BOTANY RAIL DUPLICATION

Technical Report 2 - Noise and Vibration Technical Report
Construction and Operation

Prepared for:

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BASIS OF REPORT

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Glossary and Abbreviations

Item	Description / Definition
AADT	Annual Average Daily Traffic
ARTC	Australian Rail Track Corporation (the proponent)
Attended noise monitoring	Operator attended noise monitoring which is completed to determine the various contributors to the noise environment of an area. It is usually done over a short period, such as 15 minutes.
At-property treatments	Acoustic treatment of individual properties used to mitigate internal noise levels. Individual treatment packages depend on the level of exceedance of the criteria but can include mechanical ventilation, upgraded glazing, window and door seals, sealing of vents and underfloor areas, etc.
Ballast	Material such as crushed rock or stone used to provide a foundation for a railway track. Ballast usually provides the bed on which railway sleepers are laid, transmits the load from train movements and restrains the track from movement.
Botany Line	A dedicated freight rail line (operated by ARTC) that forms part of the Metropolitan Freight Network. The line extends from near Marrickville Station to Port Botany.
CEMP	Construction Environmental Management Plan
CNVMP	Construction Noise and Vibration Management Plan
Construction ancillary facilities	Temporary facilities during construction that include, but are not limited to, construction work areas, sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices, and construction compounds.
Construction compound	An area used as the base for construction activities, usually for deliveries and the storage of plant, equipment and materials, and/or construction site offices and worker facilities.
Council, the	Bayside Council
CSR	Combined services route
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own.
dBA	Decibel, A-weighted
DEC	Department of Environment and Conservation (now EPA)
DECC	Department of Environment and Climate Change (now EPA)
DECCW	Department of Environment, Climate Change and Water (now EPA)
Detailed design	The stage of design where project elements are designed in detail, suitable for construction
Down track	Rail track for trains travelling away from Port Botany
EIS, the	Botany Rail Duplication environmental impact statement
Embankment	A raised area of earth or other materials used to carry a rail line in certain areas
EMP	Environmental Management Plans
EPA	Environment Protection Authority
ER	Environmental Representative
Existing rail corridor	The corridor within which the existing rail infrastructure is located. In the study area, the existing rail corridor is the Botany Line.
Formation	The earthworks/material on which the ballast, sleepers and tracks are laid.

Item	Description / Definition
Heavy vehicles	A heavy vehicle is classified as a Class 3 vehicle (a two-axle truck) or larger, in accordance with the Austroads Vehicle Classification System.
HNA	Highly Noise Affected. Relates to construction noise levels of ≥75 dBA and is the point above which there may be strong community reaction to noise construction noise levels.
ICNG	Interim Construction Noise Guideline
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
INP	Industrial Noise Policy
L_{AE} or SEL	Sound Exposure Level – used to characterise events and is normalised to one second
L_{Aeq}	The average noise level during a measurement period, such as the daytime or night-time
L_{AFmax}	The maximum noise level measured during a monitoring period, using 'fast' weighting
LGA	Local government area
Metropolitan Freight Network	A network of dedicated railway lines for freight in Sydney, linking NSW's rural and interstate rail networks with Port Botany. The Metropolitan Freight Network is managed by ARTC.
NATA	National Association of Testing Authorities
NCA	Noise Catchment Area
NML	Noise Management Level
Noise intensive equipment	Construction equipment that is particularly noisy and causes annoyance. Includes items such as rockbreakers, concrete saws or ballast tampers
NPfI	Noise Policy for Industry
NSW	New South Wales
OLS	Obstacle Limitation Surface
ONVR	Operational Noise and Vibration Review. This is an assessment that confirms the noise and vibration impacts from the project, based on the final design, and defines the mitigation measures used to control the impacts.
OOH	Out of Hours
OOHW	Out of Hours Work
Possession	A period of time during which a rail line is closed to train operations to permit work to be carried out on or near the line.
Project site, the	The area that would be directly affected by construction (also known as the construction footprint). It includes the location of operational project infrastructure, the area that would be directly disturbed by the movement of construction plant and machinery, and the location of the storage areas/compounds etc, that would be used to construct that infrastructure.
Project, the	The construction and operation of the Botany Rail Duplication
RBL	Rating Background Level. This is the background noise level measured at a particular location. The method for calculating the RBL is defined in the NSW *Noise Policy for Industry*.
Realistic worst-case scenarios	Realistic worst-case construction scenarios have been developed to assess the potential impacts from the project. These scenarios are based on the noisiest items of equipment which would likely be required to complete the works.
RING	Rail Infrastructure Noise Guideline

