752	6%
Queen Street (north of Great Western Highway)	10714	3%	1631	2%	16114	5%	2231	2%
Great Western Highway (east of Gipps Street)	65145	6%	10139	2%	65145	6%	10139	2%
Great Western Highway (west of Gipps Street)	63197	7%	9960	2%	63197	7%	9960	2%
Kent Road (north of the M4)	24194	5%	4106	3%	24878	5%	4378	2%
Kent Road (south of the M4)	11230	3%	2007	2%	14066	4%	2461	2%
Mamre Road (south of the Great Western Highway)	27644	15%	6614	3%	27644	15%	6614	3%
Mamre Road (north of Luddenham Road)	47385	8%	8749	4%	48393	8%	8940	4%
Luddenham Road (west of Mamre Road)	16002	2%	3242	2%	17363	3%	3478	2%
Luddenham Road (north of Elizabeth Drive)	13944	2%	2856	2%	14902	3%	3013	2%
Elizabeth Drive (west of Badgerys Creek Road)	18858	6%	4886	3%	19663	6%	5035	3%
Elizabeth Drive (east of Badgerys Creek Road)	20667	8%	5216	4%	22369	8%	5535	3%
Badgerys Creek Road (north of The Northern Road)	2600	6%	1041	8%	4147	9%	1414	5%
The Northern Road (west of Badgerys Creek Road)	36478	4%	5990	5%	37868	4%	6134	4%
The Northern Road (east of Badgerys Creek Road)	29631	3%	5940	5%	31021	3%	6019	4%
Derwent Street (St Marys)	510	0%	90	0%	510	0%	90	0%
Phillip Street (Badgerys Creek)	588	5%	1077	3%	590	5%	1077	3%
Station St (St Marys)	574	8%	1049	5%	20	100%	20	100%

(1) Day = 7am to 10pm, Night = 10pm to 7am

Table 5-24 Summary of operational traffic predictions on existing sub-arterial and arterial roads – ultimate year (2036)

Location	Distance to closest representative residential receiver (metres)	RNP classification	RNP criteria[1]		Predicted noise level of base traffic[1]		Predicted noise level of base traffic with Project traffic[1]		Increase in noise level generated by Project traffic[1]		Complies?[1]	
			Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day	Night	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$
Glossop Street (north of the Great Western Highway)	15	Sub-arterial	60	55	67	62	68	62	1.6	0.0	YES	YES
Great Western Highway (east of Queen Street)	25	Arterial	60	55	67	62	68	62	0.5	0.3	YES	YES
Great Western Highway (west of Queen Street)	50	Arterial	60	55	63	58	63	58	0.1	0.0	YES	YES
Queen Street (north of Great Western Highway)	90	Sub-arterial	60	55	50	45	53	46	2.3	1.0	YES	YES
Great Western Highway (east of Gipps Street)	200	Arterial	60	55	58	51	58	51	0.0	0.1	YES	YES
Great Western Highway (west of Gipps Street)	25	Arterial	60	55	69	62	69	62	0.0	0.1	YES	YES
Kent Road (north of the M4)	10	Sub-arterial	60	55	69	63	69	63	0.3	0.3	YES	YES
Kent Road (south of the M4)	20	Sub-arterial	60	55	61	56	62	57	1.2	0.8	YES	YES
Mamre Road (south of the Great Western Highway)	20	Sub-arterial	60	55	66	60	66	60	0.0	0.0	YES	YES
Mamre Road (north of Luddenham Road)	20	Sub-arterial	60	55	69	63	69	64	0.0	0.1	YES	YES
Luddenham Road (west of Mamre Road)	25	Sub-arterial	60	55	62	58	63	58	0.6	0.3	YES	YES
Luddenham Road (north of Elizabeth Drive)	45	Sub-arterial	60	55	58	54	59	54	0.4	0.1	YES	YES
Elizabeth Drive (west of Badgerys Creek Road)	30	Sub-arterial	60	55	63	59	63	59	0.1	0.0	YES	YES
Elizabeth Drive (east of Badgerys Creek Road)	50	Sub-arterial	60	55	61	56	61	57	0.4	0.2	YES	YES
Badgerys Creek Road (north of The Northern Road)	20	Sub-arterial	60	55	57	55	59	56	2.4	0.7	YES	YES
The Northern Road (west of Badgerys Creek Road)	40	Arterial	60	55	64	58	64	59	0.2	0.1	YES	YES
The Northern Road (east of Badgerys Creek Road)	30	Arterial	60	55	64	60	64	60	0.2	0.1	YES	YES
Derwent Road (north of The Northern Road)	25	Local	55	50	59	52	58	52	-1.8	0.0	YES	YES
Phillip Street (peak 1hr volumes for local road)	10	Local	55	50	63	64	60	64	-3.2	0.0	YES	YES
Station Street (peak 1hr volumes for local road)	10	Local	55	50	63	65	55	57	-8.2	-8.1	YES	YES

