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Sydney Metro – Western Sydney Airport

Chapter 10
Noise and vibration

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10 Noise and vibration

This chapter assesses the potential noise and vibration impacts during the construction and operation of the project, and identifies mitigation measures to address these impacts. The full noise and vibration assessment is provided in Technical Paper 2 (Noise and vibration).

10.1 Overview

Construction noise and vibration would be managed in accordance with the Sydney Metro Construction Noise and Vibration Standard (CNVS) (Appendix H) which provides standard mitigation measures and additional mitigation measures for certain noise and vibration impact levels. Site specific mitigation measures have also been identified to reduce noise and vibration impacts, including potential for acoustic sheds to be installed. An Operational Noise and Vibration Review would be undertaken as the design develops to ensure that the project does not result in significant operational noise and vibration impacts.

The project environment is undergoing substantial planned urban growth associated with the Western Sydney Aerotropolis and broader Western Parkland City. Projects either currently approved or planned, such as the Western Sydney International and the future M12 Motorway project, together with the project, will substantially change the existing noise environment. Changes to the noise environment from these projects would include increased road and rail transport, aircraft noise and residential and other urban development.

Where receivers are close to construction sites (such as at St Marys and Orchard Hills) or where the existing background noise levels are low (such as at the rural environments of Luddenham and Bringelly), the noise impacts during some of the works are expected to temporarily be ‘high’, particularly where noise intensive equipment such as concrete saws, concrete vibrators or hydraulic hammers are in use close to receivers. Realistic worst case and typical scenarios for noise emissions from construction have been assessed. The realistic worst case scenarios include noisiest equipment working within the equipment work area, operating at 100 per cent duty for the 15 minute assessment period. The typical case scenarios include all equipment assessed as working within the equipment work area, operating over a proportion of the 15 minute assessment period based on the expected utilisation. The worst case airborne noise impacts are generally predicted to occur during enabling works, piling and initial excavation and finishing works. Enabling works such as roadworks and power supply works could occur during daytime, evening or night-time hours. Other works such as piling and excavation would generally occur during daytime hours, unless an acoustic shed is installed over the site to minimise impacts.

There are a number of sensitive receivers that are highly noise affected (residences that experience noise levels greater than 75 dB during standard hours) for different construction scenarios. Highly noise affected receivers are located in noise catchment areas NCA 03, NCA 06 and NCA 08 as predominantly as a result of excavation and earthworks (Scenario 4) and, to a lesser extent, finishing works (Scenario 9). There are predicted to be 49 (NCA03), 16 (NCA06), 53 (NCA08) and nine (NCA12) highly noise affected receivers during worst case for excavation and earthworks (Scenario 4).

The main potential sources of construction ground-borne noise and vibration are associated with the use of tunnel boring machines (TBMs) during tunnelling. The worse-case predicted ground-borne noise impacts are generally compliant with the management levels of result in only ‘minor’ impacts for most receivers. ‘Moderate’ or ‘high’ impacts are however predicted above the St Marys to Orchard Hills tunnel and above the Western Sydney International to Bringelly tunnel, either due to the tunnel being shallow at this location or sensitive receivers being near the station shaft excavation works. However, these impacts will be transient at any individual receiver as tunnelling progresses.

Buildings potentially affected by temporary exceedances of vibration cosmetic damage screening criteria to buildings would be identified before commencement of construction activities. Exceedances of the human comfort vibration criteria may occur, meaning occupants of affected buildings may be able to perceive the impacts at times when vibration intensive equipment is in use nearby.

There would also be minor construction or operational traffic noise impacts to receivers near a number of roads including Glossop Street, Kent Road, Great Western Highway and The Northern Road. Many of the roads utilised by traffic associated with construction or operation of the project already exceed the noise criteria without the project due to existing traffic movements.

10.2 Legislative and policy context

10.2.1 Off-airport

The relevant assessment guidelines, standards and policies that were considered as part of the off-airport noise and vibration assessment include:

- *Australian Standard AS 1055: Description and measurement of environmental noise*
- *Interim Construction Noise Guideline* (ICNG) (DECCW, 2009)
- *Rail Infrastructure Noise Guideline* (RING) (EPA, 2013)
- *Noise Policy for Industry* (NPI) (EPA, 2017)
- *NSW Road Noise Policy* (RNP) (DECCW, 2011)
- *Assessing Vibration a technical guideline* (AVTG) (DECC, 2006)
- *ISO 14837-1 2005 Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General Guidance*
- *German Standard DIN 4150-3: Structural Vibration – effects of vibration on structures*
- *US Federal Transit Administration Manual* (Federal Transit Administration, 2018)
- *Sydney Metro Construction Noise and Vibration Standard* (Sydney Metro, 2020)
- *State Environmental Planning Policy (Infrastructure) 2007* (Infrastructure SEPP).

10.2.2 On-airport

In addition to the above guidelines and policies, the Airports (Environment Protection) Regulations 1997 (Cth) (Airports Regulations) also provide specific criteria to be met at sensitive receivers from construction noise and operational rail traffic noise generated on airport land.

Schedule 4 of the Airports Regulations sets out indicators of noise that are considered to be excessive. Under the Airports Regulations, excessive noise in itself is not an offence, but is one of a number of factors which need to be considered in determining whether the noise offensively intrudes on amenity. Other factors include the volume and noise characteristics, time of day and duration of the noise, background noise levels at the time the noise is generated and the location of the sensitive receiver or commercial receiver in relation to the noise source.

An assessment in accordance with Schedule 4 of the Airports Regulations is detailed in Sections 10.5.2 and 10.6.2.

10.3 Assessment methodology

10.3.1 Overview

The assessment methodology for construction and operational noise and vibration impacts involved:

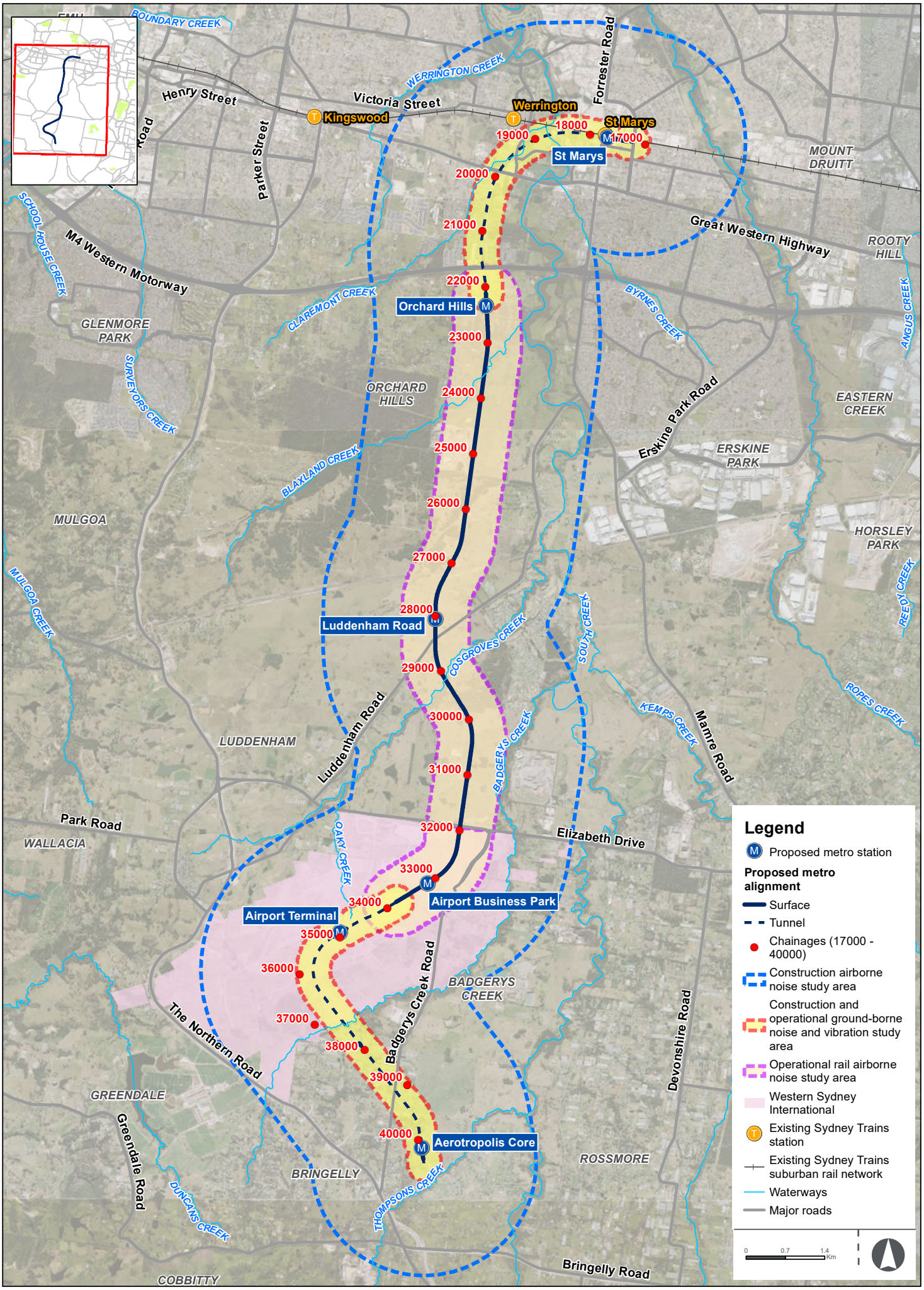
- identifying and classifying sensitive receivers
- characterising the existing noise environment based on attended and unattended noise measurements at specific locations across the project area
- determining noise and vibration management levels in accordance with relevant guidelines
- modelling to quantify the potential construction and operational noise and vibration impacts for key project elements including:
    - ground-borne noise and vibration from metro trains operating within tunnels

  - airborne noise from metro trains operating on the surface
  - airborne noise from mechanical plant and tunnel ventilation systems at stations, services facilities and other ancillary facilities
- assessing the significance of potential impacts identified
- examining the proposed construction methodologies and identifying mitigation measures that are likely to be required to minimise construction noise and vibration impacts
- preparing and documenting reasonable and feasible performance outcomes and mitigation measures that would be implemented for the project.

10.3.2 Study area

The study area for the noise and vibration assessment was defined by each noise or vibration generating component of the project (e.g. construction noise from worksites etc, operational rail noise from relevant project elements such as station, tracks and the stabling and maintenance facility). The study area for each assessment is shown in Figure 10-1 and expressed as distance from the main track alignment as follows:

- construction assessment - airborne noise: two kilometres and ground-borne noise and vibration: 300 metres
- operation assessment - airborne noise: 600 metres and ground-borne noise and vibration: 300 metres.



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Noise and vibration assessment study areas

Figure 10-1

10.3.3 Representative construction scenarios

Representative construction scenarios have been developed to assess the likely impacts from the various construction phases for the project with an indicative construction program provided in Section 4.3.3 of Technical Paper 10 (Noise and vibration). Detailed descriptions of the scenarios are provided in Section 4.3.4 of Technical Paper 10 (Noise and vibration) and are summarised below.

Scenario 1 (SC01) – Enabling works

Key noise generating construction activities undertaken as part of the assessed enabling works scenario would include demolition of buildings, transport network adjustments to facilitate construction vehicle access and establishing construction compounds and work sites

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

- use of hydraulic hammers (~ five per cent utilisation per shift) during site establishment works at St Marys
- use of concrete vibrators (~20 per cent utilisation per shift) during site establishment works at the Claremont Meadows services facility, and Aerotropolis Core
- use of dozers (~80 per cent 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 tunnelling, excavation and 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 segment manufacture and storage, material handling and grout batching).

High noise generating plant utilised as part of these activities includes use of multiple hydraulic hammers (~30 per cent utilisation per shift) during station box excavation works at St Marys, Orchard Hills, Western Sydney International tunnel portal, and the Airport Terminal.

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, bored pile construction and construction of the superstructure.

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

- use of hydraulic hammers (~60 per cent utilisation per shift) during bridge construction works along the off-airport construction corridor
- use of concrete vibrators (~20 per cent 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.

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

- use of hydraulic hammers (~30 per cent utilisation per shift) during station excavation works at Orchard Hills, the Western Sydney International tunnel portal, Airport Business Park, and Aerotropolis Core

- use of dozers and articulated dump trucks (~80 per cent 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 such as support columns and foundations for vertical transport structures and the station buildings.

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

- use of concrete vibrators (~50 per cent utilisation per shift) during station concrete works at St Marys
- use of concrete saws and hydraulic hammers (~20 per cent utilisation per shift) during station concrete works at Orchard Hills
- use of jackhammers (~60 per cent 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, and other ancillary facilities including the Claremont Meadows and Bringelly services facilities and substation.

High noise generating plant utilised as part of these activities includes use of concrete saws (~80 per cent 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 and track slab and rail fastening.

High noise generating plant utilised as part of these activities include use of concrete vibrators (~20 per cent 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 commuter car parking and bus layover.

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

- use of concrete vibrators (~50 per cent utilisation per shift) during station fitout works at St Marys
- use of concrete saws (~20 per cent utilisation per shift) during station fitout works at Luddenham Road
- use of concrete saws (~20 per cent utilisation per shift) during station fitout works at Aerotropolis Core.

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 and removing materials, waste and redundant structures from the works sites.

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

- use of hydraulic hammers (~30 per cent 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.

Construction assessment scenarios include use of the noisiest available plant and equipment and the assessment 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 (Appendix H).

10.3.4 Construction noise metrics and emission scenarios

Noise metrics most relevant to construction noise are described below and were evaluated for daytime (7am-6pm), evening (6-10pm) and night-time (10pm-7am) periods:

- rating background level (RBL) or LA90 (period) – the background noise level in the absence of proposed construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods and is used to set the LAeq(15 minute) noise management levels (NMLs) for residential receivers
- $L_{Aeq\ (period)}$ – the 'energy average noise level' evaluated over a defined measurement period (typically 15 minutes for construction noise or the relevant daytime, evening or night-time period for ambient noise monitoring)
- L_{Amax} – the 'maximum noise level' for an event, used in the assessment of potential sleep disturbance and awakening during night-time periods.

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 per cent 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.

10.3.5 Noise catchment areas and sensitive receivers

Noise Catchment Areas (NCAs) are groups of sensitive receivers that are likely to experience similar impacts from the project. The sensitivity of occupants to noise and vibration varies according to the nature of the occupancy and the activities performed within the affected premises. For example, premises with sensitive equipment or uses are more likely to be sensitive to vibration and groundborne noise than residential premises, which in turn are more sensitive than typical commercial premises.

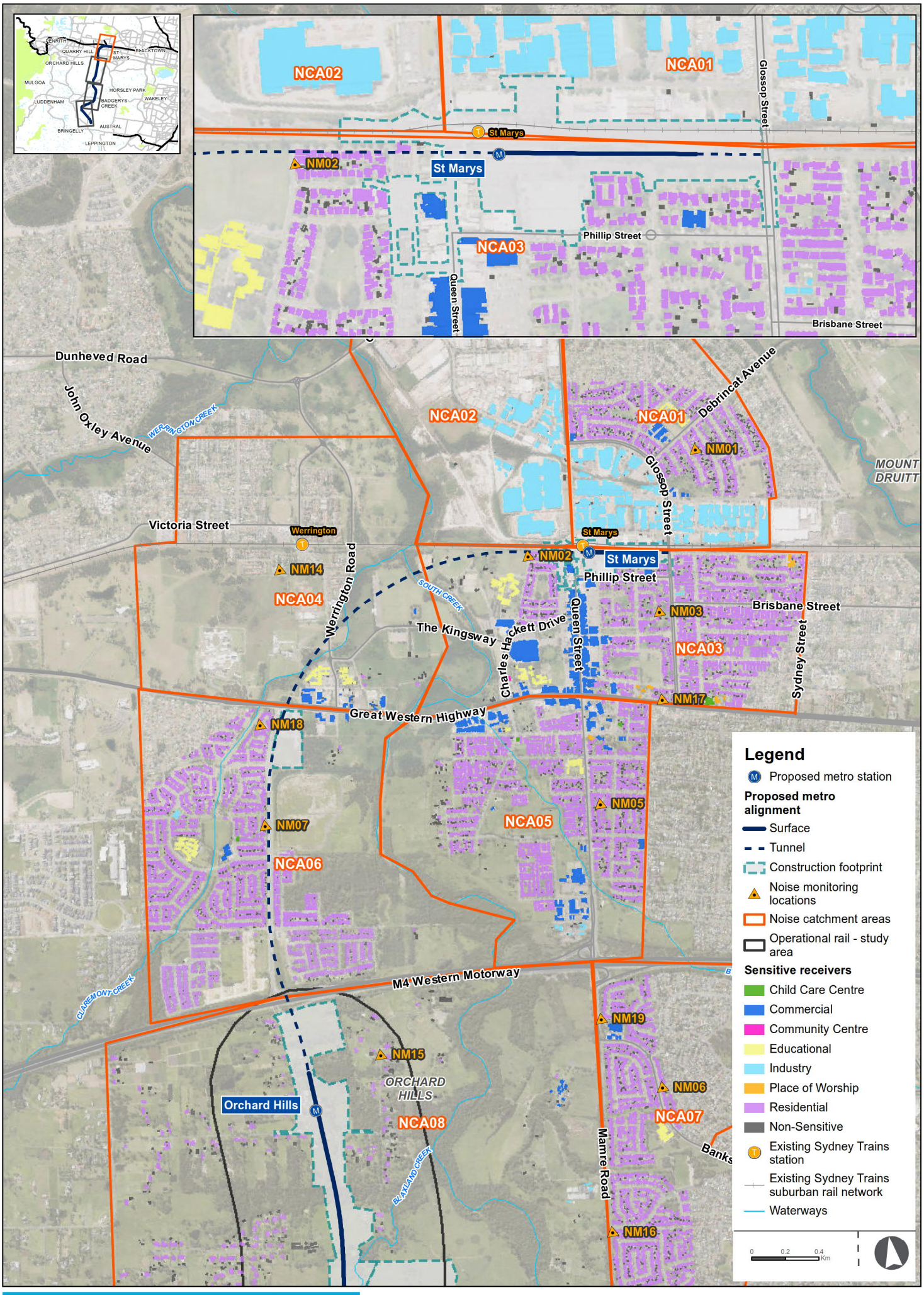
Predicted impacts for each NCA are considered to represent typical noise and vibration impacts at each individual receiver within that NCA. The NCAs are delineated by landmark features, such as roads, to encompass groupings of houses with similar background noise environments. These NCAs contain sensitive receivers approximately two kilometres around the project.