Item	Description / Definition
RMS	Root Mean Square
RNP	Road Noise Policy
ROL	Road Occupancy Licence
Secretary's environmental assessment requirements (SEARs)	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning and Environment under section 115Y of the Environmental Planning and Assessment Act 1979 (NSW).
SLR	SLR Consulting Australia Pty Ltd
SSI	State significant infrastructure. Major transport and services infrastructure considered to have State significance as a result of size, economic value or potential impacts.
Standard Construction Hours	Monday to Friday 7 am to 6 pm and Saturdays from 8 am to 1 pm
Study area, the	The study area is defined as the wider area including and surrounding the project site, with the potential to be directly or indirectly affected by the project (eg by noise and vibration, visual or traffic impacts). The actual size and extent of the study area varies according to the nature and requirements of each assessment and the relative potential for impacts but which is sufficient to allow for a complete assessment of the proposed project impacts to be undertaken.
SWL	Sound Power Level
Sydney Gateway	A NSW Government initiative to respond to the forecast growth of Sydney Airport and Port Botany. Sydney Gateway comprises road connections to Sydney Airport's domestic and international airport terminals from the Sydney motorway network at St Peters interchange (being delivered by Roads and Maritime Services)
Terminals 2/3	Sydney Airport's domestic terminals
TfNSW	Transport for NSW
Triggered receiver	A receiver which is above the appropriate noise criteria
Unattended noise monitoring	Noise monitoring which is typically completed over a seven day period using unattended noise monitoring equipment. The equipment is left in a certain location to measure the existing background noise levels during the daytime, evening and night-time.
Up Track	Rail track for trains travelling towards Port Botany
VC	Vibration Criterion
VDV	Vibration Dose Value
Worst-case impacts and noise levels	The worst-case (ie highest) impacts or noise levels predicted in this report

1 Introduction

1.1 Overview

Australian Rail Track Corporation (ARTC) proposes to construct and operate a new second track typically within the existing Botany Line rail corridor between Mascot and Botany, in the Bayside local government area (LGA). The Botany Rail Duplication ('the project') would increase freight rail capacity to and from Port Botany. The location of the project is shown in **Figure 1**.

The project is State Significant Infrastructure in accordance with Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State Significant Infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

This report has been prepared to accompany the environmental impact statement (EIS) to support the application for approval of the project, and address the requirements of the Secretary of the Department of Planning and Environment environmental assessment requirements (the SEARs), issued on 21 December 2018.

1.1.1 Overview of the project

The project would involve:

- Track duplication – constructing a new track predominantly within the rail corridor for a distance of about three kilometres
- Track realignment (slewing) and upgrading – moving some sections of track sideways (slewing) and upgrading some sections of track to improve the alignment of both tracks and minimise impacts to adjoining land uses
- New crossovers – constructing new rail crossovers to maintain and improve access at two locations (totalling four new crossovers)
- Bridge works – constructing new bridge structures at Mill Stream, Southern Cross Drive, O'Riordan Street and Robey Street (adjacent to the existing bridges), and re-constructing the existing bridge structures at Robey Street and O'Riordan Street
- Embankment/retaining structures – construction of a new embankment and retaining structures adjacent to Qantas Drive between Robey and O'Riordan streets and a new embankment between the Mill Stream and Botany Road bridges.