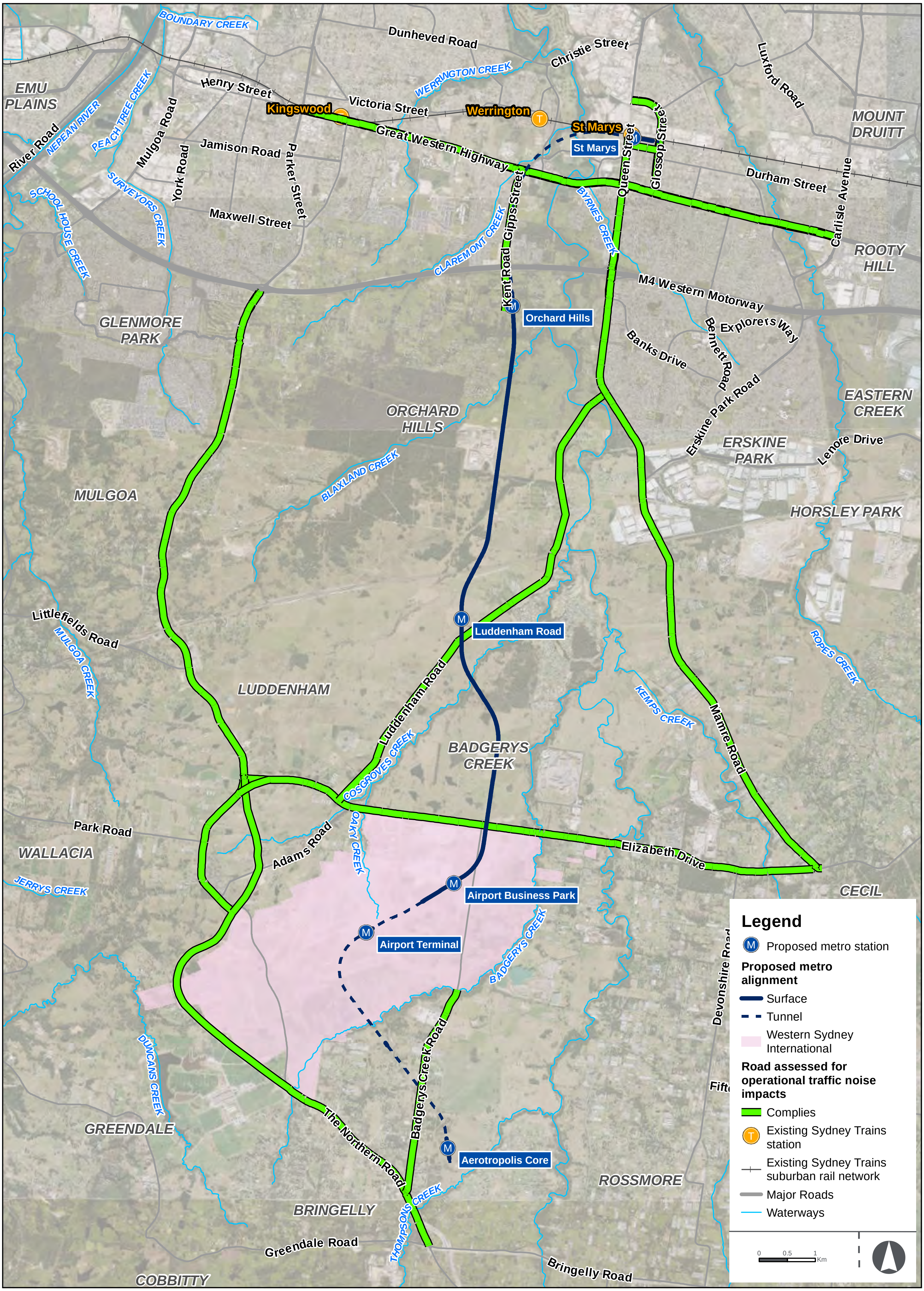
(1) Day = 7am to 10pm, Night = 10pm to 7am