The project has the potential to adversely impact nearby properties that are considered sensitive to noise and vibration. Receivers potentially sensitive to noise and vibration have been categorised based on their use, as defined in the NPI as follows:

- residential noise sensitive receivers
- non-residential noise sensitive receivers
- commercial and industrial noise sensitive receivers
- vibration sensitive receivers.

These NCAs, the noise monitoring locations, and the individual sensitive receiver locations for the project are shown in Figure 10-2.

Further discussion regarding the NCAs adopted for the assessment of the project and the identified sensitive receivers is provided in Section 3.1 and Appendix A.1 of Technical Paper 2 (Noise and vibration).



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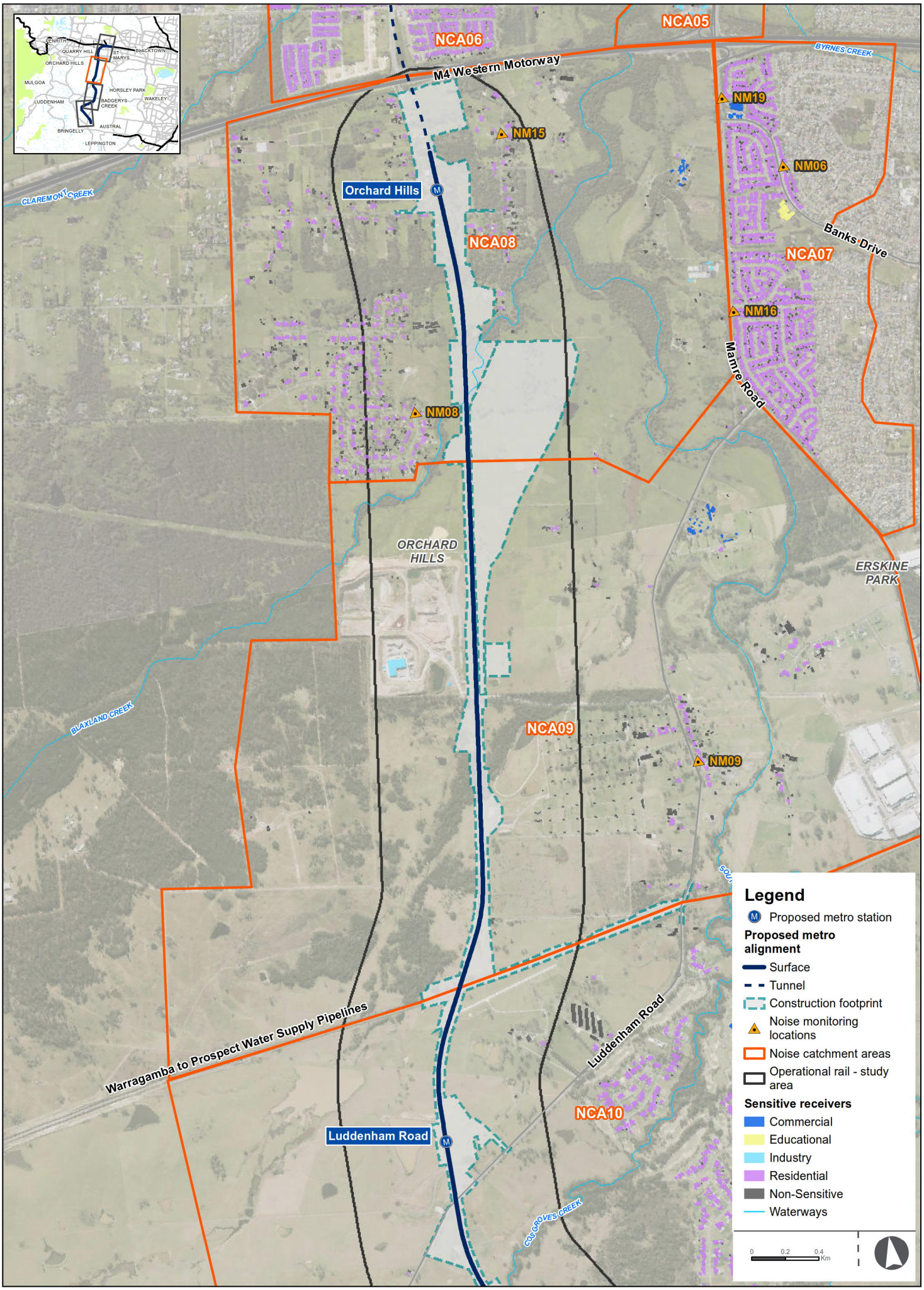
Noise catchment areas and sensitive receiver locations

Figure 10-2a



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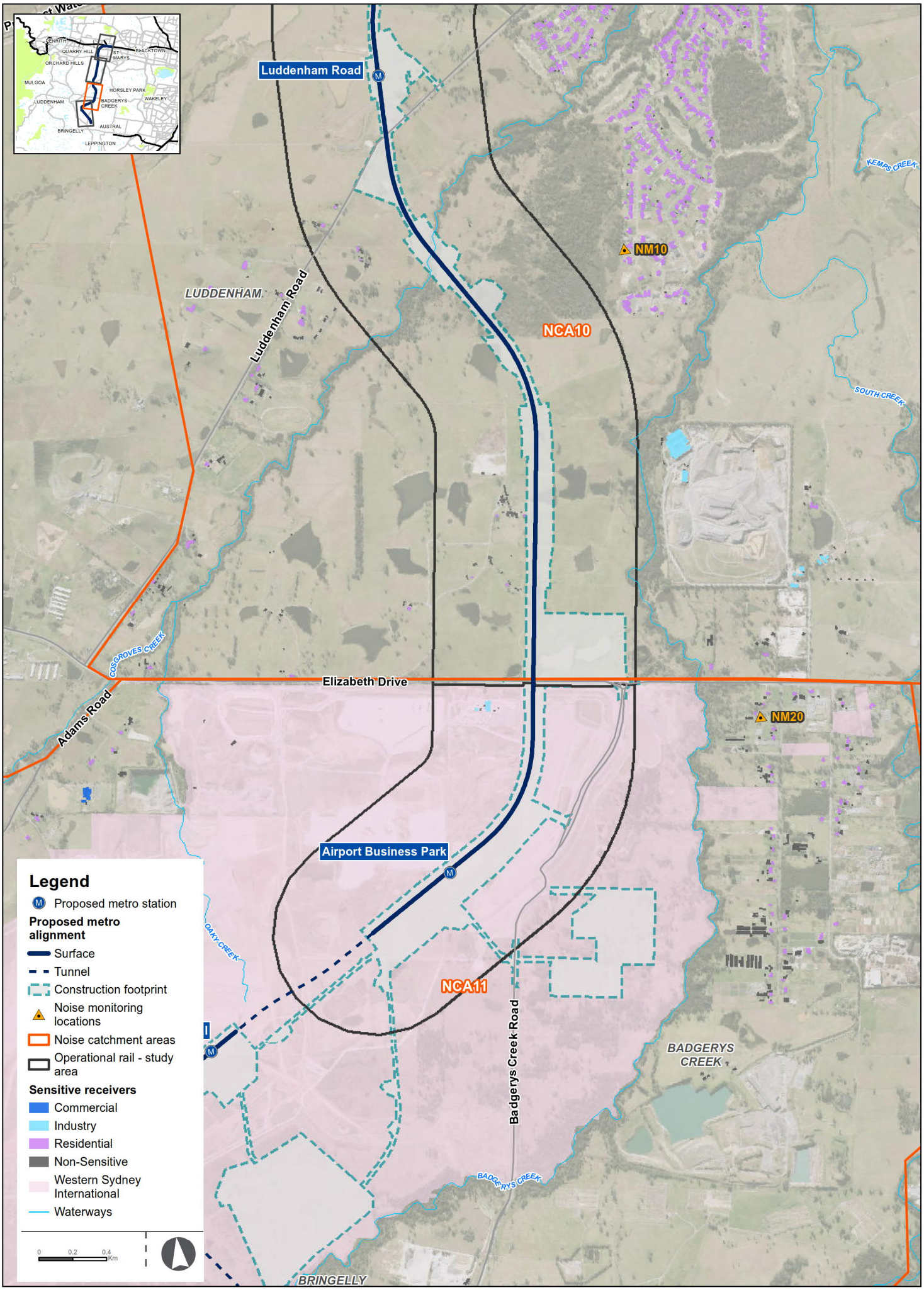
Noise catchment areas and sensitive receiver locations

Figure 10-2b



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Noise catchment areas and sensitive receiver locations

Figure 10-2c

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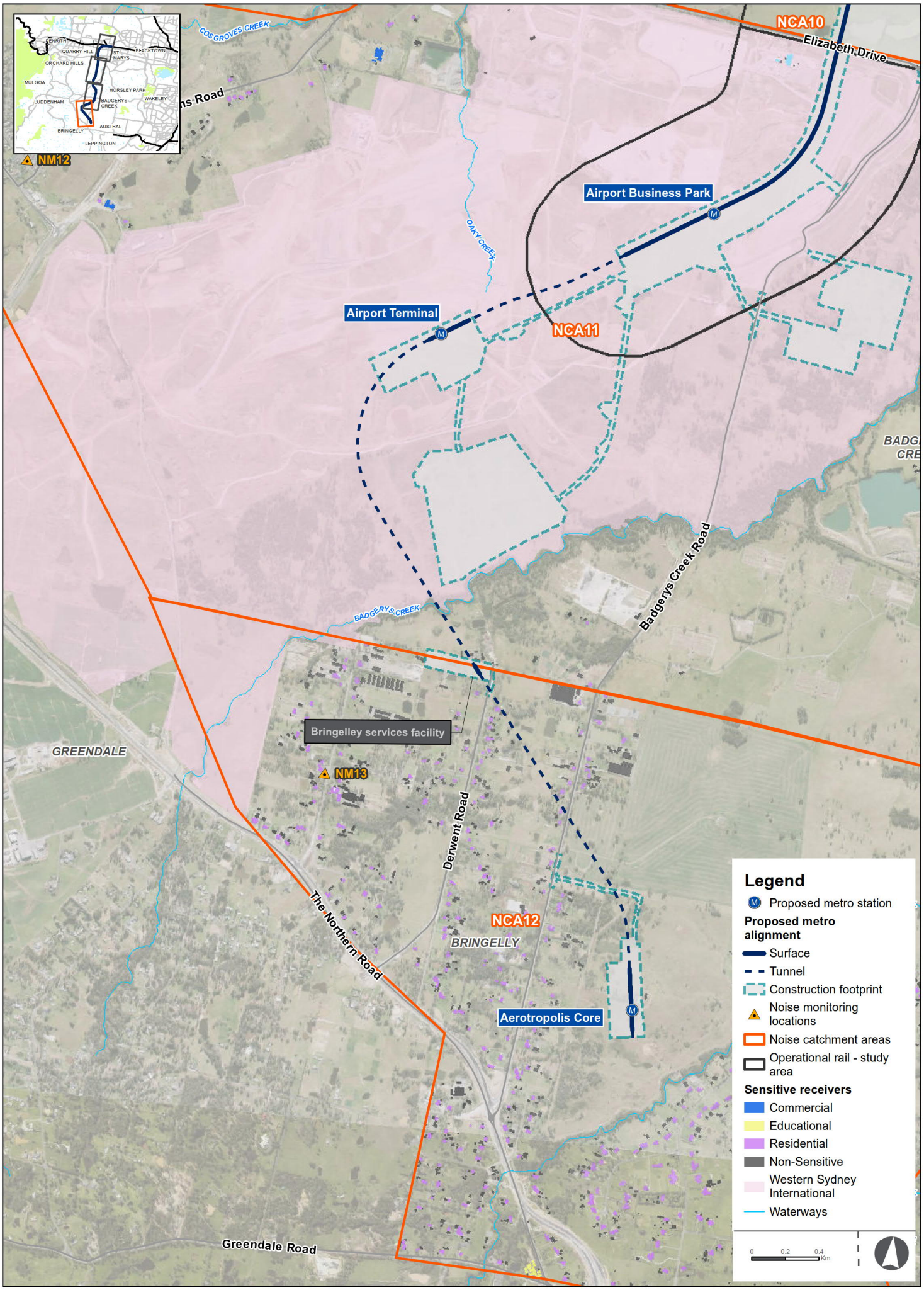

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Noise catchment areas and sensitive receiver locations

Figure 10-2d

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10.3.6 Construction noise management levels

Construction airborne noise guidelines

The ICNG requires the development of Noise Management Levels (NMLs) and a comparison of predicted construction noise levels with the NMLs. The 'worst case' noise levels from construction of a project are predicted and then compared to the NMLs in a 15-minute assessment period to determine the likely impact of the project.

Table 10-1 sets out the application of the management levels for noise at residences. Section 4.1.1 of Technical Paper 2 (Noise and vibration) provide further details of the NMLs for residential receivers within each defined NCA.

Table 10-1 ICNG noise management levels for residential receivers

Time of Day	NML, dBA $L_{eq,\ 15\ min}$	Application
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 $L_{eq,15\ min}$ 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 must 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).
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 must 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 dBA above the noise affected level, the proponent must consult with the community.

NMLs have been derived for the identified land uses, and representative RBLs for residential receivers have been based on noise monitoring of the existing environment.

Table 10-2 presents the NMLs for non-residential sensitive receivers associated with the project.

Table 10-2 Noise management levels for non-residential sensitive receivers

Land use	Noise management level (dBA $L_{eq,\ 15\ min}$)
Educational	55 dBA [1] (Internal noise level 45 dBA)
Commercial (offices, retail outlets)	70 dBA (external noise level)
Commercial (industrial)	75 dBA (external noise level)
Active recreation	65 dBA (external noise level)
Passive recreation	60 dBA (external noise level)
Place of worship	55 dBA [1] (Internal noise level 45 dBA)
Child care centres	55 dBA [1] (Internal noise level 45 dBA)

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

Construction ground-borne noise guidelines

Ground-borne noise is generated by vibration transmitted through the ground and into a structure when vibration intensive equipment is in use, such as during tunnelling works using TBMs, roadheaders or rockbreakers. The CNVS refers to guidance in the ICNG, which specifies evening and night-time ground-borne noise management levels for residences and commercial. The ICNG management levels indicate when management actions should be implemented. These are presented in Table 10-3.

Table 10-3 Ground-borne noise management levels for residential and commercial sensitive receivers

Time of day	Ground-borne noise management level ($L_{eq,15min}$)
Daytime 7am-6pm	45 dBA at residences; 50 dBA at commercial receivers
Evening 6-10pm	40 dBA at residences
Night-time 10pm-7am	35 dBA at residences

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

10.3.7 Construction vibration guidelines

The effects of vibration in buildings can be divided into different categories being:

- loss of amenity due to perceptible vibration, (human comfort)
- where the integrity of the building may be compromised including:
  - structural or cosmetic damage
  - impacts to heritage buildings
- where impacts may affect sensitive scientific and medical equipment
- where structures and utilities sensitive to vibration are encountered.

These are discussed further in the following sections.

Human comfort

The CNVS requires the assessment of vibration impacts on human comfort in accordance with AVTG. AVTG presents preferred and maximum vibration values, above which there is considered to be a risk that the amenity and comfort of people occupying buildings would be adversely affected. The preferred vibration values are not mandatory limits but should be sought to be achieved through application of all feasible and reasonable mitigation measures.

The applicable vibration dose values (VDV) for intermittent vibration are shown in Table 10-4.

Table 10-4 Vibration dose values for human exposure from intermittent vibration

Location	Assessment period	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

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am

The vibration guideline also presents values for continuous and impulsive vibration. These values are detailed in Table 4-5 of Technical Paper 2 (Noise and vibration).

When short-term works such as piling, demolition and construction give rise to impulsive vibrations, strict restrictions on allowable vibration values (levels) 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.

Cosmetic building damage

Vibration screening levels (Peak Particle Velocity (PPV)) for cosmetic building damage are provided for intermittent vibration sources in Table 10-5.

Table 10-5 Recommended vibration limits for cosmetic damage

Type of building	Peak component particle velocity (PPV)
Reinforced or framed structures	10 mm/s
Unreinforced or light framed structures	5 mm/s

At locations where the predicted (or measured) vibration levels are greater than those in Table 10-5, monitoring would be undertaken during construction.

Heritage structures

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 of three mm/s PPV would be considered.

Heritage structures that are potentially at risk of cosmetic damage would be identified by the contractor prior to the commencement of construction works. The Construction Noise and Vibration Management Plan (CNVMP) would include management at these locations including building condition surveys before the commencement of construction activities and after construction is completed.

A summary of the identified heritage buildings that would potentially be at risk of threshold or cosmetic damage are shown in Table 10-6. Further detail on the heritage significance of these items is provided in Section 12.4 of Chapter 12 (Non-Aboriginal heritage).

Table 10-6 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

Heritage Receiver	Construction site	Listing	Significance	Approximate distance to construction footprint
Warragamba to Prospect Water Supply Pipelines	Off-airport corridor	WaterNSW s170 (SHI 4580161X)	State	Located within the construction footprint
McGarvie-Smith Farm	Off-airport corridor	Penrith LEP 2010 I857	Local	0 to 300 metres

Sensitive scientific and medical equipment

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

Other vibration sensitive structures and utilities

Construction of the project could potentially affect other utilities and assets which may be particularly sensitive to vibration. Examples include pipelines (for example the Warragamba to Prospect Water Supply Pipelines which is a critical item of infrastructure for Sydney), tunnels, fibre optic cables and high-pressure gas pipelines.

The vibration criteria applicable to utilities and assets is outlined in Table 10-7.

Table 10-7 Guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework

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

10.3.8 Construction road traffic noise guidelines

The CNVS 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 10-8 are exceeded, investigation of mitigation options would be required.