Further information on the key elements of the project is provided in the EIS.

Ancillary work would include bi-directional signalling upgrades, drainage work and protecting/relocating utilities.

Subject to approval of the project, construction is planned to start at the end of 2020, and is expected to take about three years for the main construction works to be undertaken. Construction is expected to be completed in late 2023 with commissioning activities undertaken in early 2024.

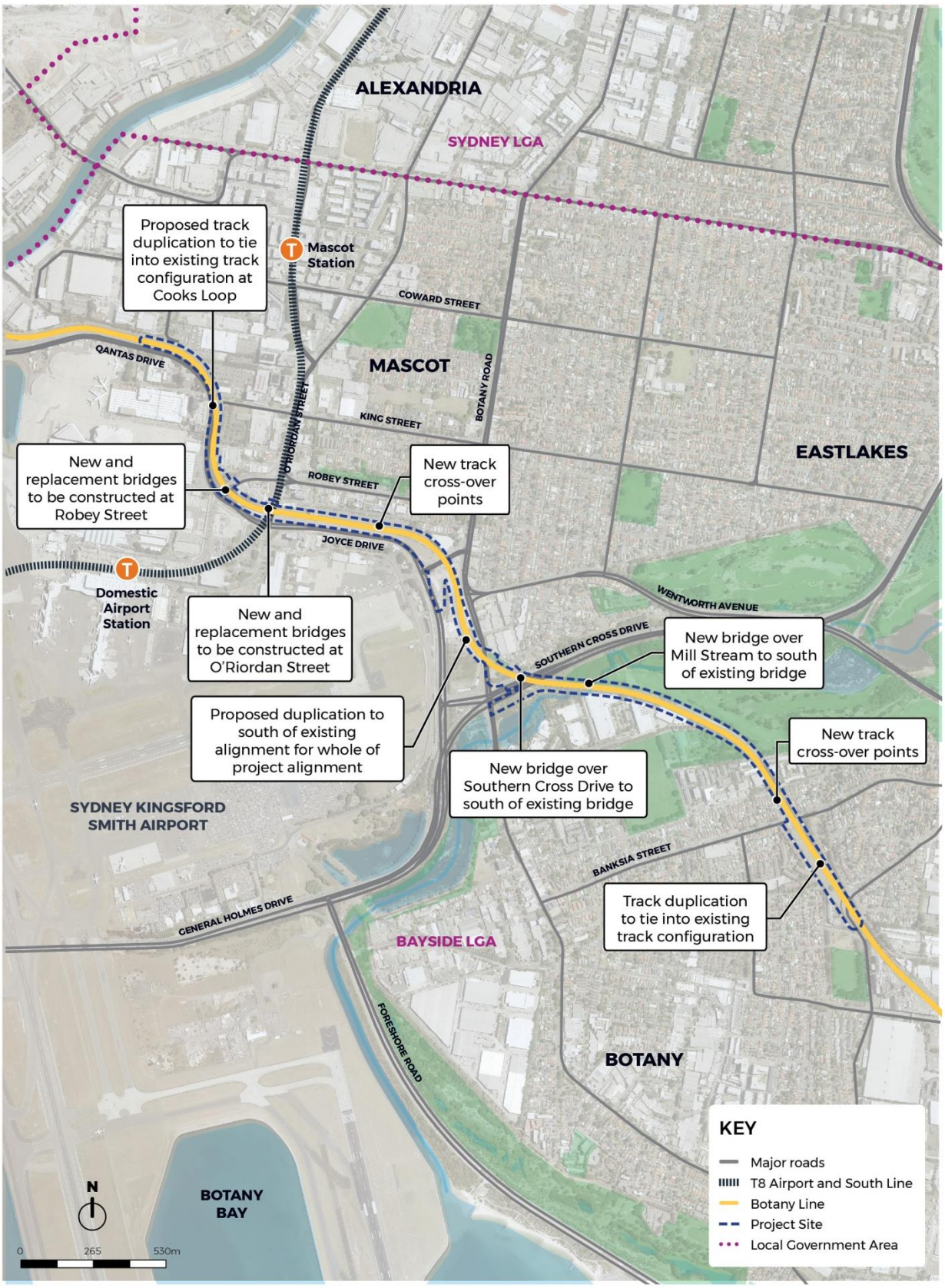
It is anticipated that some features of the project would be constructed while the existing rail line continues to operate. Other features of the project would need to be constructed during programmed weekend rail possession periods when rail services along the line cease to operate.