Table 5-25 Summary of operational traffic predictions on new local roads – ultimate year (2036)

Location	Distance to closest representative residential receiver (metres)	RNP classification	RNP criteria[1]		Predicted noise level of base traffic[1]		Complies?[1]	
			Day $L_{eq,1hr}$	Night $L_{eq,1hr}$	Day $L_{eq,1hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$
Kent Street Station Road	20	Local	55	50	52	45	YES	YES
Luddenham Road Station Road	40	Local	55	50	49	40	YES	YES
Aerotropolis Core Station Road	50	Local	55	50	51	40	YES	YES

(1) Day = 7am to 10pm, Night = 10pm to 7am

(2) Green cells indicate compliance with RNP criteria



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Operational road traffic noise summary

Figure 5-14

Table 5-25 indicates that all new roads built as part of the project are expected to comply with the RNP criteria.

Table 5-24 identifies that multiple sub-arterial and arterial roads are predicted to exceed the RNP criteria, and therefore reasonable and feasible should be investigated. The following mitigation measures have been considered:

- road design and traffic management
- quieter pavement surfaces
- in-corridor noise barriers/mounds
- at-property treatments or localised barriers/mounds'

A lot of the roads are expected to already exceed the RNP criteria without the operation of the project (for the 'no-build' scenario). Further to this, any increase in road traffic noise generated by the operation of the project would result in an increase of less than 2dB.

Road design and traffic management measures are not reasonable as the roads are already currently in use.

Due to the limited operational road traffic noise impacts generated by the project, re-surfacing the roads with quieter pavement, installing in-corridor noise barriers/mounds, at-property treatments or localised barriers/mounds are not considered reasonable.

6 Cumulative impact

An overview of the noise sensitive receivers most likely to be adversely impacted by cumulative construction noise from the project and surrounding projects are shown in Figure 6-1. The figure presents the locations where the construction noise levels during standard hours exceed 50 dBA $L_{eq,15min}$ for more than one project (i.e. this is not the cumulative sum of construction noise, rather an indication where the project and surround projects are predicted to exceed 50 dBA $L_{eq,15min}$ during standard hours). The assessment is based on the worst case (highest) predicted noise level over the duration of the projects that have been considered. It is noted that 50 dBA $L_{eq,15min}$ was selected as it represents the typical standard hours construction noise target for most NCAs (typical range is approximately 45-55 dBA across the project) and for consistency with the approach that was adopted for the cumulative impact assessment that was undertaken for the future M12 Motorway project.

The noise sensitive receivers that are identified in Figure 6-1 would benefit from:

- consultation with the proponents of the surrounding projects, which may include consideration of construction staging to minimise noise emissions and provide opportunities for respite
- consideration of the CNVMP for the surrounding projects during development of the CNVMP for the project

As noted in Section 3.3, the future noise environment during operation of the project is expected to be largely different to that currently experienced. This is due to the future development of the area with significant spend in infrastructure such as the Western Sydney International and future M12 Motorway. It has not been possible to assess the noise impacts in a quantitative manner due to the varying noise metrics used for assessment of items such as aircraft, road and rail noise.

6.1 St Marys Intermodal

The proposed St Marys Intermodal will be located within the south-eastern portion of NCA02 for the project. The closest noise sensitive receivers to the St Marys Intermodal that will also be adversely impacted by the project are located on Camira Street, which is approximately 200m southeast of the intermodal, and approximately 100 metres west of St Marys Station.

Construction of St Marys Intermodal would be undertaken in five distinct stages, during standard construction hours over a period of seven months. It is possible that the Intermodal construction works would be completed prior to construction of the project commencing. However, a conservative approach adopted for the purpose of this assessment is to assume that construction of the intermodal would overlap construction of the project.