Table 10-8 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	55 $L_{eq,15hr}$ dBA	50 $L_{eq,1hr}$ dBA

10.3.9 Sleep disturbance and awakening

Construction noise during the night (10pm to 7am Monday to Saturday, 10pm Saturday to 8am Sunday) has the potential to awaken residents from sleep. The RNP has been used as the primary guidance relevant to the assessment of sleep disturbance and awakening.

The RNP notes that the Environmental Criteria for Road Traffic Noise (ECRTN) (RTA, 1999) discussed a guideline aimed at limiting sleep disturbance and awakening due to environmental noise of, $L_{AF1,1min}$ should not exceed the L_{A90} + 15 dB. This means, the typical maximum noise level should not exceed the background noise level + 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 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. This + 10 dB correction indicates noise difference from outside to inside from a building façade with windows partially open.

The NPI 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 dB aligns with construction NMLs (as defined in Section 10.3.6) and would be covered under the assessment against construction NMLs. 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, have been adopted.

10.3.10 On-airport construction noise management guidelines

Construction noise generated by works undertaken on-airport is regulated by the Airports Regulations. This regulation provides specific criteria that should not be exceeded at sensitive receivers. Schedule 4 of the Airports Regulations use the term ‘sensitive receptors’ as having the same meaning as ‘sensitive receivers’. As such for the purposes of consistency, the term ‘sensitive receiver’ is used throughout this Environmental Impact Statement including in relation to the on-airport assessment. 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 Schedule 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 receiver. For commercial receivers, 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.

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 would be undertaken across both on-airport and off-airport construction sites.

The Western Sydney Airport Noise and Vibration Construction Environmental Management Plan (Western Sydney Airport, 2019f) is also used to manage noise and vibration impacts associated with construction works for Western Sydney International.

10.3.11 Operational rail noise management guidelines

The RING states that noise trigger levels (a level that, if exceeded, would indicate a potential noise impact on the community, and so trigger a management response) 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 expected opening year for the project. 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.

Airborne rail noise – off-airport

Noise trigger levels for residential land uses are provided in Table 10-9. Noise trigger levels for non-residential receivers are provided in Table 10-10. The alignment is considered a new rail line development for the purpose of the operational noise assessment.

Table 10-9 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 10-10 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

Commercial receivers such as offices or industrial receivers are not considered as noise sensitive receivers within the RING and were not assessed for noise from the operational rail.

Airborne rail noise – on-airport

Noise generated by rail traffic on airport land is regulated by the Airports Regulations. These regulations specify that noise generated from rail traffic operated at an airport and measured at the receiver 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 receivers, the time of day, duration, characteristics of noise, background noise level, and nature of the business conducted at the site should also be considered when determining whether noise is excessive.

Rail ground-borne noise and vibration

The RING provides guidance on the assessment and management of ground-borne noise and vibration impacts generated by railways. The RING provides the following trigger levels for ground-borne noise as outlined in Table 10-11 and applies to both off-airport and on-airport assessments.

Table 10-11 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 $_{Smax}$

Note 1: L_{Smax} 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 the AVTG. The AVTG recommends the use of the VDV (see Section 10.3.7) for assessment of intermittent vibration. Acceptable VDV values are outlined in Table 10-12.

Table 10-12 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

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

Notes:
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

Stations and ancillary facilities noise trigger levels

The procedure for the derivation of noise trigger levels for stations and ancillary facilities is presented in Appendix F1 of Technical Paper 2 (Noise and vibration). The relevant operational noise sources associated with ancillary facilities at each station and service facility are summarised in Table 10-3, along with relevant limiting criteria and offsets to nearest sensitive receivers.

Table 10-13 Project noise sources and criteria for stations, service facilities and ancillary facilities

Station	NCA (NM)[2]	Nearest receiver type	PNTL[1]
St Marys	NCA03 (NM03)	Residential	36
	NCA03 (NM03)	Commercial	65
	NCA03 (NM03)	Industrial	70
	NCA03 (NM03)	Residential	36
	NCA03 (NM03)	Residential	36
Orchard Hills	NCA08 (NM08)	Residential	35
	NCA08 (NM08)	Hotel/Residential	35
Luddenham Road	NCA10 (NM10)	Residential	35
Airport Business Park	NCA11 (NM20)	Residential	35
	NCA11 (NM20)	Residential	35
	NCA11 (NM20)	Commercial	65
Airport Terminal	NCA11 (NM11)	Commercial	65
Aerotropolis Core	NCA13 (NM13)	Residential	39
	NCA13 (NM13)	Commercial	65
Claremont Meadows services facility	NCA07 (NM07)	Residential	41
	NCA07 (NM07)	Residential	41
Bringelly services facility	NCA11 (NM13)	Industrial	70

Notes:
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 shown in Figure 10-2.

Stabling and maintenance facility noise trigger levels

In assessing the noise impact of the stabling and maintenance facility on residential receivers, both intrusiveness and amenity levels have been considered. The most stringent trigger level forms the 'proposal noise trigger level' (PNTL) for the project.

A summary of the PNTL applicable to the project is presented in Table 10-14.

Table 10-14 Project noise trigger levels for the stabling and maintenance facility

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, $L_{eq,15min}$[2]	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

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, $L_{eq,15min}$[2]	Screening level, L_{Fmax}[3]
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

Notes:
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.
2. Morning shoulder: 5 am to 7 am noise trigger levels derived from night time RBLs for all locations.
3. Sleep disturbance noise trigger levels applied to night time periods.
4. The full procedure for the derivation of PNTLs is presented in Appendix F1 of Technical Paper 2 (Noise and vibration).

Road traffic noise

Applicable noise criteria for each road type are presented in Table 10-8. Where the criteria are exceeded, the RNP states that 'feasible and reasonable mitigation measures would be investigated. The RNP (which applies to the off-airport assessment only) states that where land use developments have 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.

10.4 Existing environment

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

The noise environment north of M4 Western Motorway is comprised of both the commercial centre of St Marys and a broader suburban landscape. The background noise environment is characterised generally by local road traffic noise, as well as pockets of industry and commercial areas focused around St Marys. The M4 Western Motorway also provides an additional source of noise for this area.

The noise environment south of the M4 Western Motorway is characteristic of a semi-rural landscape. The background noise environment is characterised 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. 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 and rural residential properties.

10.4.1 Off-airport

Background noise monitoring

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. The noise monitoring locations selected for the assessment were considered to be representative of the existing background noise environment in each NCA (see Figure 10-2).

The locations and results of the attended and unattended monitoring are detailed in Table 3-3 and Table 3-4 of Technical Paper 2 (Noise and vibration) respectively.

10.4.2 On-airport

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 predicted impacts from the construction noise assessment for Western Sydney International as part of the *Western Sydney Airport – Environmental Impact Statement* (Department of Infrastructure and Regional Development, 2016b), 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 to where bulk earthworks occur.

No sensitive receivers currently exist within Western Sydney International. In the future, the on-airport sensitive receivers would broadly consist of the new airport terminal and ancillary buildings, air traffic control tower, and the proposed business park to be constructed as part of Western Sydney International. As these receivers have not yet been built and would 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.

10.4.3 Future noise environment

Western Sydney is a fast growing area due to heavy economic investment. The area will be transformed into the Western Parkland City, and as a result in the near future the existing noise environment is likely to substantially change. 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 semi-rural noise environment south of the M4 Western Motorway. The future noise environment will consist of noise generated from the construction of infrastructure (including transport) and commercial and residential development, operation of transport infrastructure (road and rail), and eventually aircraft noise during the day, evening and night.

For areas that are not developed and (at the time of the assessment) 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 Infrastructure SEPP can be met. Guidelines such as *Development near Rail Corridors and Busy Roads – Interim Guideline* (Department of Planning, 2008b) 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 Greater Penrith to Eastern Creek Growth Investigation Area would also be required.

The future noise environment was only considered in relation to the operation of the project. Construction noise impacts, whilst they could be significant, would be short term, and prior to the timeframe over which broad scale land use change would occur. The effect of increased background noise would result in any future acoustic assessment that relies on background noise levels to set noise criteria (such as the NPI and ICNG) that are likely to be higher than those currently adopted for this assessment. As such, 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. When considering feasible and reasonable mitigation of noise impacts it is therefore important to consider what the future noise environment would be like, and how this might affect the noise mitigation approach.

10.5 Potential impacts – construction

10.5.1 Off-airport

Airborne noise

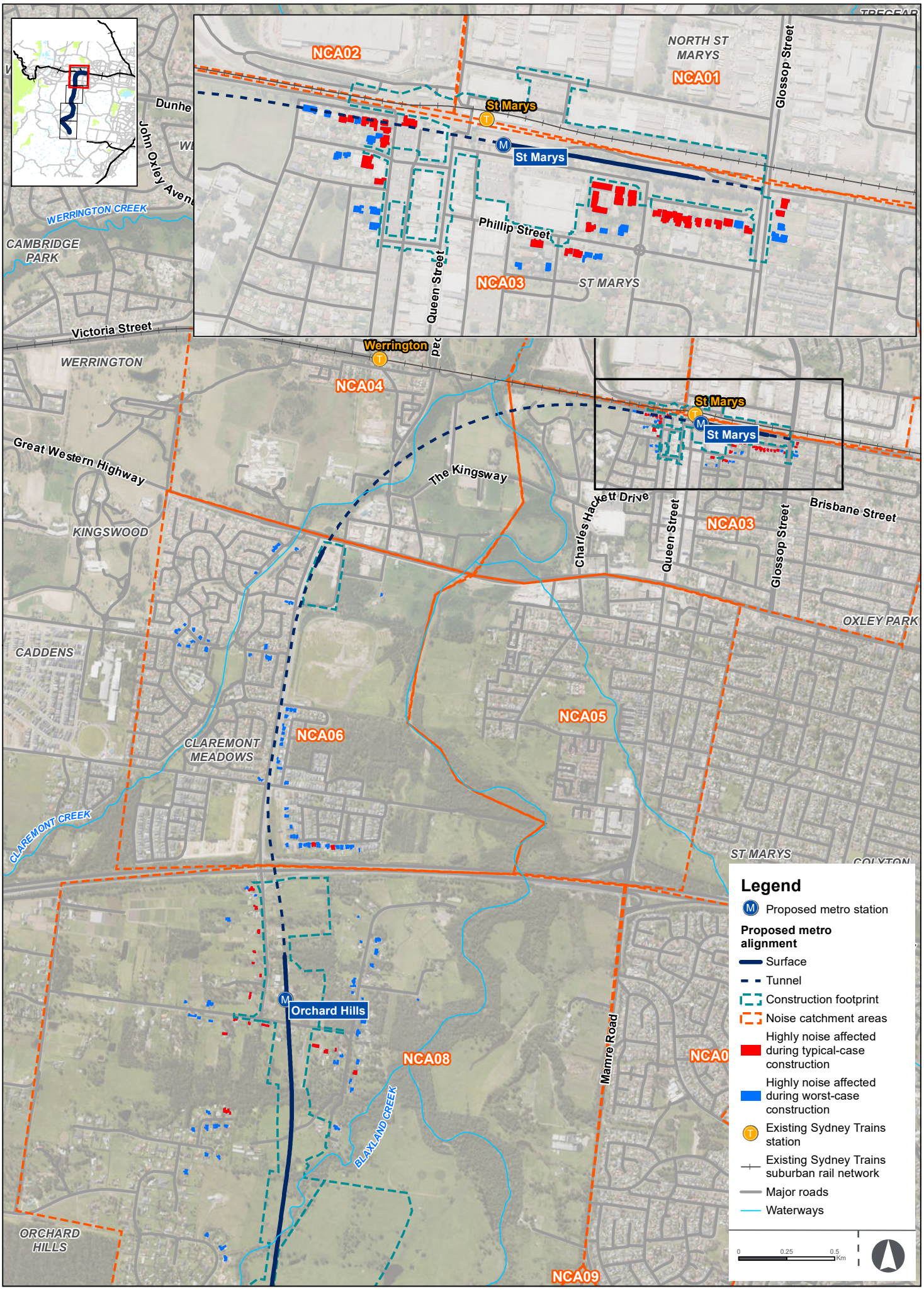
During construction activities, the predictions indicate that construction noise levels could, at some receivers, be greater than NMLs, highly noise affected levels, and in some cases, sleep disturbance and awakening screening levels.

Table 10-15 and Figure 10-3 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 scenario. Highly noise affected receivers occur in NCA03, NCA06 and NCA08 predominantly as a result of excavation and earthworks (Scenario 4) and, to a lesser extent, finishing works (Scenario 9) and are further discussed in Section 4.4 of Technical Paper 2 (Noise and vibration).

Table 10-15 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 - (1,385 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 - (1,051 receivers assessed within NCA)	0 (0)	0 (0)	N/A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NCA06 – (1,315 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 – (229 receivers assessed within NCA)	0 (1)	0 (19)	0 (3)	18 (53)	0 (9)	0 (0)	1 (6)	0 (0)	1 (26)
NCA09 – (68 receivers assessed within NCA)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
NCA10 – (378 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)

Notes:
Results in brackets indicate number of receivers exceeding highly noise affected NMLs assuming full utilisation of plant (i.e. realistic worst case).
N/A refers to no works for that scenario within that NCA.

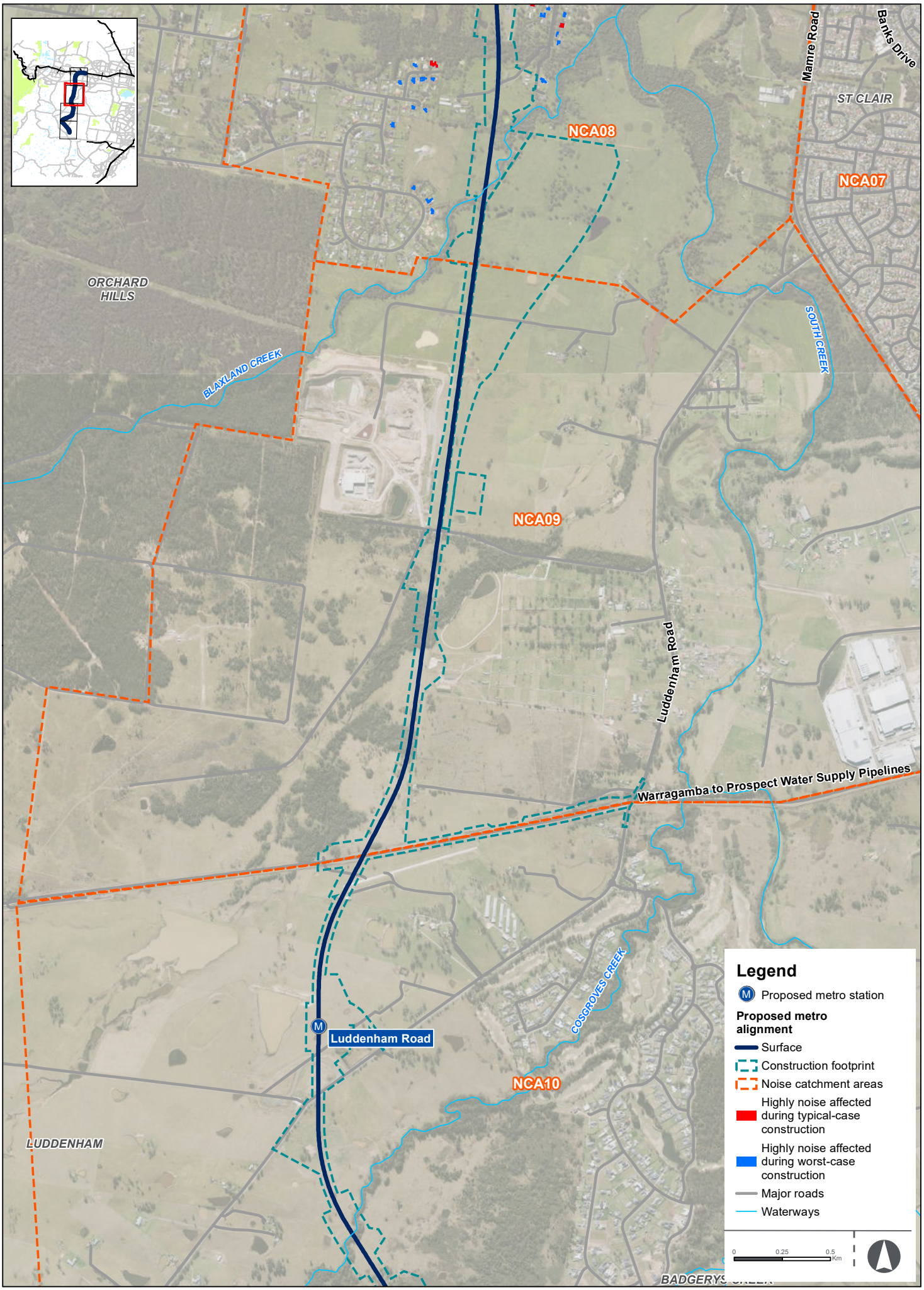


Sydney Metro – Western Sydney Airport

Off-airport – highly noise affected receivers during construction

Figure 10-3a

Indicative only, subject to design development



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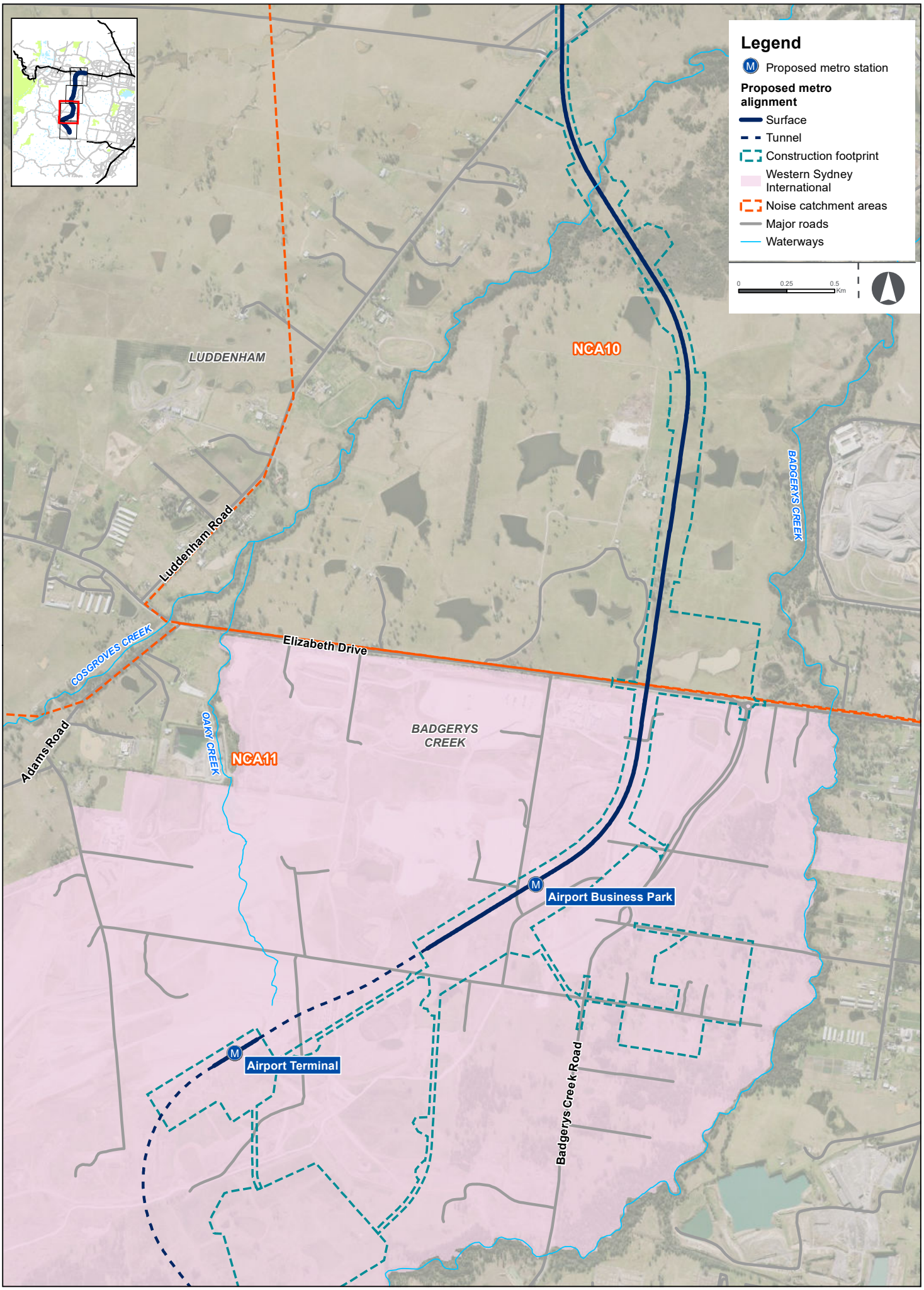
Sydney Metro – Western Sydney Airport