The project would operate as part of the existing Botany Line and would continue to be managed by ARTC. ARTC is not responsible for the operation of rolling stock. Freight rolling stock are currently, and would continue to be, provided by a variety of operators. Following the completion of works, the existing functionality of surrounding infrastructure would be restored.

Key features of the project are shown on **Figure 1**.

Figure 1 Botany Rail Duplication Location

Figure 2 Botany Rail Duplication Project Overview



1.2 Purpose and Scope of this Report

The purpose of this report is to assess the potential noise and vibration impacts from the construction and operation of the project. This noise and vibration assessment addresses the relevant SEARs for the EIS, as outlined in **Table 23**.

The report:

- Describes the existing environment with respect to noise and vibration
- Assesses the impacts of constructing and operating the project on the nearby communities and receivers
- Evaluates the potential cumulative impact of the project with other major infrastructure projects
- Recommends measures to mitigate the predicted impacts.

1.3 Structure of this report

The structure of this report is outlined below.

- **Section 1** – provides an introduction to the report
- **Section 2** – describes the existing noise environment in the study area
- **Section 3** – defines the criteria relevant to the project
- **Section 4** – outlines the methodology used to predicted and assess the potential impacts
- **Section 5** – summarises the construction noise and vibration assessment
- **Section 6** – summarises the operational noise and vibration assessment
- **Section 7** – assesses the potential cumulative impacts from the project and other major projects
- **Section 8** – discusses the recommended mitigation for the project
- **Section 9** – provides a conclusion for the project.

1.4 Terminology

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

2 Existing Environment

2.1 Study Area

The project is located in the suburbs of Mascot, Botany and Pagewood and is close to a number of major existing road and rail transportation corridors, including Sydney Kingsford Smith Airport which is located to the south west of the project.

Major roads include Joyce Drive, Qantas Drive and O'Riordan Street in the north-western extent near to Sydney Airport Terminals 2/3, and Southern Cross Drive and Botany Road in the south-east. The Botany Line is a freight only line which connects Port Botany to the Metropolitan Freight Network (MFN).

Existing noise levels at the project site are generally dominated by transportation noise, with road, rail and aircraft noise affecting most locations during the daytime. During the evening and night-time ambient noise levels typically decrease due to a reduction in road traffic volumes on the surrounding road network. There is also a curfew on flights at Sydney Airport from 11 pm to 6 am.

The suburbs of Mascot and Botany have areas of residential receivers which adjoin the Botany Line corridor in some locations. Commercial areas are located in the western section of the study area near Sydney Airport and also in the eastern section near to Botany Road, where noise from light industrial activities is present as times.

The study area covers the approximate area where physical works associated with the project would occur, extending around 500 m in either direction to the north and south of the rail corridor. The western extent of the study area extends to near Alexandra Canal in Mascot and the eastern extent finishes to the south of the Stephen Road bridge in Botany.

The assessment has been summarised using eight Noise Catchment Areas (NCAs) that reflect the land uses in the study area. These are shown in **Figure 3** and described **Table 1**.