Construction noise for the proposed St Marys Intermodal was assessed for the following stages:

- site establishment and delivery of materials
- bulk earthworks
- trenches/utilities
- pavement/hardstand construction
- building delivery and installation.

The largest number of exceedances of the standard hours ICNG noise targets are predicted to occur along Camira Street and Kalang Avenue, where 21-30 dBA exceedances of the targets would occur. The noisiest stages of construction would be the site establishment and delivery of materials, bulk earthworks and pavement/hardstand construction.

Based on the assessment of areas where the construction noise levels would exceed 50 dBA $L_{eq,15min}$ for the project and St Marys Intermodal, the most sensitive area would be bounded by Kalang Avenue, Camira Street, Carinya Avenue and Kungala Street.

6.2 Future M12 Motorway project

The future M12 Motorway project would be constructed in an east-west direction across the southern portion of NCA10 for the project. The nearest noise sensitive receivers would be located within NCA10 and NCA11 of the project.

Construction of the future M12 Motorway project, if approved, would commence in Q2, 2022 and continue through to Q4, 2025, a period of 45 months. This would overlap the planned construction period of the project which spans 66 months and is planned to commence in Q3, 2021 with completion scheduled for Q4, 2026.

Construction noise for the future M12 Motorway project was assessed as part of the Environmental Impact Statement for that project for the following stages:

- ancillary facility establishment / decommissioning
- ancillary facilities
- utilities and drainage - including relocation of existing
- demolition
- clearing
- earthworks
- bridge works
- road works
- signage, lighting and landscaping.

Exceedances of the standard hours ICNG noise targets by more than 20 dB for construction of the future M12 Motorway project are predicted to occur for the project NCA10, and up to 20 dB for the project NCA11.

Based on the assessment of areas where the construction noise levels would exceed 50 dBA $L_{eq,15min}$ for the project and future M12 Motorway project, the most sensitive groups of receivers would be located:

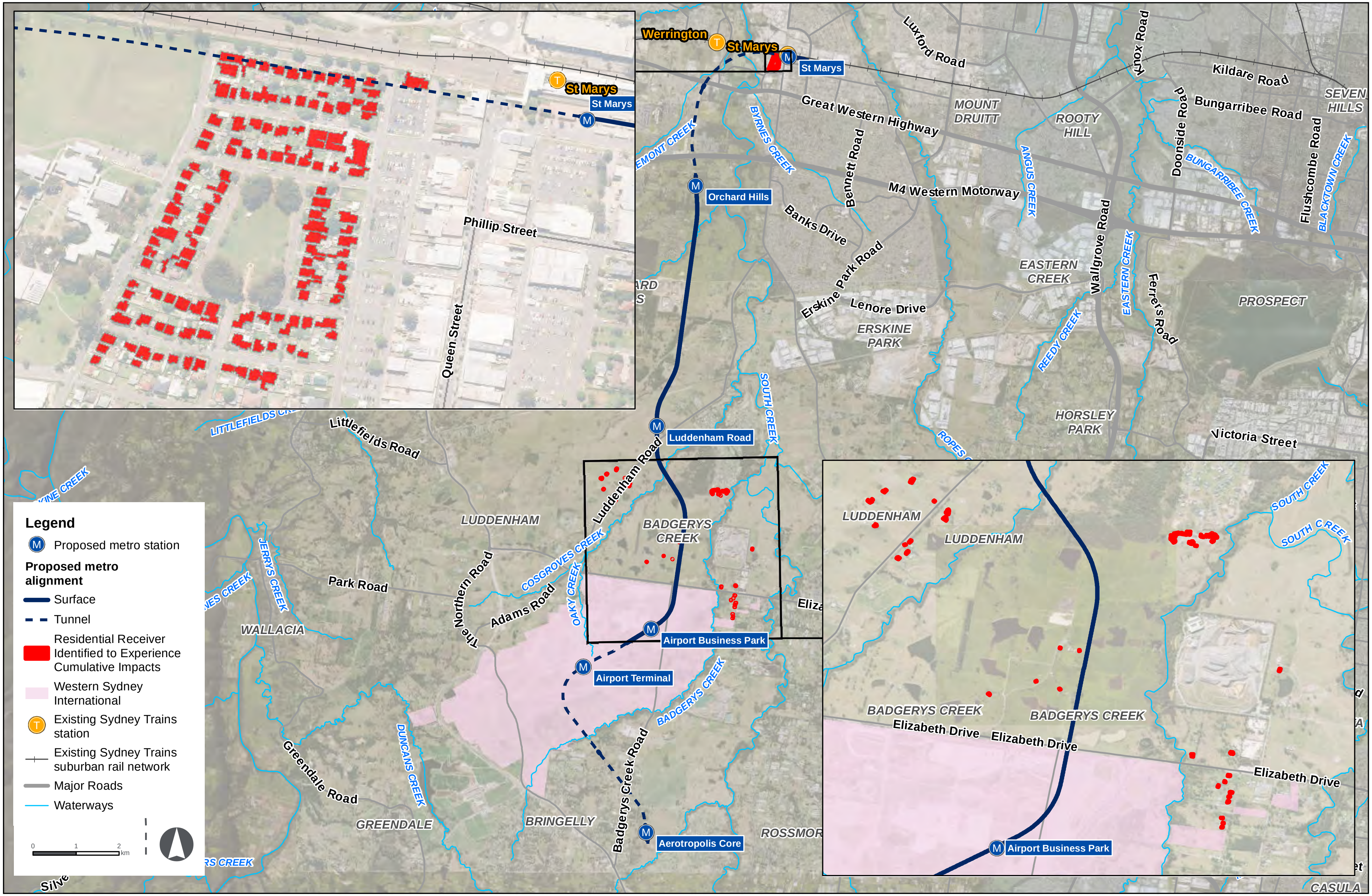
- immediately to the north and south of Elizabeth Drive near Lawson Road, Badgerys Creek
- Farmingdale Court, Luddenham
- located on the eastern and western sides of Luddenham Road, Luddenham, approximately 1.6 to 2 km north of the Elizabeth Road intersection with Luddenham Road.