Off-airport – highly noise affected receivers during construction

Indicative only, subject to design development

Figure 10-3b

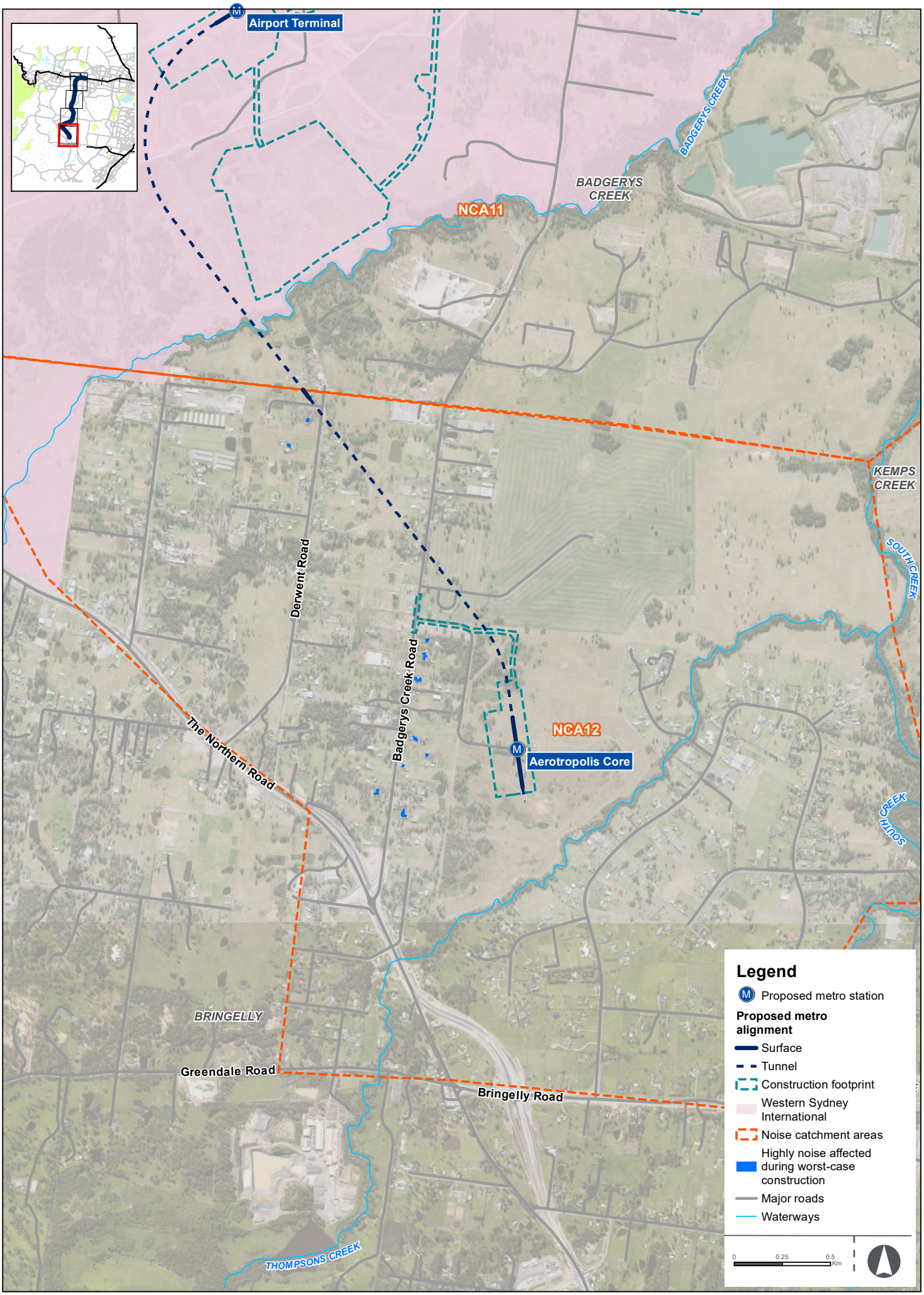


Sydney Metro – Western Sydney Airport

Off-airport – highly noise affected receivers during construction

Figure 10-3c

Indicative only, subject to design development



Sydney Metro – Western Sydney Airport

Off-airport – highly noise affected receivers during construction

Indicative only, subject to design development

Figure 10-3d

A summary of the main findings from the construction noise assessment is provided in the following sections. A detailed breakdown of the predicted noise levels is provided in Section 4.5 of Technical Paper 2 (Noise and vibration), with predicted noise impact maps of receivers within the study area presented in Appendix B.4 of Technical Paper 2 (Noise and vibration). The results are pre-mitigation and exceedances of NMLs are likely to be reduced once mitigation measures are applied in accordance with the CNVS.

NCA01 (St Marys, north of T1 Western Line and east of Forrester Road)

In NCA01 765 noise sensitive receivers were assessed. The predicted NML exceedances within NCA01 are presented in Table 10-16. The tables for each NCA show the number of receivers experiencing exceedances of NMLs for day, evening and night, and also show the number of receivers experiencing a 0-10 dB, number of receivers experiencing 10-20 and number of receivers experiencing 20 dB above NMLs. No exceedances of highly noise affected management levels are predicted to occur within NCA01.

During standard construction hours the following potential airborne noise impacts were predicted for NCA01 for residential receivers:

- 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) – most residential receivers would be affected, with predicted noise levels mainly influenced by the intermittent use of hydraulic hammers that would exceed NMLs by up to 17 dB to 21 dB for around eight months of the construction period
  - station fitout, precinct and transport integration works (Scenario 8) – predicted noise levels are mostly influenced by the use of multiple concrete vibrators
  - finishing works (Scenario 9) – predicted noise levels are mainly influenced by the intermittent use of hydraulic hammers.

Of the residential receivers that are predicted to be affected, impacts are generally experienced during excavation and earthworks (Scenario 4). The highest construction noise during this scenario would be as 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 (for typical and worst case respectively). Figure 10-3 shows the distribution of NML exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA01.

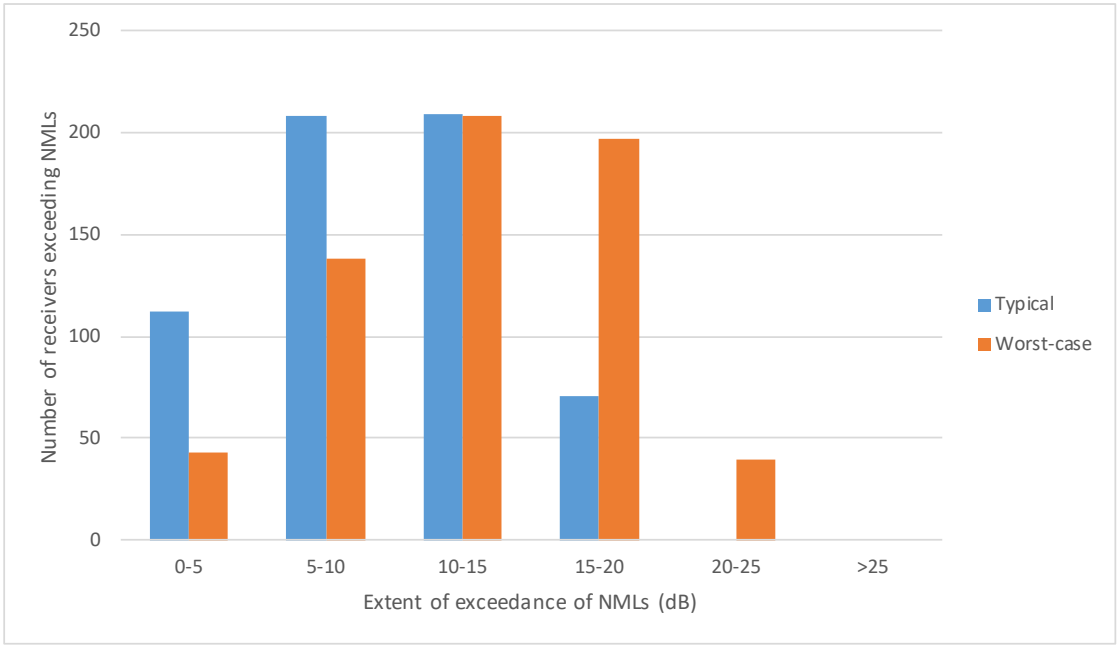


Figure 10-4 NCA01 NML exceedances – standard hours – earthworks and excavation (Scenario 4)

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA01 for residential receivers:

- exceedances of NMLs are only predicted during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Key findings are as follows:
    - residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2) with use of the TBMs at St Marys, exceeding NMLs by up to 10 dB
    - exceedances of sleep disturbance and awakening screening levels would occur during testing and commissioning as part of finishing works, exceeding NMLs by up to 3 dB.

During standard construction hours the following potential airborne noise impacts were predicted for NCA01 for non-residential receivers:

- 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). Key findings are as follows:
    - the school is predicted to be most affected during excavation and earthworks (Scenario 4)
    - construction noise during Scenario 4 is mainly influenced by hydraulic hammers during station box excavation works at St Marys, exceeding NMLs by up to 10 dB to 14 dB for around eight months of the construction period
    - industrial receivers along Harris Street are predicted to experience exceedances of NMLs of up to 5 dB to 7 dB, during excavation and earthworks (Scenario 4).

These exceedances would be managed through the measures 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 per cent to 50 per cent.

Table 10-16 NCA01 – overview of NML exceedances at residential receivers – typical and (worst case)

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +
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

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +
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)

Notes:
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
Shaded 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).
In NCA01 765 noise sensitive receivers were assessed.
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA02 (St Marys, north of T1 Western Line and west of Forrester Road)

There are 41 noise sensitive receivers in NCA02. 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.

These exceedances would be managed through the conventional methods as outlined in the CNVS.

NCA03 (St Marys, between the T1 Western Line and Great Western Highway, east of South Creek)

In NCA03 1,385 noise sensitive receivers were assessed. The predicted NML exceedances within NCA03 are presented in Table 10-17.

During standard construction hours the following potential airborne noise impacts were predicted for NCA03 for residential receivers:

- 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) – noise levels mainly influenced by the intermittent use of hydraulic hammers during station box excavation at St Marys that would exceed NMLs by up to 40 dB to 44 dB for around eight months of the construction period
  - station fitout, precinct and transport integration works (Scenario 8) – exceedances of NMLs are a result of the use of multiple concrete vibrators
  - finishing works (Scenario 9) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers.

Of the residential receivers that are predicted to be affected, impacts are generally experienced 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 (for typical and worst case respectively). Figure 10-5 shows the distribution of NML exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA03.

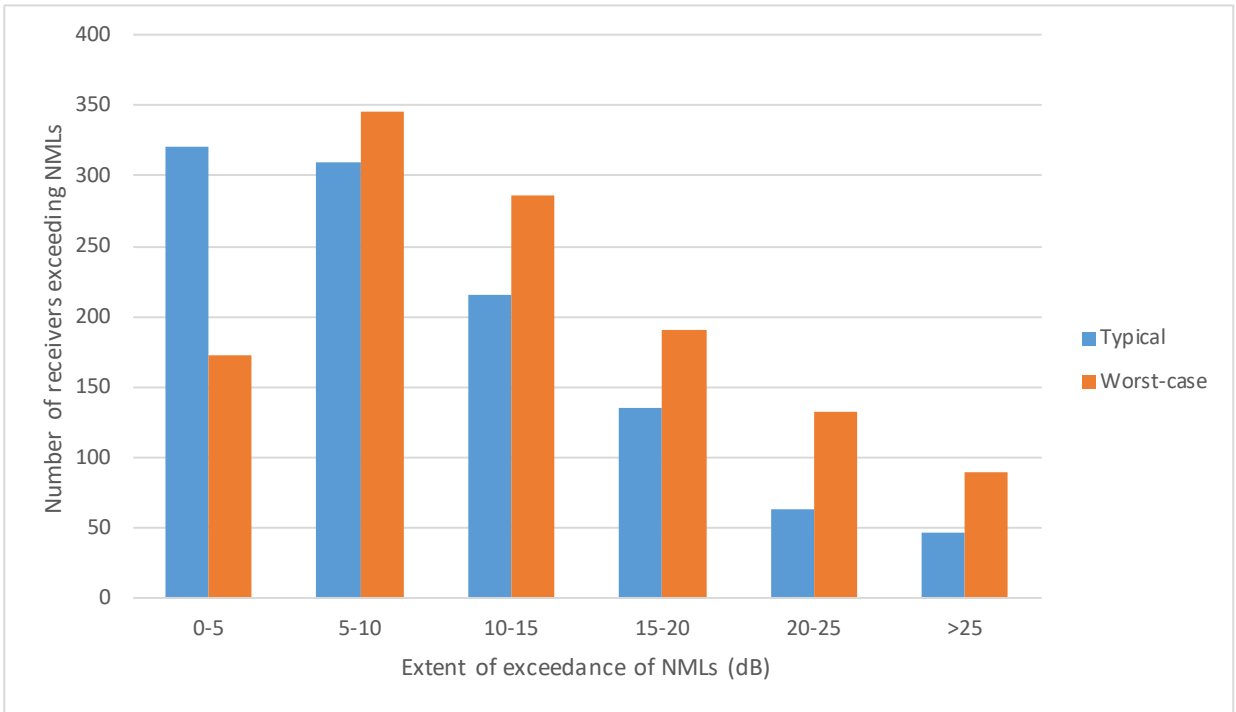


Figure 10-5 NCA03 NML exceedances – standard hours – earthworks and excavation (Scenario 4)

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA03 for residential receivers:

- only experiences exceedances of NMLs during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Key findings are as follows:
    - residential receivers are predicted to be most affected during tunnelling and associated works (Scenario 2) mainly influenced by intermittent the use of the TBM at St Marys, exceeding NMLs by up to 18 dB
    - exceedances of sleep disturbance and awakening screening levels during testing and commissioning as part of finishing works, exceeding NMLs by up to 31 dB.

During standard construction hours the following potential airborne noise impacts were predicted for NCA03 for non-residential receivers:

- 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). Key findings are as follows:
    - St Marys Public School and St Marys Anglican Church are predicted to be most affected during excavation and earthworks (Scenario 4)
    - construction noise during Scenario 4 is mainly 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 for around eight months of the construction period.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

Table 10-17 NCA03 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 db	10-20 db	20 db +	0-10 db	10-20 db	20 db +	0-10 db	10-20 db	20 db +	0-10 db	10-20 db	20 db +
SC01 – Enabling works	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	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
SC04 – Earthworks and excavation	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	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	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

Activity	Exceedances of sleep 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 db	10-20 db	20 db +	0-10 db	10-20 db	20 db +	0-10 db	10-20 db	20 db +	0-10 db	10-20 db	20 db +
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	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	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)

Notes:
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
Shaded 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)
In NCA03 1385 noise sensitive receivers were assessed.
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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

NCA04 (St Marys, between the T1 Western Line and Great Western Highway, west of South Creek)

In NCA04 26 noise sensitive receivers were assessed. The predicted NML exceedances within NCA04 are presented in Table 10-18. No exceedances of highly noise affected management levels are predicted to occur within NCA04.

During standard construction hours the following potential airborne noise impacts were predicted for NCA04 for residential receivers:

- the most affected receivers are predicted to be located along Tenant Road. Some of the highest impact works occur during:
    - tunnelling and associated works (Scenario 2) – exceedances of NMLs are mainly influenced by the use of concrete vibrators
    - excavation and earthworks (Scenario 4) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers at Claremont Meadows services facility that would exceed NMLs by up to 18 dB to 23 dB for around six months of the construction period
    - finishing works (Scenario 9) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers.