Figure 3 Site Plan, Receivers and Noise Monitoring Locations

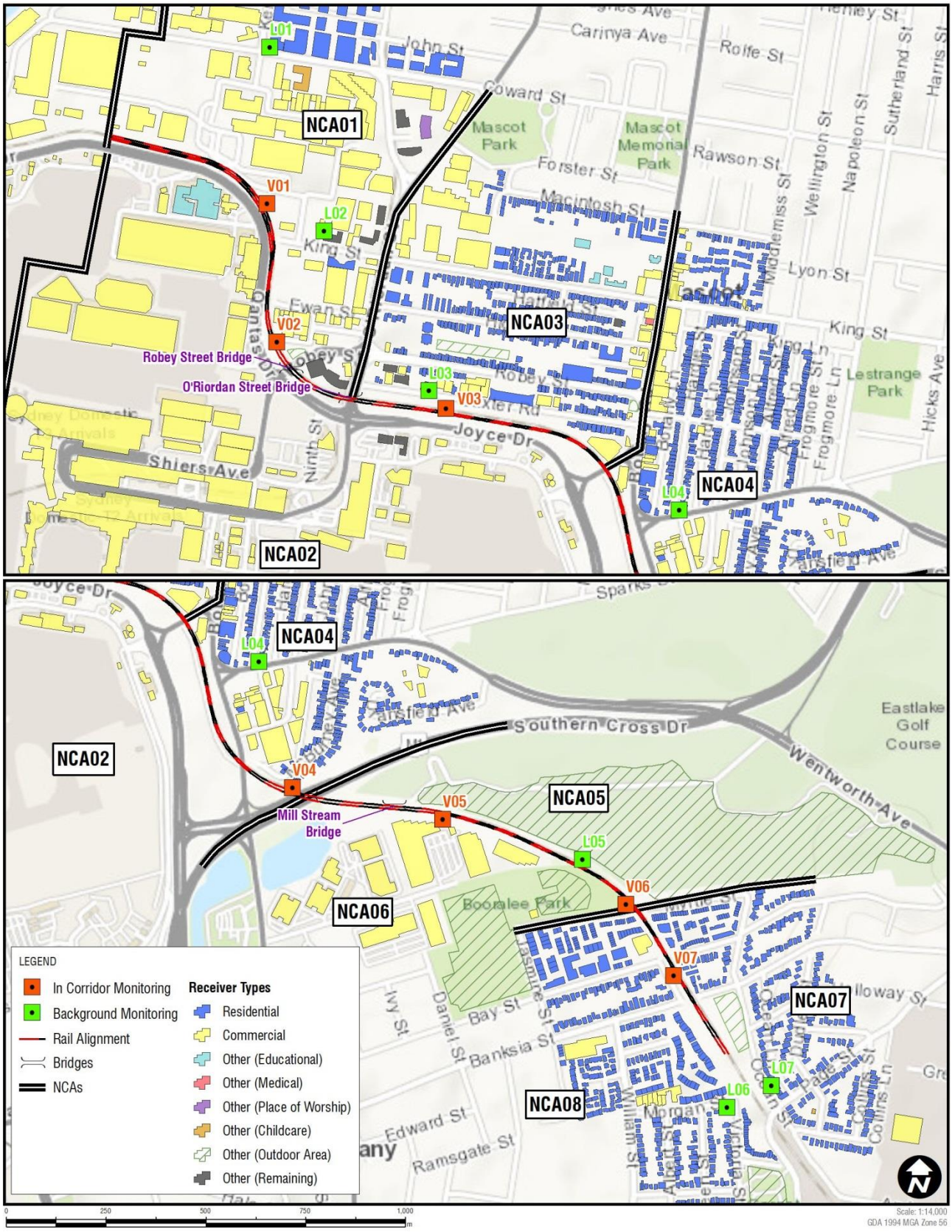


Table 1 Noise Catchment Areas and Surrounding Land Uses

NCA	Minimum Distance[1]	Description
NCA01	10 m	Located to the north of the Botany Line and Sydney Airport. This catchment is mainly commercial with some distant residential receivers in the north, near to Coward Street. A number of hotels are in this catchment, including the Stamford Plaza Hotel which is immediately north of the rail corridor. Robey Street Bridge and O'Riordan Street Bridge are in this catchment.
NCA02	40 m	This catchment is to the south of the rail corridor and covers Sydney Airport. The catchment is mainly commercial with the Qantas Flight Training Centre in the west, adjacent to Qantas Drive, and the Ibis Budget and Mantra Hotel near to the Joyce Drive and O'Riordan Street intersection.
NCA03	20 m	This catchment is located to the north of the rail corridor in Mascot and is mainly residential, with the nearest receivers being opposite the rail corridor on Baxter Road. Two hotels, Quest Mascot and Felix Hotel, are located near to O'Riordan Street. Mascot Public School is located in the north of the catchment on King Street.
NCA04	10 m	Located to the east of the rail corridor in Mascot and to the north of Southern Cross Drive. The catchment is mainly residential with the nearest receivers being on Botany Road and McBurney Avenue. An area of commercial use is located near to Wentworth Avenue and Botany Road. Southern Cross Drive Bridge is in the south extent of this catchment. Airport East construction works are currently being completed in this catchment.
NCA05	30 m	This catchment is to the north of the rail corridor and is the Eastlake golf course.
NCA06	25 m	Located to the south of the rail corridor and to the south of Southern Cross Drive. The catchment is of commercial use. Mill Stream Bridge is located in the north of the catchment.
NCA07	15 m	Located to the east of the rail corridor in Pagewood. This catchment is generally residential with the nearest receivers being adjacent the project on Myrtle Street, Banksia Street and Ocean Street.
NCA08	15 m	Located to the west of the rail corridor in Botany. This catchment is mainly residential with the nearest receivers being adjacent the project on Ellis Street, Morgan Street and Victoria Street.