6.2.1 McGarvie Farm vibration

Should the future M12 Motorway project be approved, the central cluster of vibration sensitive receivers located at McGarvie Farm would be removed. As such, this would remove potential construction vibration restrictions for the site as the remaining two western complex buildings (high significance) would be located at sufficient distance from construction activities not to be adversely affected by construction vibration.

6.3 Western Sydney International

The construction activity for Western Sydney International with the greatest potential for noise emissions is associated with the bulk earthworks for the site. However, due to the large size of Western Sydney International, there are no areas beyond its site boundary that are predicted to have construction noise levels in excess of 50 dBA $L_{eq,15min}$. As a result, construction of the project and Western Sydney International is not anticipated to result in cumulative noise impacts at any sensitive receiver locations.



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Cumulative Construction Noise Impacts

Figure 6-1

7 Proposed management and mitigation measures

7.1 Approach to the management and mitigation

This chapter describes the environmental management approach for the project for noise and vibration during construction and operation. Further details on the environmental management approach for the project are provided in Chapter 25 (Environmental management and mitigation) of the Environmental Impact Statement.

A Construction Environmental Management Framework (CEMF) (Appendix E of the Environmental Impact Statement) describes the approach to environmental management, monitoring and reporting during construction. Specifically, it lists the requirements to be addressed by the construction contractor in developing the CEMP, sub-plans, and other supporting documentation for each specific environmental aspect.

The Construction Noise and Vibration Management Plan (CNVMP) is a specific sub plan required by the CEMF. Preparation of the CNVMP would incorporate, as a minimum, the standard mitigation measures provided in the CNVS.

An Overarching Community Communications Strategy (OCCS) (Appendix C of the Environmental Impact Statement) provides a framework for communication and engagement during construction and provides measures for addressing community concerns in relation to noise and vibration impacts.

7.2 Performance outcomes

The performance outcomes for the project in relation to noise and vibration are outlined in Table 7-1.