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA04 for residential receivers:

- only experiences exceedances of NMLs and sleep disturbance and awakening screening levels associated with testing and commissioning of the Claremont Meadows services facility during finishing works (Scenario 9). Key findings are as follows:
    - exceedances of NMLs are a result of the use of the periodic use of heavy vehicles for around 12 months during testing and commissioning at Claremont Meadows, exceeding NMLs by up to six to 18 dB
    - exceedances of sleep disturbance and awakening screening levels during testing and commissioning as part of finishing works, exceeding NMLs by up to 11 dB.

During standard construction hours the following potential airborne noise impacts were predicted for NCA04 for non-residential receivers:

- 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). Key findings are as follows:
    - Kurrambee School is predicted to be mainly affected during excavation and earthworks (Scenario 4)
    - construction noise during Scenario 4 is mainly influenced by hydraulic hammers during excavation works at Claremont Meadows services facility, exceeding NMLs by up to 6 to 10 dB for around six months of the construction period.

These exceedances would be managed through conventional methods 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 per cent to 50 per cent.

Table 10-18 NCA04 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +
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

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +
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)

Notes

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

Shaded 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).

In NCA04 26 noise sensitive receivers were assessed.

N/A refers to no works for that scenario within that NCA.

Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA05 (Claremont Meadows, between the Great Western Highway and M4 Western Motorway, east of South Creek)

In NCA05 1,051 noise sensitive receivers were assessed. The predicted NML exceedances within NCA05 are presented in Table 10-19. No exceedances of highly noise affected management levels are predicted to occur within NCA05.

During standard construction hours the following potential airborne noise impacts were predicted for NCA05 for residential receivers:

- the most affected receivers are predicted to be located along Schleicher Street. Some of the highest impact works occur during:
  - site establishment (Scenario 1) – exceedances of NMLs are a result of the use of concrete saws
  - tunnelling and associated works (Scenario 2) – exceedances of NMLs are a result of the use of hydraulic hammers
  - excavation and earthworks (Scenario 4) – most residential receivers affected with predicted noise levels mostly influenced by the intermittent use of hydraulic hammers during station and portal excavation at Orchard Hills and excavation at Claremont Meadows that would exceed NMLs by up to 15 dB to 20 dB for around eight months of the construction period
  - finishing works (Scenario 9) – exceedances of NMLs are a result of by the intermittent use of hydraulic hammers.

Of the residential receivers that are predicted to be affected, impacts are generally experienced 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 (for typical and worst case respectively). Figure 10-6 shows the distribution of NML exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA05.

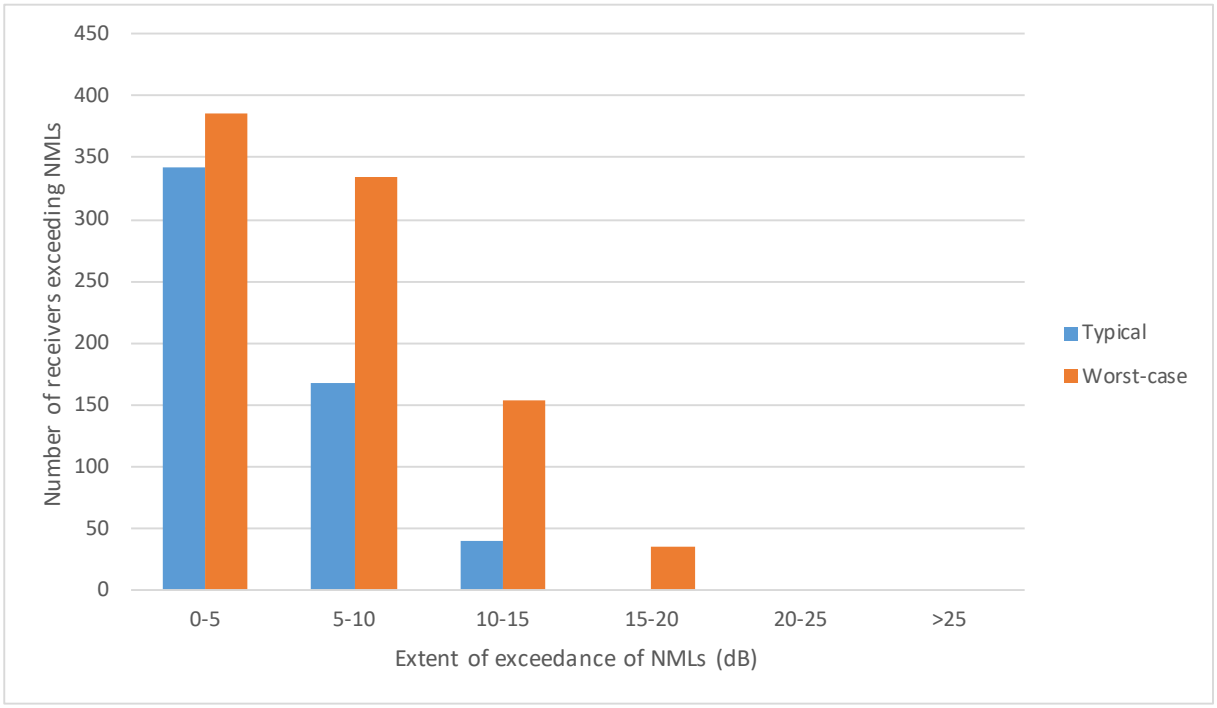


Figure 10-6 NCA05 NML exceedances – standard hours – earthworks and excavation (Scenario 4)

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA05 for residential receivers:

- only experiences exceedances of NMLs during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Key findings are as follows:
    - exceedances of NMLs are a result of operation of the TBM during tunnelling and associated activities, and testing and commissioning of the Orchard Hills construction site and Claremont Meadows services facility during finishing works, exceeding NMLs by up to 2 dB.

During standard construction hours the following potential airborne noise impacts were predicted for NCA05 for non-residential receivers:

- 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). Key findings are as follows:
    - Mirrabooka Study Centre, My First School Daycare Centre, and Koala Corner Children's Centre are predicted to be mainly affected during excavation and earthworks (Scenario 4)
    - construction noise during Scenario 4 is mainly influenced by hydraulic hammers during excavation works at Claremont Meadows services facility and at 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 for around eight months of the construction period.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

Table 10-19 NCA05 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +
SC01 - Enabling works	N/A	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	0 (0)	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	N/A
SC04 - Earthworks and excavation	N/A	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	0 (0)	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	N/A	0 (96)	0 (0)	0 (0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +
SC07 - Rail systems fitout	0 (0)	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	N/A	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	0 (0)	308 (648)	1 (86)	0 (0)	0 (76)	0 (0)	0 (0)	0 (76)	0 (0)	0 (0)	0 (76)	0 (0)	0 (0)

Notes:
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
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).
In NCA05 1051 noise sensitive receivers were assessed.
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA06 (Claremont Meadows, between the Great Western Highway and M4 Western Motorway, west of South Creek)

In NCA06 1,315 noise sensitive receivers were assessed. The predicted NML exceedances within NCA06 are presented in Table 10-20.

During standard construction hours the following potential airborne noise impacts were predicted for NCA06 for residential receivers:

- the most affected receivers are predicted to be located along Doncaster Avenue. Some of the highest impact works occur during:
  - site establishment (Scenario 1) – exceedances of NMLs are a result of the use of concrete saws
  - tunnelling and associated works (Scenario 2) – exceedances of NMLs are a result of the use of hydraulic hammers
  - excavation and earthworks (Scenario 4) – most residential receivers affected with predicted noise levels mostly influenced by the intermittent use of hydraulic hammers during station and portal excavation at Orchard Hills and excavation at Claremont Meadows that would exceed NMLs by up to 28 dB to 33 dB for around eight months of the construction period
  - finishing works (Scenario 9) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers.

Of the residential receivers that are predicted to be affected, impacts are generally 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 (for typical and worst case respectively). Figure 10-7 shows the distribution of NML exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA06.

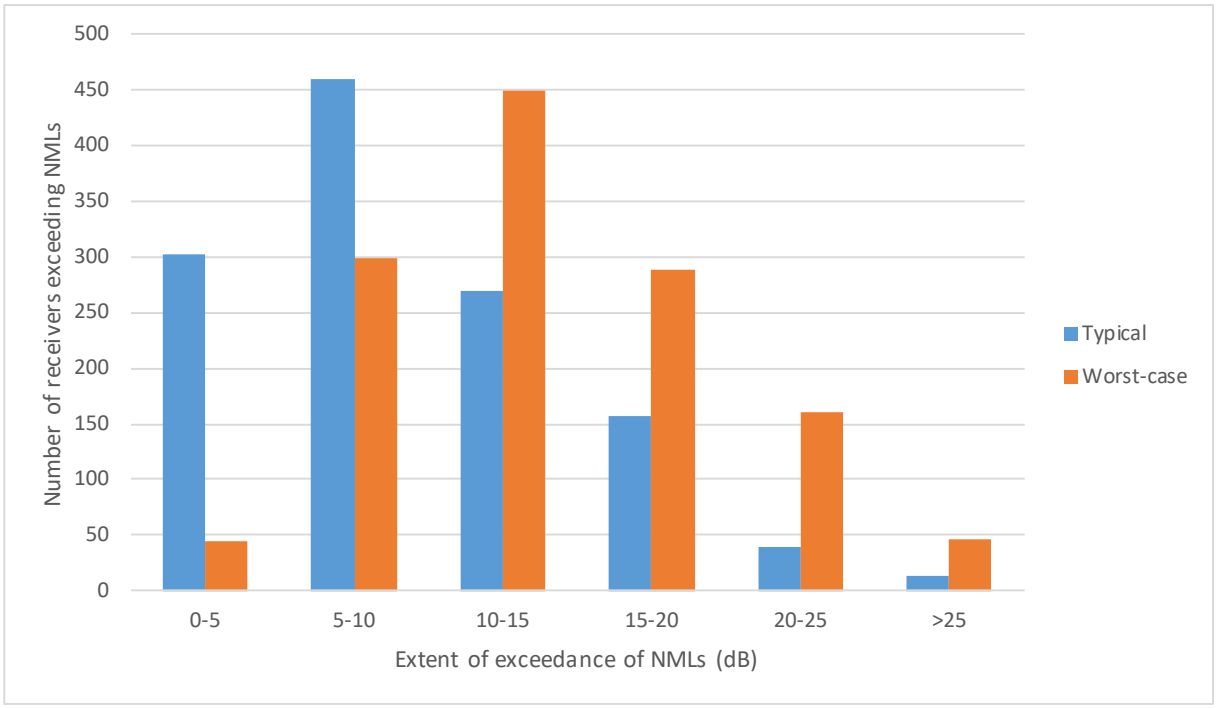


Figure 10-7 NCA06 NML exceedances – standard hours – earthworks and excavation (Scenario 4)

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA06 for residential receivers:

- only experiences exceedances of NMLs during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Key findings are as follows:
    - exceedances of NMLs are a result of operation of the TBM during tunnelling and associated activities, exceeding NMLs by up to 22 dB, and testing and commissioning of the Orchard Hills construction site during finishing works
    - exceedances of sleep disturbance and awakening screening levels by up to 14 dB are predicted to occur during tunnelling and associated works, and finishing works (Scenarios 2 and 9).

During standard construction hours the following potential airborne noise impacts were predicted for NCA06 for non-residential receivers:

- 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). Key findings are as follows:
    - Claremont Meadows Public School is predicted to be mainly affected during excavation and earthworks (Scenario 4)
    - construction noise during Scenario 4 is mainly influenced by hydraulic hammers during excavation works at Claremont Meadows services facility and Orchard Hills, exceeding NMLs by up to 8 to 13 dB.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

Table 10-20 NCA06 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB dB +
SC01 – Enabling works	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	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	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	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	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	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	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	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	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)

Notes: N/A refers to no works for that scenario within that NCA.

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
Shaded 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)
In NCA06 1315 noise sensitive receivers were assessed
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA07 (Orchard Hills, south of the M4 Western Motorway, east of Mamre Road)

In NCA07, 999 noise sensitive receivers were assessed. The predicted NML exceedances within NCA07 are presented in Table 10-21.

During standard construction hours the following potential airborne noise impacts were predicted for NCA07 for residential receivers:

- the most affected receivers are predicted to be located along Mamre Road. Some of the highest impact works occur during:
    - excavation and earthworks (Scenario 4) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers during station and portal excavation at Orchard Hills that would exceed NMLs by up to 7 dB to 12 dB for around eight months of the construction period.

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA07 for residential receivers:

- only experiences exceedances of NMLs during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Key findings are as follows:
    - 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
    - exceedances of NMLs are a result of operation of the TBM during tunnelling and associated activities at the Orchard Hills construction site, exceeding NMLs by up to 7 dB, and testing and commissioning of the Orchard Hills construction site and off-airport corridor during finishing works
    - no exceedances of sleep disturbance and awakening screening levels are predicted to occur.

During standard construction hours the following potential airborne noise impacts were predicted for NCA07 for non-residential receivers:

- exceedances of NMLs are predicted at Banks Public School during excavation and earthworks (Scenario 4). Key findings are as follows:
    - Banks Public School is predicted to be mainly affected during excavation and earthworks (Scenario 4)
    - construction noise during Scenario 4 is mainly influenced by intermittent use of hydraulic hammers during station and portal excavation works at Orchard Hills, exceeding NMLs by up to 7 to 11 dB for around eight months of the construction period.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

The most affected receivers are predicted to be located along Mamre Road. Of the residential receivers that are predicted to be affected, impacts are generally experienced 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 (for typical and worst case respectively). Figure 10-8 shows the distribution of NML exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA07.

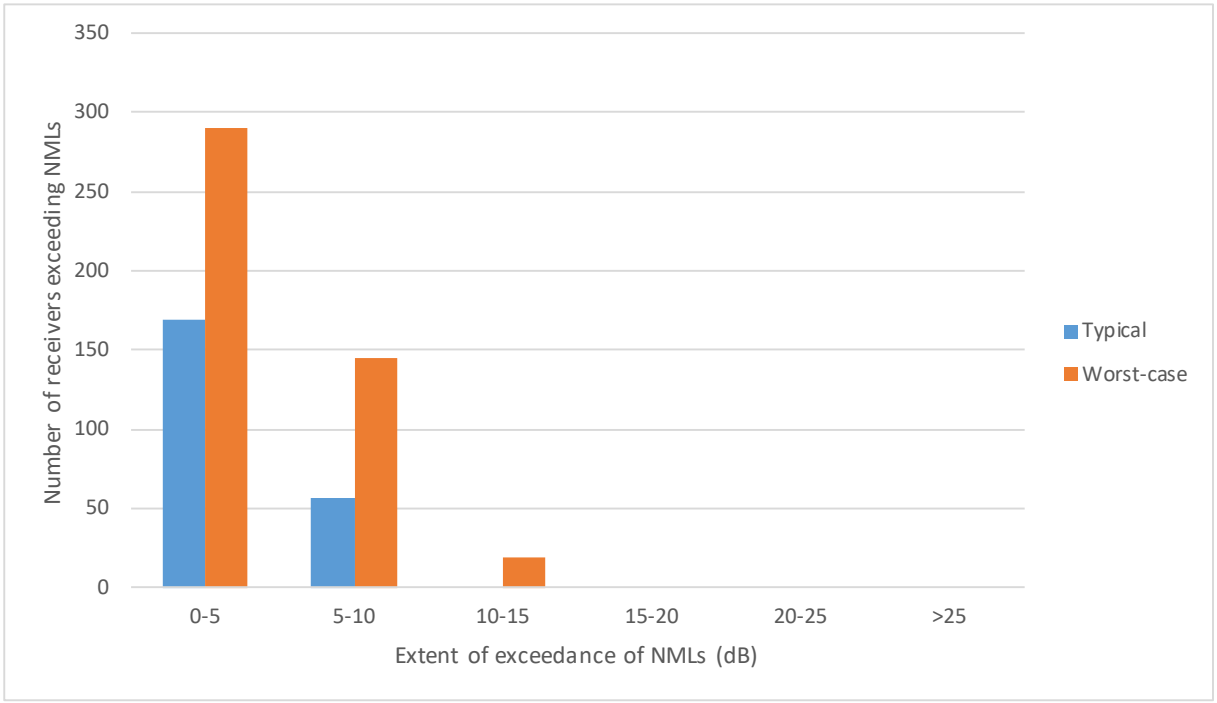


Figure 10-8 NCA07 NML exceedances – standard hours – earthworks and excavation (Scenario 4)

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Table 10-21 NCA07 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC01 - Enabling works	N/A	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	0 (0)	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	N/A	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	N/A	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	N/A	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	N/A	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	0 (0)	78 (231)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC08 - Station fitout, precinct and transport integration works	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
SC09 - Finishing works	0 (0)	78 (259)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	103 (295)	0 (10)	0 (0)

Notes:
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
Shaded 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)
In NCA07 999 noise sensitive receivers were assessed
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA08 (Orchard Hills, south of the M4 Western Motorway, between Mamre Road and Calvers Road)

In NCA08, 229 noise sensitive receivers were assessed. The predicted NML exceedances within NCA08 are presented in Table 10-22.

During standard construction hours the following potential airborne noise impacts were predicted for NCA08 for residential receivers:

- 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 mainly influenced by the use of hydraulic hammers
  - excavation and earthworks (Scenario 4) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers during station and portal excavation at Orchard Hills that would exceed NMLs by up to 26 dB to 29 dB for around eight months of the construction period.

Of the residential receivers that are predicted to be affected. Impacts are generally 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 (for typical and worst case respectively). Figure 10-9 shows the distribution of NML exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA08.