Note 1: Approximate minimum horizontal distance in metres from track to nearest sensitive receiver.

2.2 Noise and Vibration Sensitive Receivers

Receivers potentially sensitive to noise and vibration have been categorised on the basis of their use, which includes residential dwellings, commercial/industrial buildings, and 'other sensitive' land uses such as educational institutions, childcare centres, medical facilities, places of worship, outdoor recreation areas, etc. Receiver types are shown in **Figure 3**.

The 'other sensitive' non-residential receivers identified in the study area are detailed in **Table 2**.

Table 2 'Other Sensitive' Receivers (Non-Residential)

NCA	Description	Address	Type
NCA01	Aero Kids Early Learning Centre	247 Coward Street, Mascot	Child care
	Citygate Followship Church	15 Bourke Road, Mascot	Place of worship
	Holiday Inn	Cnr of O'Riordan St & Bourke Rd, Mascot	Hotel
	Ibis Sydney Airport	205 O'Riordan Street, Mascot	Hotel
	Stamford Plaza Sydney Airport	Cnr of Robey St & O'Riordan St, Mascot	Hotel
	Adina Apartments	17 Bourke Road, Mascot	Hotel
	Toybox Early Learning[1]	15 Bourke Road, Mascot	Child care
	Travelodge	289 King Street, Mascot	Hotel
	Pullman Hotel	191 O'Riordan Street, Mascot	Hotel
	Coleman Reserve	4 Coleman Street, Mascot	Outdoor passive
NCA02	Ibis Budget Sydney Airport	5 Ross Smith Avenue, Mascot	Hotel
	Mantra Hotel	3 Ross Smith Avenue, Mascot	Hotel
	Qantas Flight Training Centre	Off Qantas Drive, Sydney Airport	Educational
NCA03	Mascot Public School	207 King Street, Mascot	Educational
	Mascot Library	2 Hatfield Street, Mascot	Library
	The Branksome Hotel[1]	60 Robey Street, Mascot	Hotel
	Quest Mascot (Hotel)	108-114 Robey Street, Mascot	Hotel
	Felix Hotel	121 Baxter Road, Mascot	Hotel
	Mascot Medical & Dental Centre	934-936 Botany Road, Mascot	Medical
	Robey Street Reserve	996 Botany Road, Mascot	Outdoor passive
	John Curtin Reserve	80-82 High Street, Mascot	Outdoor passive
NCA05	Eastlake Golf Course	9 Wentworth Avenue, Pagewood	Outdoor active
NCA06	Botany Aquatic Centre	Myrtle Street & Jasmine Street, Botany	Outdoor active
	Booralee Park	Bay Street & Daniel Street, Botany	Outdoor active
NCA07	Pagewood Kindergarten	1A Dudley Street, Pagewood	Child care
	Gaiarine Gardens	Ocean Street, Pagewood	Outdoor passive
NCA08	Garnet Jackson Reserve	Victoria Street, Botany	Outdoor active