Table 7-1 Performance outcomes

SEARS desired performance outcome	Project performance outcome	Timing
Construction noise and vibration (including airborne noise, ground-borne noise and blasting) is effectively managed to minimise adverse impacts on acoustic amenity Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage	Construction noise and vibration impacts on local communities (including airborne noise and ground-borne noise and vibration) are managed in accordance with the Sydney Metro Construction Noise and Vibration Standard, the Interim Construction Noise Guideline, and the Airports (Environment Protection) Regulations 1997	Construction
	Structural damage to buildings, heritage items and public utilities and infrastructure, including the Warragamba to Prospect Water Supply Pipelines, from construction vibration to be avoided	
Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community	Operational noise and vibration levels from rail operations are managed in accordance with the Rail Infrastructure Noise Guidelines and Airports (Environment Protection) Regulations 1997 Operational noise levels for the stabling and maintenance facility, stations and other fixed infrastructure are managed in accordance with the *Noise Policy for Industry 2017*	Operation

7.3 Proposed mitigation Measures

In addition to the standard mitigation measures outlined in the CNVS and future CNVMP, project specific mitigation measures have been identified. These are included in Table 7-2.

Table 7-2 Project management and mitigation measures

Ref	Mitigation measures	Applicable location(s)
Noise and vibration - construction		
NV1	Where acoustic sheds are installed, the internal lining and type of material used in the construction of the sheds would be considered during design development and construction planning to ensure appropriate attenuation is provided	St Marys construction site Claremont Meadows services facility construction site Orchard Hills construction site Western Sydney International tunnel portal construction site Airport Terminal construction site Bringelly services facility construction site Aerotropolis Core construction site
NV2	To avoid potential vibration impacts to the Warragamba to Prospect Water Supply Pipelines, a detailed construction vibration assessment would be undertaken in accordance with the Guidelines for Development Adjacent to the Upper Canal and Warragamba Pipelines (WaterNSW, 2020) and would consider the following requirements: • confirm velocity limits for construction activities and the impact the works will have on WaterNSW assets • excavation methods would be undertaken in accordance with German Standard DIN 4150-3:2016 (2.5 mm/s PPV) • vibration monitoring would be undertaken prior to and during construction for high risk construction activities • vibration monitoring reports would be provided to WaterNSW	Off-airport construction corridor
Noise and vibration - operation		
NV3	An Operational Noise and Vibration Review would be prepared during design development to confirm the mitigation measures required to manage: • airborne and ground-borne noise impacts from rail operations • airborne noise impacts from the stabling and maintenance facility • airborne noise impacts from fixed industrial sources, including stations and services facilities	All

8 Conclusion

This technical paper documents the noise and vibration impact assessment undertaken for the project and will be used to inform further design development and construction planning, and provide regulators, stakeholders and the community with information about potential noise and vibration impacts from the project and how they will be managed.

The prevailing background and ambient (existing) noise levels surrounding the project were determined through a combination of unattended and operator attended noise surveys in accordance with the AS 1055 and the NPfI. The existing noise environment can be grouped into two separate noise environments, north and south of the M4 Western Motorway. The noise environment north of M4 Western Motorway is typical of a suburban landscape, with the noise environment characterised by local road traffic noise as well as pockets of industry and commerce around St Marys. The noise environment south of M4 Western Motorway is characteristic of a semi-rural landscape, mostly influenced by natural sounds, little road traffic noise, and generally moderately low background noise levels.

Construction noise and vibration impacts have been identified and assessed. Airborne noise predictions indicate that construction noise levels could significantly impact the closest receivers during the worst case 15 minute periods. These impacts include exceedance of NMLs, highly noise affected receivers, and in some cases, sleep disturbance and awakening. Ground-borne construction noise predictions indicate sensitive receivers above the St Marys to Orchard Hills tunnel and above the Western Sydney International to the Bringelly tunnel, may experience significant exceedances of management targets. Additionally, some heritage, residential, and non-residential receivers located within and adjacent to the construction footprint have been predicted to exceed cosmetic damage and human comfort vibration screening levels.

Potential noise impacts from construction traffic on public roads has been identified along Kent Road (south of the M4 Western Motorway) and Badgerys Creek Road (north of The Northern Road).

Predicted construction noise and vibration impacts will be managed in accordance with the CNVS.