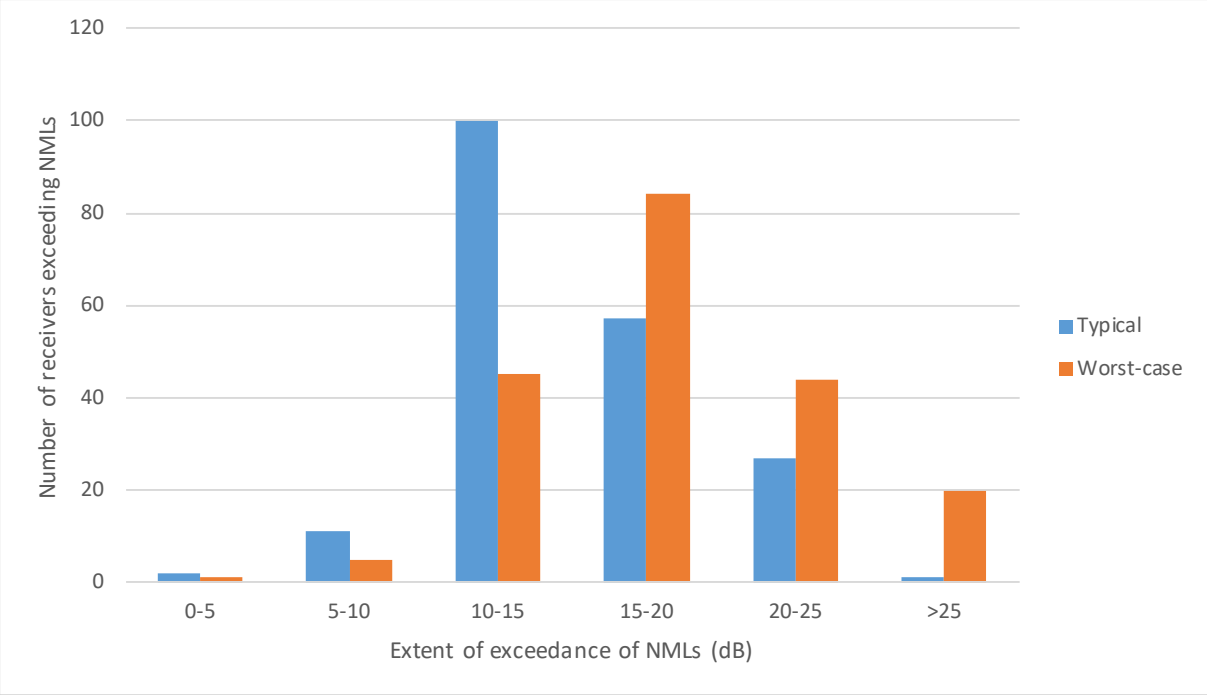


Figure 10-9 NCA08 NML exceedances – standard hours – earthworks and excavation (Scenario 4)

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA08 for residential receivers:

- only experiences exceedances of NMLs during tunnelling and associated works, and finishing works (Scenarios 2 and 9). Key findings are as follow:
    - exceedances of NMLs are a result of operation of the TBM at St Marys during tunnelling and associated works, and finishing works, exceeding NMLs by up to 17dB
    - exceedances of sleep disturbance and awakening screening levels are predicted to occur during tunnelling and associated works, and finishing works (Scenarios 2 and 9), exceeding NMLs by up to 15 dB.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

Table 10-22 NCA08 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC01 - Enabling works	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	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	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	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	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	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	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)

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC08 - Station fitout, precinct and transport integration works	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	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)

Notes:
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
Shaded 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 ws;
Red cells indicate an exceedance of NMLs >20dB for typical construction work
Results in brackets indicate noise level predictions assuming full utilisation of plant (i.e. realistic worst case)
In NCA08 229 noise sensitive receivers were assessed
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA09 (Orchard Hills, generally between Blaxland Creek and the Warragamba to Prospect Water Supply Pipelines)

In NCA09, 68 noise sensitive receivers were assessed. The predicted NML exceedances within NCA09 are presented in Table 10-23.

During standard construction hours the following potential airborne noise impacts were predicted for NCA09 for residential receivers:

- 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 mostly influenced by the use of dozers
  - bridge and viaduct construction (Scenario 3) – exceedances of NMLs are a result of the intermittent use of hydraulic hammers along the off-airport construction corridor, exceeding NMLs by up to 17 dB to 20 dB for around 12 months of the construction period
  - rail systems fitout (Scenario 7) – exceedances of NMLs are a result of the use of concrete vibrators, dozers, and loaders.

These exceedances would be managed through the conventional methods as outlined in the CNVS.

Of the residential receivers that are predicted to be affected, impacts are generally 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 (for typical and worst case respectively). Figure 10-10 shows the distribution of NML exceedances during bridge and viaduct construction (Scenario 3) for residential receivers within NCA09.

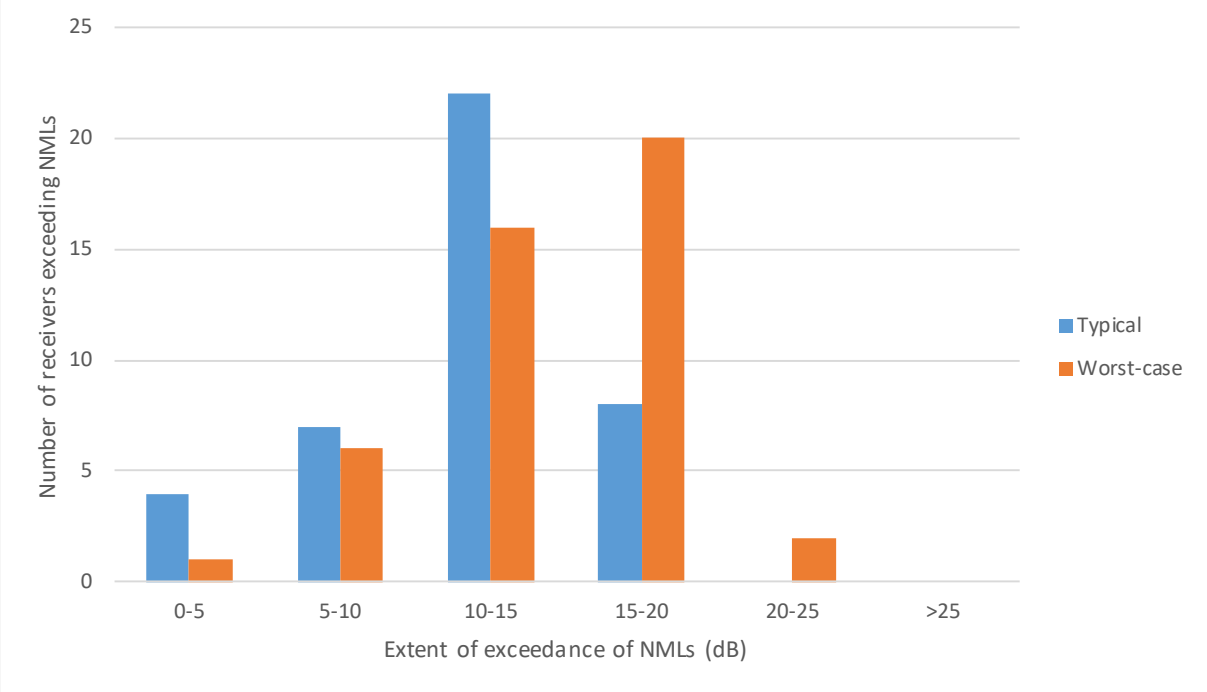


Figure 10-10 NCA09 NML exceedances – standard hours – bridge and viaduct construction (Scenario 3)

Table 10-23 NCA09 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC01 - Enabling works	N/A	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	0 (0)	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	N/A	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	N/A	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	N/A	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	N/A	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	0 (0)	23 (10)	18 (29)	0 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC08 - Station fitout, precinct and transport integration works	N/A	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	0 (0)	28 (12)	13 (29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Notes:
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
Shaded 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).
In NCA09 68 noise sensitive receivers were assessed
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA10 (Luddenham, between the Warragamba to Prospect Water Supply Pipelines and north of Elizabeth Drive)

In NCA10 378 noise sensitive receivers were assessed. The predicted NML exceedances within NCA10 are presented in Table 10-24.

During standard construction hours the following potential airborne noise impacts were predicted for NCA10 for residential receivers:

- 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) – exceedances of NMLs are a result of the use of dozers
  - bridge and viaduct construction (Scenario 3) – most residential receivers affected with predicted noise levels as result of intermittent use of hydraulic hammers along the off-airport construction corridor, exceeding NMLs by up to 20 dB to 25 dB for around 12 months of the construction period
  - earthworks and excavation (Scenario 4) - exceedances of NMLs are a result of the use of dump trucks and graders
  - rail systems fitout (Scenario 7) – exceedances of NMLs are a result of the use of concrete vibrators, dozers, and loaders.

These exceedances would be managed through the conventional methods as outlined in the CNVS.

Of the residential receivers that are predicted to be affected, impacts are generally experienced 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 (for typical and worst case respectively). Figure 10-11 shows the distribution of NML exceedances during bridge and viaduct construction (Scenario 3) for residential receivers within NCA10.

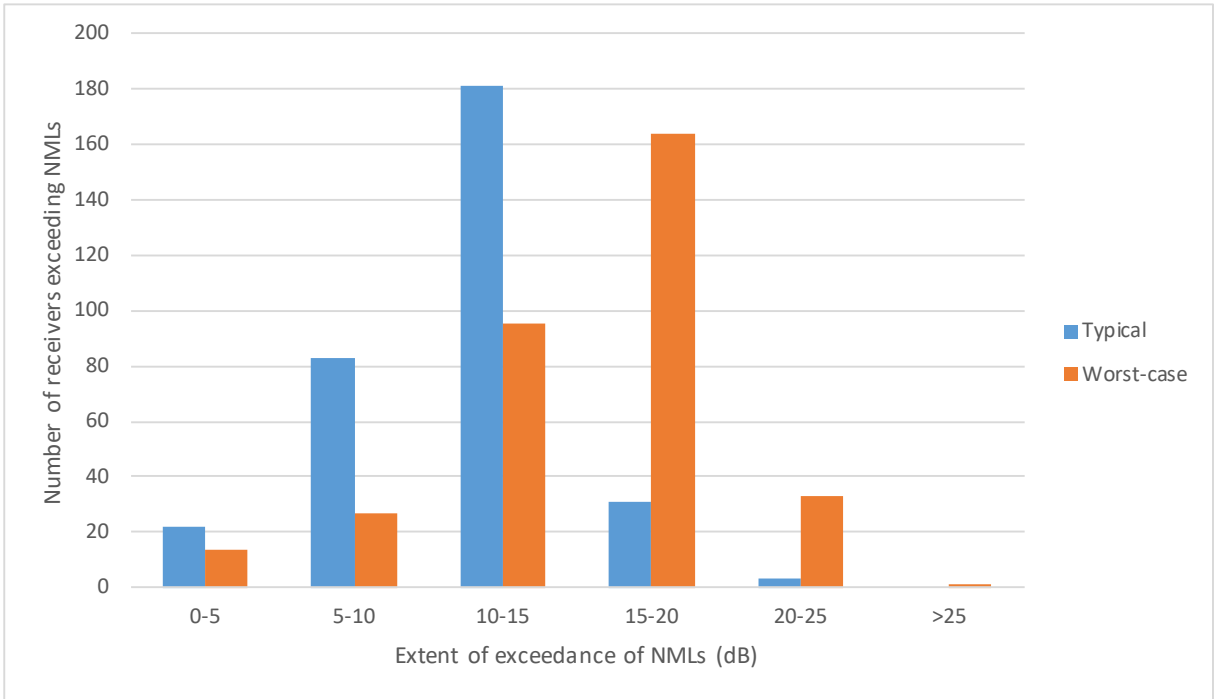


Figure 10-11 NCA10 NML exceedances – standard hours – bridge and viaduct construction (Scenario 3)

Table 10-24 NCA10 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC01 - Enabling works	N/A	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	N/A
SC03 - Bridge and viaduct construction	N/A	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	N/A	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	N/A	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	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
SC07 - Rail systems fitout	N/A	195 (165)	111 (155)	1 (1)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC08 - Station fitout, precinct and transport integration works	N/A	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	N/A	199 (78)	105 (240)	1 (6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
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
Shaded 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).
In NCA10 378 noise sensitive receivers were assessed
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA11 (Badgerys Creek, south of Elizabeth Drive to generally southern boundary of Western Sydney International)

In NCA11, 68 noise sensitive receivers were assessed. The predicted NML exceedances within NCA11 are presented in Table 10-25.

During standard construction hours the following potential airborne noise impacts were predicted for NCA11 for residential receivers:

- the most affected receivers are predicted to be located along Lawson Road. Some of the highest impact works occur during:
    - enabling works (Scenario 1) – exceedances of NMLs are a result of the use of dozers
    - bridge and viaduct works (Scenario 3) – exceedances of NMLs are a result of the use of hydraulic hammers
    - earthworks and excavation (Scenario 4) – exceedances of NMLs are a result of the use of graders, dump trucks and dozers during rail embankment cut works along the on-airport construction corridor that would exceed NMLs by up to 13 dB to 18 dB for around 12 months of the construction period
    - finishing works (Scenario 9) – exceedances of NMLs are a result of the use of dump trucks and dozers.

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA11 for residential receivers:

- only experiences exceedances of NMLs during finishing works (Scenarios 2 and 9). Key findings are as follows:
    - exceedances of NMLs are a result of periodic operation heavy vehicle movements during testing and commissioning at the Bringelly services facility for around 12 months, exceeding NMLs by up to 3 dB to 16 dB
    - exceedances of sleep disturbance and awakening screening levels are predicted to occur during finishing works (Scenario 9), exceeding NMLs by up to 6 dB.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

Table 10-25 NCA11 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
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)

Notes:
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
Shaded 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).
In NCA11 68 noise sensitive receivers were assessed
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

NCA12 (Bringelly, generally south of the boundary of Western Sydney International to Bringelly Road)

In NCA12, 396 noise sensitive receivers were assessed. The predicted NML exceedances within NCA12 are presented in Table 10-26.

During standard construction hours the following potential airborne noise impacts were predicted for NCA12 for residential receivers:

- the most affected receivers are predicted to be located along Badgerys Creek Road and the northern section Dawson Road. Some of the highest impact works occur during:
    - enabling works (Scenario 1) – exceedances of NMLs are a result of the use of dozers
    - earthworks and excavation (Scenario 4) – residential receivers affected with predicted noise levels are most influenced as a result of the use of hydraulic hammers during station excavation works at the Aerotropolis Core Station, and excavation at the Bringelly services facility that would exceed NMLs by up to 23 dB to 29 dB for around eight months of the construction period
    - station construction (Scenario 5) – exceedances of NMLs are a result of the use of hydraulic hammers and concrete saws at Aerotropolis Core Station
    - station fitout, precinct and transport integration works (Scenario 8) – exceedances of NMLs are a result of the use of multiple mobile cranes at Bringelly services facility and Aerotropolis Core Station.

During out-of-hours construction works the following potential airborne noise impacts were predicted for NCA12 for residential receivers:

- only experiences exceedances of NMLs during finishing works (Scenario 9). Key findings are as follows:
    - exceedances of NMLs are a result of heavy vehicle movements during testing and commissioning at the Bringelly services facility and Aerotropolis Core Station, exceeding NMLs by up to 11 to 21 dB
    - exceedances of sleep disturbance and awakening screening levels are predicted to occur during finishing works (Scenario 9), exceeding NMLs by up to 14 dB.

Of the residential receivers that are predicted to be affected, impacts are generally experienced during excavation and earthworks (Scenario 4). The highest construction noise during this scenario would be as 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 (for typical and worst case respectively). Figure 10-12 shows the distribution of exceedances during excavation and earthworks (Scenario 4) for residential receivers within NCA12.

These exceedances would be managed through the conventional methods 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 per cent to 50 per cent.

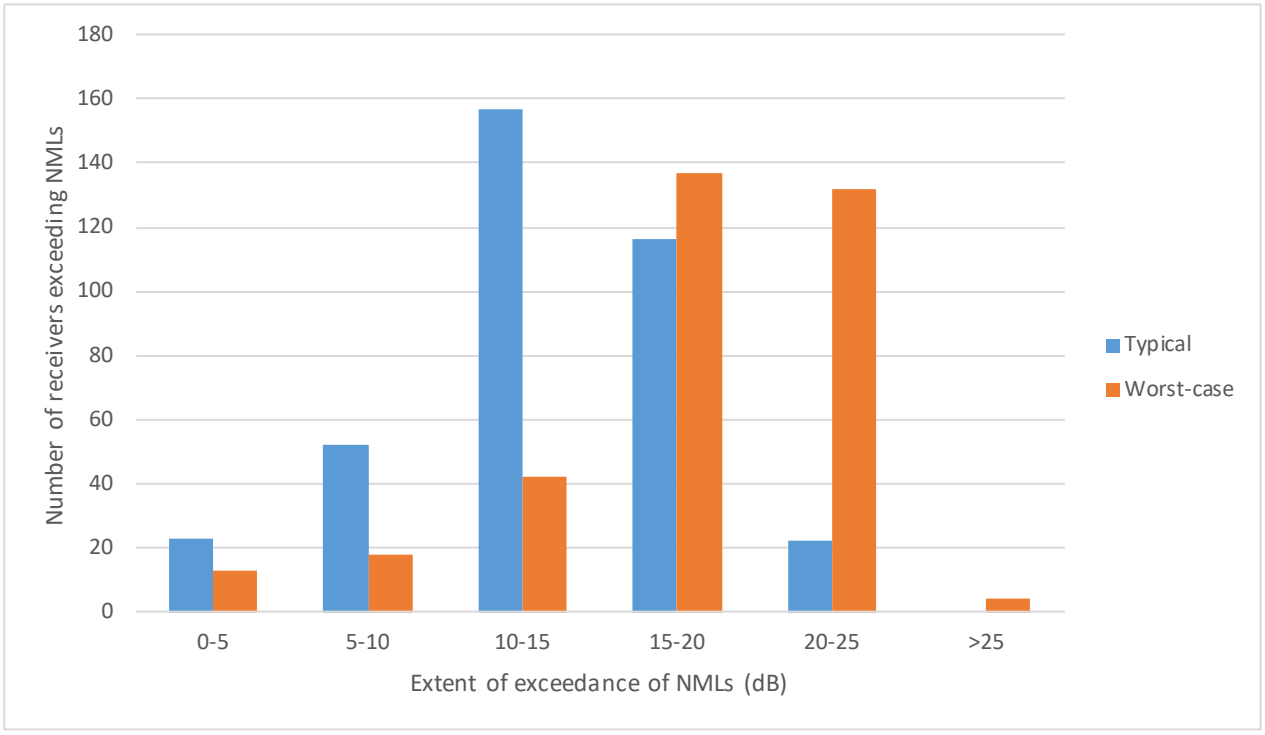


Figure 10-12 NCA12 NML exceedances – standard hours – earthworks and excavation

Table 10-26 NCA12 – overview of NML exceedances at residential receivers – typical and worst case

Activity	Exceedances of sleep 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 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB +	0-10 dB	10-20 dB	20 dB+
SC01 - Enabling works	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	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	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	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	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	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	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	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	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)

Notes:
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
Shaded 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).
In NCA12 396 noise sensitive receivers were assessed
N/A refers to no works for that scenario within that NCA.
Where more exceedances of NMLs are predicted in an exceedance range (e.g. 0-10 dB) 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.