Operational ground-borne noise and vibration impacts from train movements have been assessed. With no attenuation, some exceedances of ground-borne NMLs have been predicted in the St Marys to Orchard Hill tunnel. Ground-borne NMLs can be achieved through the provision of high attenuation rail fixings for small localised sections of rail track adjacent the affected sensitive receiver. Ground-borne noise for all future buildings within Western Sydney International is likely to be suitably managed with standard attenuation rail fixings.

Airborne noise from the operational rail corridor is predicted to meet the noise trigger levels outlined in the RING, without the need for any specific noise mitigation. Controls may be required for future development.

Operational noise and vibration impacts associated with the stabling and maintenance facility located at Orchard Hills have been assessed. Predicted noise levels are generally expected to comply with relevant noise criteria at the nearest receivers in NCA07 and NCA09 for all scenarios and all assessment periods. Noise levels at receivers in NCA08 are predicted to experience noise level exceedances of up to 8 dBA during the morning shoulder and night time periods and 7 dBA during the daytime and evening periods. Sleep disturbance and awakening impacts are not predicted at any sensitive receivers. An ONVR would be prepared to consider measures to mitigate these impacts. Impacts could be mitigated through provision of a noise barrier to the west of the facility, and/or reconfiguration of the stabling yard layout to utilise on site buildings to provide screening. Further, investigation of the occurrence of adverse meteorological conditions would be completed, and ambient background noise levels would be confirmed, taking into account the effect of future development of the area on background noise levels when determining feasible and reasonable mitigation.

Noise from operations associated with ancillary facilities have been assessed, the maximum allowable overall sound power level of all mechanical and electrical plant has been determined at each location to comply with relevant noise criteria at the nearest sensitive receivers. With the installation of appropriate noise attenuation measures, and based on a review of similar projects it is considered that noise from ancillary facilities can be managed to achieve the maximum noise levels outlined in this paper.

Operational road traffic noise impacts associated with additional traffic on public roads and new access roads at station precincts have been assessed. Minor exceedances of traffic noise trigger levels are predicted along multiple existing arterial and sub-arterial roads. Due to the minor nature of predicted traffic noise impacts, no further mitigation is considered reasonable or feasible. Operational road traffic noise impacts are largely predicted to comply with relevant noise criteria at the nearest existing sensitive receivers to be affected by these additional traffic volumes. A more detailed assessment of road traffic noise impacts and mitigation measures would be completed as part of design development in accordance with the RNP, which provides guidance on reasonable and feasible mitigation and management measures.

Through the implementation of standard mitigation measures, as outlined in the Sydney Metro CNVS, and specific mitigation measures as outlined in Chapter 7 of this technical paper, it is concluded all noise and vibration performance outcomes for the project can be achieved.

9 Glossary

Reference	Title
Airports Regulations	Airports (Environment Protection) Regulations 1997
Airports Act	*Airports Act 1996*
AVTG	Assessing Vibration a technical guideline
AS 1055	Australian Standard AS 1055: Description and measurement of environmental noise
AS 2436	Australian Standard AS 2436:2010 – Guide to noise and vibration control on construction, demolition and maintenance sites
CNVG	Construction Noise and Vibration Guideline
DEFRA	Department for Environment, Food and Rural Affairs (United Kingdom), Update of noise database for prediction of noise on construction and open sites – Phase 3: Noise measurement data for construction plant used on quarries (DEFRA noise database)
-	Development Adjacent to the Upper Canal and Warragamba Pipelines
-	Development near Rail Corridors and Busy Roads – Interim Guideline
-	Western Sydney Aerotropolis Plan
DIN 4150-3	German Standard DIN 4150-3: Structural Vibration - effects of vibration on structures
-	Greater Sydney Region Plan
ICNG	Interim Construction Noise Guideline
ISO 14837-1	ISO 14837-1 2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General Guidance
NPfI	Noise Policy for Industry
Kilde Report 130	Nordic Rail Prediction Method
RNP	*NSW Road Noise Policy*
RING	Rail Infrastructure Noise Guideline
RIVAS	Railway Induced Vibration Abatement Solutions
Infrastructure SEPP	*State Environmental Planning Policy (Infrastructure)*
CNVS	Sydney Metro Construction Noise and Vibration Standard
-	Transportation Noise Reference Book
USFTA	US FTA Manual