A limited number of receivers in NCA10, NCA11 and NCA12 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 2 dBA higher than the highest noise level. Only a small number of receivers are likely to experience cumulative impacts and for limited periods of time when the highest noise generating construction activities in each area are occurring simultaneously.

Ground-borne noise (tunnelling works)

Ground-borne noise predictions for all noise sensitive receivers adjacent to the tunnelling construction works are presented in Figure 4.6 and Figure 4.7 of Technical Paper 2 (Noise and vibration) for the St Marys to Orchard Hills and Western Sydney International to Bringelly tunnels respectively.

The ground-borne noise results indicate that for a number of noise sensitive receivers along the tunnel alignment, the levels may exceed management levels (between around five dB and 20 dB), however these exceedances would be for a relatively short duration. It is predicted that up to 38 receivers may exceed the ICNG residential night management level 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 would be different depending on its horizontal and vertical offset from the alignment and the rate of travel of the TBM. The duration of exposure also depends on the time that the cutting heads of the TBM are operational.

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, noting that for much of the length of the two proposed tunnel sections, the depths would be greater than this - typically between 25 and 40 metres below ground level). The potential duration of exposure for noise sensitive receivers, for the case where the TBM rate of progression is around 95 metres per week are summarised in Table 10-27.

Table 10-27 Estimated duration of impacts from tunnel boring machines

Horizontal offset of buildings from tunnel based on 15 metre tunnel depth	Estimated duration of exposure above ground-borne noise targets
0 to 15 metres	Three to four nights
15 to 25 metres	Two to three nights
25 to 35 metres	One to two nights
35 to 40 metres	Zero to one night
Greater than 40 metres	Low probability of adverse impacts

Vibration (surface works)

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 be greater than the vibration guidelines. Table 4-28 of Technical Paper 2 (Noise and vibration) presents the vibration intensive equipment (and associated minimum working distances) for the proposed surface works.

The St Marys Railway Station Group (including the goods shed, jib crane, and station building) and McGarvie-Smith Farm (central cluster of buildings) heritage receivers 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 during the construction work. It is noted that two buildings of high

significance in the western cluster of buildings on McGarvie-Smith Farm would not be adversely impacted by vibration due to construction of the project. The Queen Street, Post-War Commercial Building and 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.

The Warragamba to Prospect Water Supply Pipelines, located within the construction footprint, has been identified as a heritage receiver and a critical infrastructure item for Sydney. The construction contractor would be responsible for liaising with the asset owner to determine acceptable vibration criteria. The associated impacts would be verified at this stage to inform any potential reasonable and feasible mitigation options.

Where works occur within minimum safe working distances, reasonable and feasible mitigation would be considered in line with the CNVS.

Vibration (tunnelling works)

The vibration levels are predicted for each sensitive receiver and are presented in Figure 4-51 and Figure 4-52 of Technical Paper 2 (Noise and vibration) 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.

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 are predicted to exceed the maximum vibration level targets. These receivers are all located on Camira Street, St Marys.

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 are located along Derwent Road and Badgerys Creek Road, Bringelly.

While there are some exceedances of ground-borne vibration trigger levels 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 at the existing St Marys Station which would be near tunnelling works. The predicted vibration levels for these buildings are provided in Table 10-28.

Table 10-28 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
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

Note 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 millimetres per second for framed/reinforced structures, and five millimetres per second for light unframed structures. However, if the buildings are categorised as structurally unsound, then a more stringent criterion of 2.5 millimetres per second 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.

Road traffic noise

The forecast peak construction year (2023/2024) traffic volumes were compared to limiting noise criteria for each period and used to predict the relative increase of road traffic noise on affected roads as a result of project related construction traffic volumes, with respect to the nearest identified receiver.

The results of the assessment are presented in Table 4-30 of Technical Paper 2 (Noise and vibration). The assessment indicates that construction road traffic noise levels are not predicted to exceed relevant RNP noise criteria at the majority of project affected roads. Based on the assessment, it is considered that 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 the M4 Western Motorway) and Badgerys Creek Road (between The Northern Road and Western Sydney International).

At Kent Road, construction traffic noise levels of up to 58 dBA are predicted during the night period (10pm to 7am), exceeding the RNP criterion by three dBA, and resulting in a relative increase of 3.8 dBA, exceeding the screening criteria of 2 dBA. Exceedances are expected to occur at all residential receivers located within 40 metres of Kent Road, resulting in around five residential properties with predicted noise levels above criteria 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 60 metres of Badgerys Creek Road, resulting in 31 residential properties exceeding criteria levels. This is a conservative assessment for Badgerys Creek Road based on the assumption that all spoil from within the Western Sydney International would be taken to external disposal locations. If the permanent 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 (see Section 10.7).

10.5.2 On-airport

Airborne noise

The predicted noise levels for each of the nine construction work scenarios for on-airport works is presented in Section 4.3.4 and Appendix B.3 of Technical Paper 2 (Noise and vibration). Maps showing the predicted noise level for residential receivers for on-airport works within the study area are presented in Appendix B of Technical Paper 2 (Noise and vibration).

The predicted noise levels for on-airport works show that no on-airport and off-airport sensitive receivers are predicted to experience noise levels that exceed the Airports Regulations specified noise limits. Limits outlined in the Airports Regulations generally align with highly noise affected NMLs (applicable during standard hours) as outlined in the ICNG. No receivers have been identified as highly noise affected within Western Sydney International.

Table 10-29 outlines the highest noise level experienced at a residential receiver in each NCA based on ICNG levels for on-airport construction works. NCA10 is located north of the airport site, NCA11 includes the airport site and areas immediately to the east and west and NCA12 is predominantly located south of the airport site. NCA10 and NCA12 are considered in this section as receivers are adjacent to the Western Sydney International and may be impacted by on-airport works.

The predicted noise levels are representative of the ‘typical’ expected noise levels. The predicted noise levels representative of the ‘worst case’ expected noise levels are presented in brackets in Table 10-29.

Table 10-29 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)

Notes:
ICNG standard hours includes Monday to Friday 7am to 6pm and Saturday 80am 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
Shaded 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)
N/A refers to no works for that scenario within that NCA.

During standard hours, NCA10, NCA11 and 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.

NCA10 (Luddenham, between the Warragamba to Prospect Water Supply Pipelines and north of Elizabeth Drive)

The following potential airborne noise levels were predicted for NCA10:

- during standard hours, residential receivers are predicted to be most affected along Elizabeth Drive by earthworks and excavation works (Scenario 4). Predicted noise levels are most influenced by excavators during rail embankment works along the on-airport construction corridor, and hydraulic hammers at the Airport business park, exceeding NMLs by up to 18 dB to 23 dB. These excavators may be used over a period of around 12 months, and hydraulic hammers may be used over a period of around six months
- during out-of-hours works, residential receivers are predicted to be most affected by tunnelling and associated works, bridge and viaduct construction, rail fitout works, and finishing works (Scenarios 2, 3, 7 and 9). Predicted noise levels are most influenced by concrete vibrators during tunnelling and associated works (Scenario 2), exceeding NMLs by up to 19 to 24 dB. These 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 a result of use of the concrete batch plant, exceeding NMLs by up to 7 dB.

NCA11 (Badgerys Creek, south of Elizabeth Drive to generally southern boundary of Western Sydney International)

The following potential airborne noise levels were predicted for NCA11:

- during standard hours, residential receivers are predicted to be most affected along Lawson Road. Predicted noise levels are most influenced by excavators during rail embankment works along the on-airport construction corridor, and hydraulic hammers at the Airport Business Park, exceeding NMLs by up to 16 dB to 20 dB. These excavators may be used over a period of around 12 months, and hydraulic hammers may be used over a period of around six months
- during out-of-hours works, residential receivers are predicted to be most affected by tunnelling and associated works, bridge and viaduct construction, rail fitout works, and finishing works (Scenarios 2, 3, 7 and 9). Predicted noise levels are associated with the operation of the tunnel segment during tunnelling and associated activities and bridge and viaduct works, trackwork and overhead wiring at the Airport business park during rail systems fitout works, and testing and commissioning of the on-airport corridor
- 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 a result of use of the concrete batch plant, exceeding NMLs by up to 14 dB.

NCA12 (Bringelly, generally south of the boundary of Western Sydney International to Bringelly Road)

The following potential airborne noise levels were predicted for NCA12:

- during standard hours, residential receivers are predicted to be most affected along Derwent Road and Mersey Road, Bringelly by enabling works (Scenario 1). Predicted noise levels are mostly influenced by the operation of dozers during site establishment, exceeding NMLs by up to 11 dB to 24 dB. These dozers may be used over a period of around 18 months
- during out-of-hours works, residential receivers are predicted to be most affected by tunnelling and associated works (Scenario 2). Predicted noise levels are mostly influenced by the use of dozers, exceeding NMLs by up to 20 to 21 dB. 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 a result of use of dozers, exceeding NMLs by up to 3 dB.

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 2 dBA higher than the highest noise level. Only a small number of receivers are likely to experience cumulative impacts and for limited periods of time when the highest noise generating construction activities in each area are occurring simultaneously.

Noise and vibration impacts and mitigation would be managed through the conventional methods as outlined in the CNVS.

Ground-borne noise and vibration

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 one 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 three to four 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.

10.6 Potential impacts – operation

10.6.1 Off-airport

Rail noise

The operational rail noise levels are predicted to be less than the relevant RING noise trigger levels at all existing 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 of Technical Paper 2 (Noise and vibration) to indicate where noise levels greater than the trigger levels may occur.

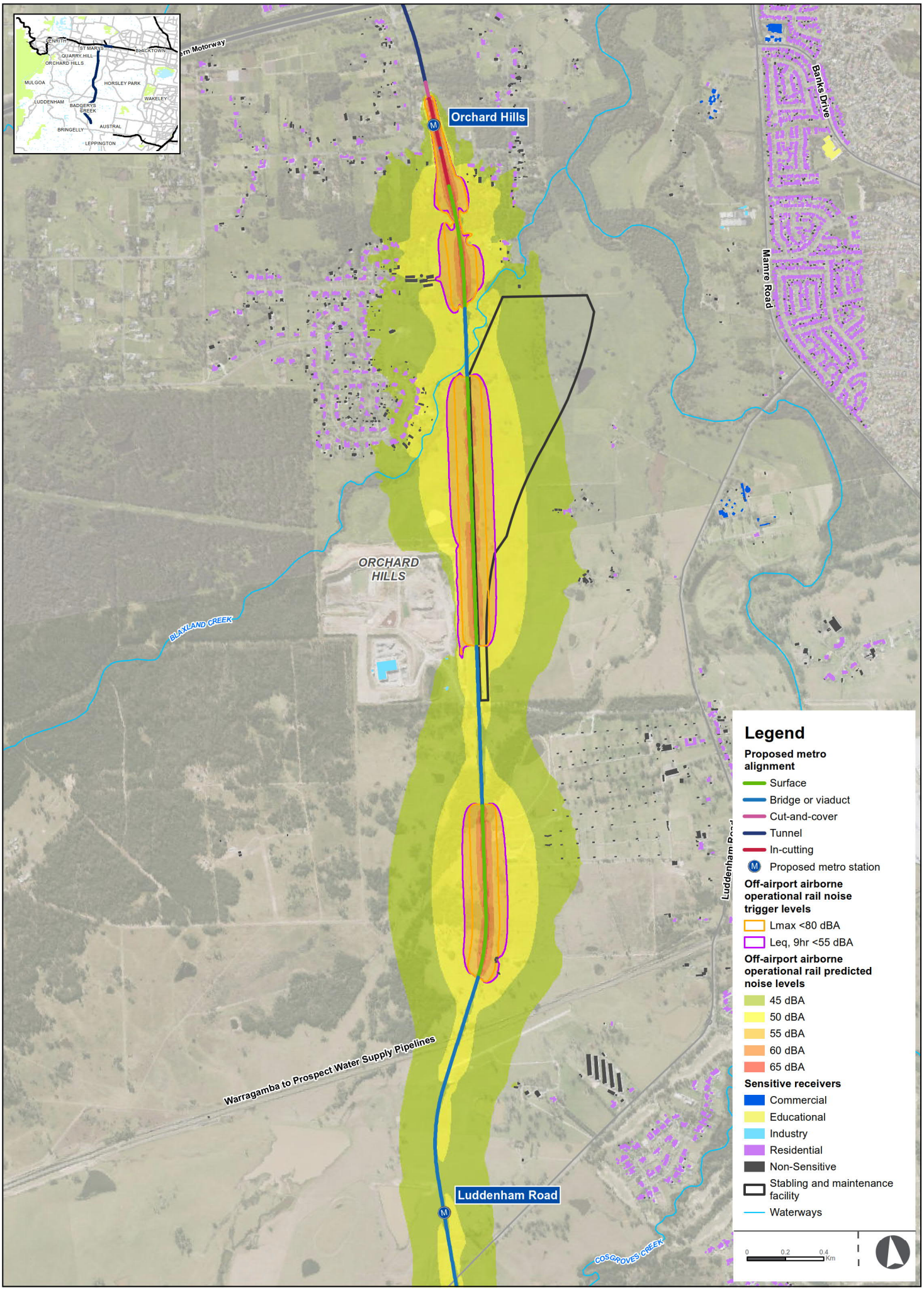
The worst affected receivers are predicted to occur in NCA08 around the Orchard Hills tunnel portal, however these receivers are not expected to exceed the relevant criteria. Noise levels at these locations are predicted to be:

- 53 dBA $L_{eq,15\ hr}$ (during daytime periods) on opening
- 50 dBA $L_{eq,9\ hr}$ (during night-time periods) on opening.

There is predicted to be an approximate dB increase in L_{eq} noise levels, during both daytime and night-time, at the most affected sensitive receivers between opening year (2026) and ultimate year (2036). However, these levels are expected to be below RING noise trigger levels.

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 design years; attributable to the change from a three-car to four-car train set.

Figure 10-13 outlines where compliance with the RING noise trigger levels occur for ultimate year (2036) operations against night time criteria that exhibits worst case impact. As shown, no sensitive receivers are predicted to experience airborne noise levels that exceed these trigger levels.

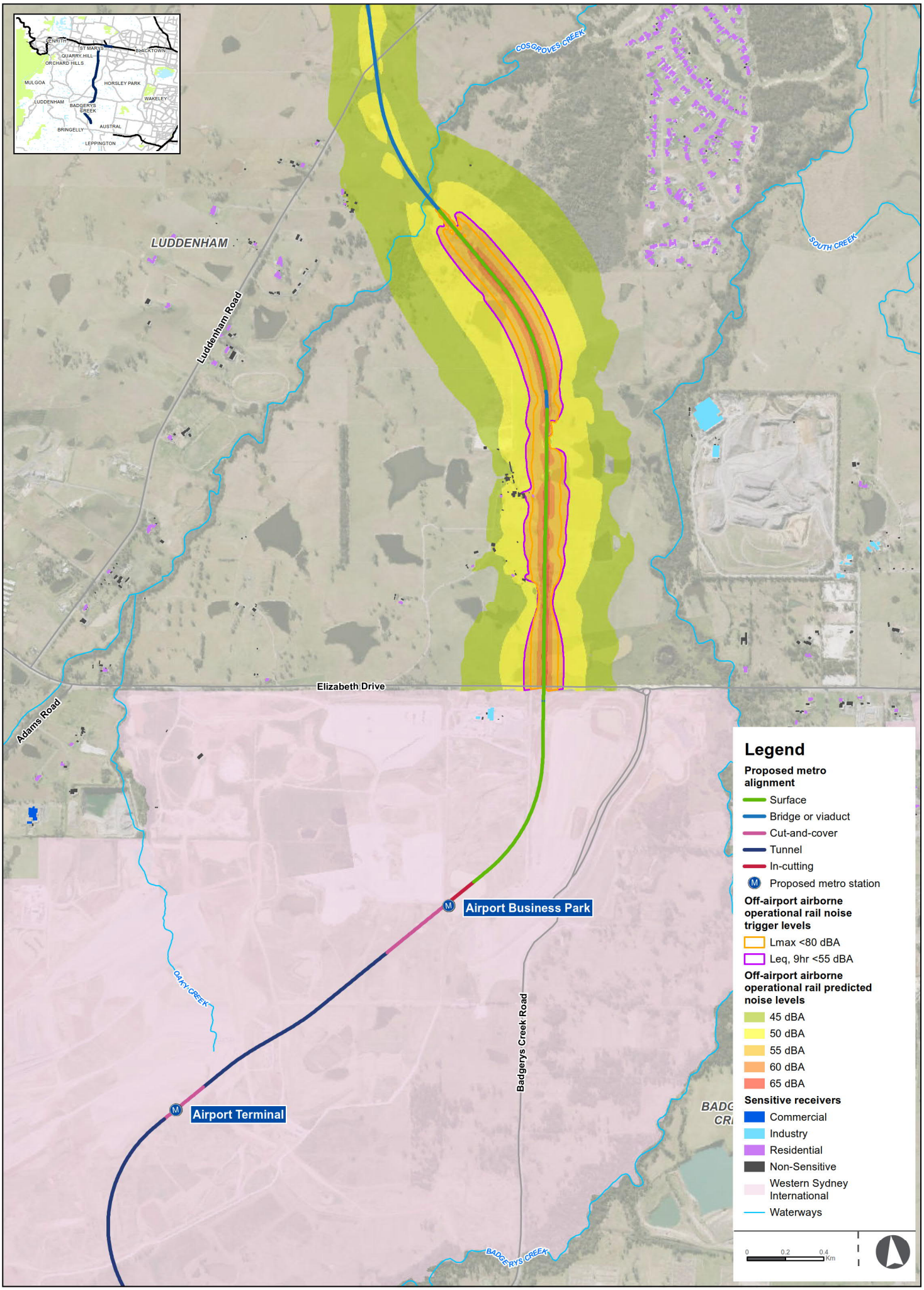


Sydney Metro – Western Sydney Airport

Off-airport – ultimate year (2036) operational rail noise impact – night

Figure 10-13a

Indicative only, subject to design development



Sydney Metro – Western Sydney Airport

Off-airport – ultimate year (2036) operational rail noise impact – night

Figure 10-13b

Indicative only, subject to design development

Noise from stations and ancillary facilities

Mechanical and electrical plant at stations

The assessment of mechanical and electrical plant has been completed using typical fixed facility noise levels at each off-airport station and assessed with PNTL (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 10-30.

Table 10-30 Predicted fixed facilities noise levels and project noise trigger levels for stations fixed facilities

Station	Nearest receiver type	Nearest receiver address	Project Noise Trigger Levels (PNTL) dBA[1]	Predicted Noise Levels, dBA
St Marys	Residential	3 Station Street	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 Road	39	30

Notes:
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 be less than relevant PNTL at the nearest receivers to all stations except St Marys. Minor exceedances of the PNTL are predicted at the nearest receivers to the St Marys underground ventilation shafts.

Mechanical and electrical plant – service facilities

The assessment of mechanical and electrical plant at the services facilities has been completed with reference to operational noise sources identified Section 5.8 of Technical Paper 2 (Noise and Vibration), whereby surface mechanical plant or tunnel ventilation components are not required. The sound power levels (SWLs) in Table 10-31 present the maximum allowable sound power levels from remaining noise sources that would be lower than the PNTL, at the identified receivers. Provided mechanical and electrical plant used for service facilities is equal to or below the SWL in Table 10-31 then the PNTL would not be exceeded.

Table 10-31 Maximum allowable mechanical and electrical plant noise – service facilities

Station	Element[1]	Sound Power Level, dBA
Claremont Meadows services facility	Miscellaneous plant (if required)	85
Bringelly services facility	Water treatment plant	85

Notes:
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.

Ventilation shafts

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.

Noise from stabling and maintenance facility

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 of Technical Paper 2 (Noise and Vibration). In addition, worst case assumptions of noise-enhancing weather conditions (temperature inversions or wind-enhancing winds) have been adopted as part of this assessment.

Noise levels from the stabling and maintenance facility are generally predicted to be less than PNTL for all scenarios, with the exception of the nearest residences in NCA08 closest to the stabling and maintenance facility boundary. It is noted that background noise levels at receivers in NCA08 are quite low, due to the largely rural background noise environment resulting in quite stringent noise limits at receivers in these areas.

The assessed noise levels from the unmitigated operation of the stabling and maintenance facility for NCA08 are summarised as follows:

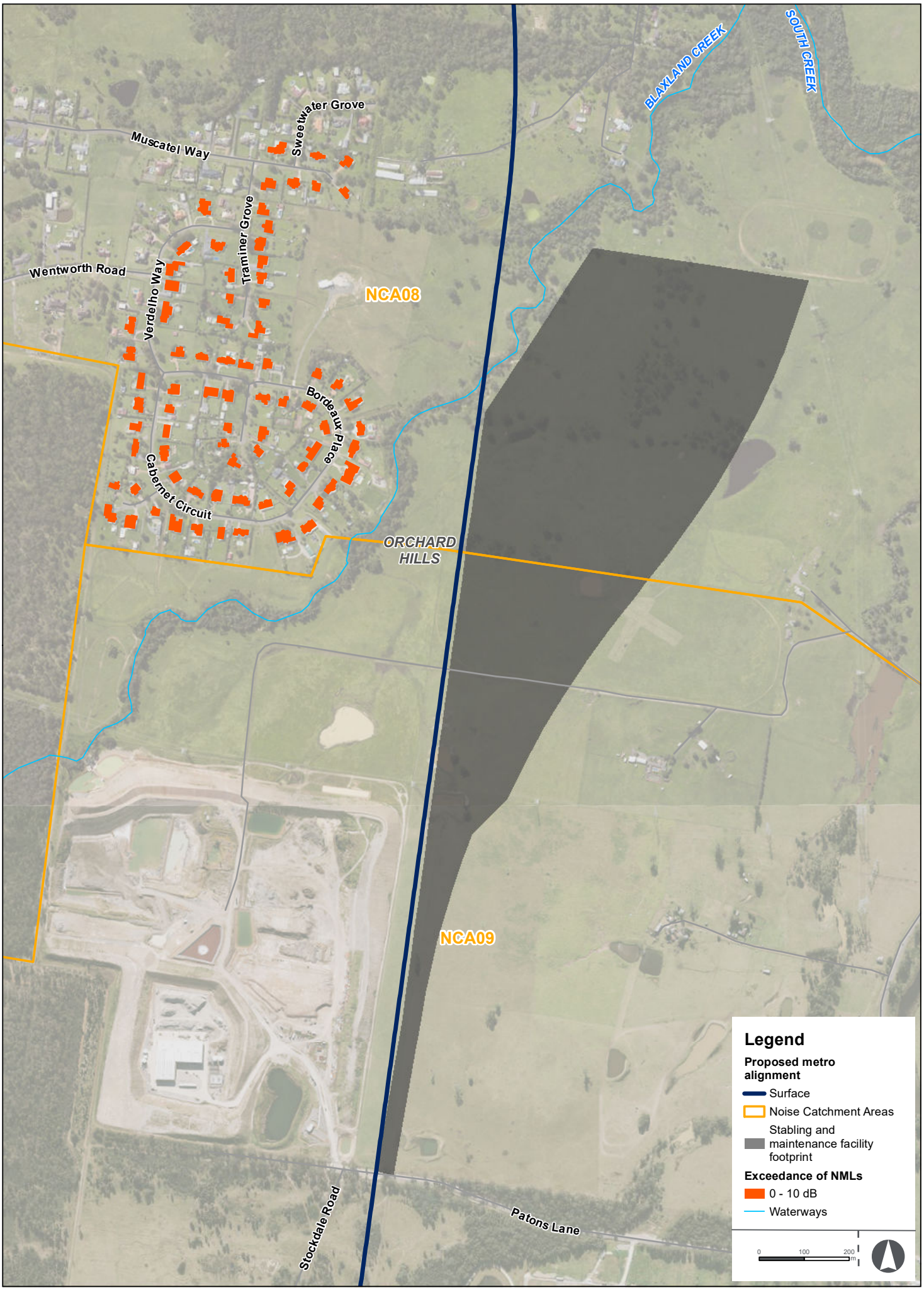
- Scenarios 1 and 6 - Morning shoulder (5am to 7am). Operational noise levels are predicted to exceed relevant trigger levels by up to 7 dBA at the nearest receivers at opening year, increasing to 8 dBA at under ultimate year conditions
- Scenarios 2 and 7 - Daytime period (7am to 6pm). Predicted noise 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 10-13).

The most effective method for managing noise impacts at receivers would be to mitigate the noise (i.e. air compressors, air conditioning and static converters) at source. Other measures such as introduction of shielding through site reconfiguration or construction of a noise barrier between source and receiver would be considered as part of design development. These measures are discussed in Chapter 7 of Technical Paper 2 (Noise and Vibration), and mitigation measures to ensure compliance with relevant criteria during typical operations are presented in Section 10.7.2.

Potential sleep disturbance and awakening 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. The predicted noise levels would not exceed relevant sleep disturbance and awakening criteria at the nearest residential receivers within NCA07, NCA08 and NCA09. 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 limits on noise generating stabling operations (including exact number of brake release activities) would be further investigated during design development.

Figure 10-14 presents the locations of the residences predicted to experience noise levels above the PNTL in NCA08 for the most stringent night time period during the ultimate year of operations (2036).



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Stabling and maintenance facility operational noise impact

Figure 10-14

Indicative only, subject to design development

Mitigation measures to ensure compliance with performance outcomes (as detailed in Section 10.7.1) and relevant criteria during operation would be further investigated during design development. 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 associated with the Western Sydney Aerotropolis and broader Western Parkland City on background noise levels when determining feasible and reasonable mitigation.

Ground-borne noise

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 the study area and assessed for operational ground-borne noise and vibration.

The St Marys to Orchard Hills tunnel has a far greater number of noise sensitive receivers near the rail alignment (within 50 metres) compared to the Western Sydney International to Bringelly tunnel. Up to 12 residential receivers are predicted to experience noise levels higher than the PNTL at the northern end of the St Marys to Orchard Hills tunnel adjacent to St Marys Station (assuming a standard attenuation trackform). This can be attributed to the proximity of buildings to the rail alignment.

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

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

Vibration

Estimated VDV predictions indicate that all buildings assessed are below the preferred VDV values.

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 estimated VDVs are below the preferred values by a substantial margin for most buildings. This does not mean that individual events (train pass-bys) would not be perceived by some receivers.

Road traffic noise

Project related vehicle movements have the potential to generate noise impacts at the nearest sensitive receivers once stations and associated infrastructure are operational. A summary of predicted noise levels from operational road traffic on sub arterial, arterial and local roads for ultimate year (2036) is presented below:

- all new roads built as part of the project are expected to comply with the RNP criteria
- multiple sub-arterial and arterial roads are predicted to exceed the RNP criteria without operation of the project. The assessment has occurred in accordance with RNP and upon consideration of reasonable and feasible noise mitigation it has been shown that there is a less than two dB increase which complies with targets and therefore no specific road traffic noise mitigation is proposed.

Due to the limited operational road traffic noise impacts generated by the project, additional changes to road design, traffic management, quieter pavement or barriers/mounds are not considered reasonable (see in Section 5.9 of Technical Paper 2 (Noise and vibration)).

10.6.2 On-airport

Rail noise

Noise levels at on-airport noise sensitive receivers are not 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 as part of the Airport Business Park. Roads are proposed to run either side of the rail alignment, providing some setback between the commercial receivers and the rail alignment.

Figure 10-15 outlines where compliance with the Airports Regulations criteria occurs for ultimate year (2036) operations at night time. No exceedances of the on-airport criteria are expected at the proposed commercial receivers for buildings set back at least 50 metres from the alignment for the opening year and ultimate year $L_{eq,24hr}$ and L_{max}, and opening year $L_{eq,8hr}$. The ultimate year $L_{eq,8hr}$ predominantly shows exceedances along the eastern side of the alignment within Western Sydney International, up to 75 metres from the alignment.

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 is not expected to impact occupants of buildings located between 50 and 75 metres of the eastern side of the alignment within the Western Sydney International.

Further to this, commercial buildings constructed within close proximity to an airport would be designed to mitigate aircraft noise, which would dominate the operational noise environment. It is expected that any buildings designed to mitigate aircraft noise would render rail noise impacts negligible when assessed at an internal location within the building.

Noise from stations and ancillary facilities

Mechanical and electrical plant

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 10-32.

Table 10-32 Maximum allowable mechanical and electrical plant noise – on-airport stations and service facilities

Station	Element[1]	Sound Power Level, dBA
Airport Business Park Station	Station, including substation	86
Airport Terminal Station	Station, including substation	99

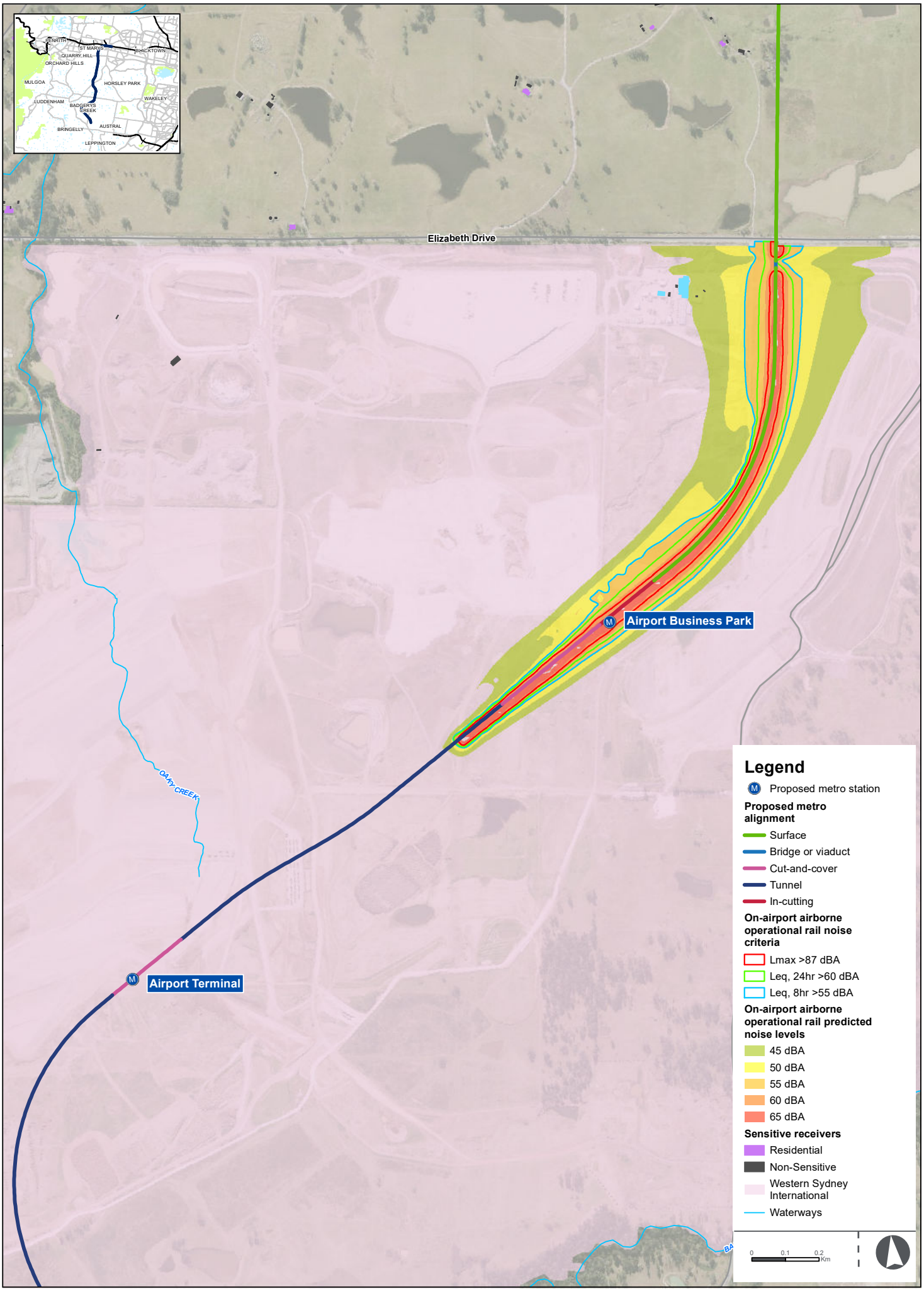
Note 1:
Services below ground not assumed to contribute to above ground noise levels at sensitive receivers. Public address systems and communications not assumed to contribute to noise levels at sensitive receivers.

The design of mechanical and electrical plant has not been finalised at this stage of the assessment and is subject to change. Provided mechanical and electrical plant used for service facilities is equal to or below the SWL in Table 10-31 then the PNTL would not be exceeded.

Ground-borne noise and vibration

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 L_{Smax} with standard attenuation track, and the VDV is predicted to be 0.02 $m/s^{1.75}$.



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On-airport – ultimate year (2036) operational rail noise impact – night

Figure 10-15

Indicative only, subject to design development

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 L_{Smax}. The VDV values are predicted to be in the range of 0.02 – 0.05 $m/s^{1.75}$.

Given there are no objective ground-borne noise criteria provided for the 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 L_{Smax} would be acceptable for the Air Traffic Control Tower, and up to 45 dBA L_{Smax} 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 0.1 $m/s^{1.75}$ for critical areas such as operating theatres and precision laboratories (see Section 10.3.11). 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.

10.7 Proposed management and mitigation measures

Environmental management for the project would be undertaken through an environmental management approach as detailed in Chapter 25 (Environmental management and mitigation). The construction and operational environmental management frameworks are discussed in Section 25.2 and 25.3 respectively.

Under these broad frameworks, a series of performance outcomes have been developed to define the minimum environmental standards that would be achieved during construction and operation (detailed in Section 10.7.1), and mitigation measures that would be applied during construction and operation to support manage identified impacts (detailed in Section 10.7.2).

10.7.1 Performance outcomes

Performance outcomes have been developed consistent with the requirements of the SEARs for the project. Performance outcomes for noise and vibration for the project are listed in Table 10-33 and identify measurable, performance-based standards for environmental management.

Table 10-33 Performance outcomes – noise and vibration

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 Regulations.	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 Regulations.	Operation

SEARs desired performance outcome	Project performance outcome	Timing
	Operational noise levels for the stabling and maintenance facility, stations and other fixed infrastructure are managed in accordance with the NPI.	

10.7.2 Mitigation measures

A CEMF 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 CEMPs, sub-plans, and other supporting documentation for each specific environmental aspect.

The CNVMP is a specific sub-plan from the CEMF that would be developed. Preparation of the CNVMP would incorporate, as a minimum, the standard mitigation measures provided in the CNVS.

The Noise and Vibration CEMP for the on-airport works would be developed in consultation with Western Sydney Airport and would be consistent with the existing Western Sydney Airport Noise and Vibration Construction Environmental Management Plan.

In addition to the standard mitigation measures outlined in the CNVS and future CNVMP, project specific mitigation measures have been identified in Table 10-34.

Table 10-34 Mitigation measures – noise and vibration

Ref	Proposed mitigation measure	Applicable location(s)
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:	Off-airport construction corridor

Ref	Proposed mitigation measure	Applicable location(s)
	• 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	
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

10.7.3 Consideration of the interaction between measures

Mitigation measures in other chapters that are relevant to the management of potential noise and vibration impacts include:

- Chapter 9 (Transport), specifically measures which address potential road traffic noise impacts during construction and operation
- Chapter 12 (Non-Aboriginal heritage), specifically measures which address the management of potential vibration impacts to heritage items within the vicinity of the project during construction.

Together, these measures would minimise the potential noise and vibration impacts of the project.

There are no mitigation measures identified in the assessment of other environmental aspects that are likely to affect the assessment of noise and vibration impacts.