Note: Where receivers of different use have been identified in the same building, the assessment applies the worst-case criteria to that building. Examples include Toybox Early Learning which is in the same building as Adina Apartments, and The Branksome Hotel which is in the same building as residential apartments.

2.3 Existing Noise Surveys and Monitoring Locations

Unattended noise monitoring was completed in the study area in June, September and October 2018. The measured noise levels have been used to determine the existing noise environment and to set criteria to assess the potential impacts from the project.

The measured existing noise levels are representative of receivers that would likely be most affected by the construction and operation of the project in each NCA. The monitoring equipment was generally located at front row receivers which would have line-of-sight to the project, with consideration of constraints such as accessibility, security and land owner permission.

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

The results of the noise monitoring have been processed with reference to the NSW EPA *Noise Policy for Industry* (EPA, 20117) (NPfI) to exclude noise from extraneous events and/or data affected by adverse weather conditions, such as strong wind or rain (measured at Sydney Airport), to establish representative existing noise levels for each NCA.

The noise monitoring locations are shown in **Figure 3** and the results are summarised in **Table 3**. Details of each monitoring location together with graphs of the measured daily noise levels are in **Appendix B**.

Table 3 Summary of Unattended Noise Logging Results

ID	Address	Measured Noise Level (dBA)[1]					
		Background Noise (RBL)			Average Noise Level (L_{Aeq})		
		Day	Evening	Night	Day	Evening	Night
L01	39 Kent Road, Botany	60	56	50	71	68	67
L02[2]	289 King Street, Mascot	60	58	53	68	66	64
L03	105 Baxter Road, Mascot	54	51	45	67	65	62
L04	87 Hardie Street, Mascot	57	54	48	69	66	64
L05	Eastlake Golf Club Pagewood	47	47 (49 actual)[3]	45	61	68	57
L06	13 Morgan Street, Botany	39	39 (41 actual)[3]	37	56	53	51
L07	38 Ocean Street, Pagewood	46	46	43	58	54	54

Note 1: Daytime is 7.00 am to 6.00 pm, evening is 6.00 pm to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Note 2: This location was influenced by noise from nearby construction works.

Note 3: The monitored evening level was found to be higher than the daytime, therefore the NPfI requires that the evening level be reduced to match the daytime level.

2.4 Attended Noise Measurements

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

The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and show that existing noise levels are typically dominated by transportation sources including road, rail and air noise, depending on location.

2.5 Train Pass-by Measurements

Noise measurements of freight trains using the existing rail infrastructure in the study area were completed in June and July 2018 at seven locations. The purpose of the survey was to measure operational rail noise from existing operations on the Botany Line to validate the rail noise assessment model. Unattended noise monitoring equipment was placed in the rail corridor, typically within 10 to 20 metres of the rail line. The locations were selected to be spread throughout the project area and measured noise levels next to curves and straight sections of track.

The monitoring sites are shown in **Figure 3** and the details of each location are in **Table 4**.

Table 4 Train Passby Measurement Locations

Location	Chainage	Distance to Near Track	Description
V01	13.000 km	7 m	Located on the northern side of the rail corridor between King Street and Kent Road, Mascot. The adjacent rail tracks include the existing Up Botany Line, Down Botany Line, and Cooks River Loop track. All three adjacent tracks were curved with a radius of approximately 250 m.
V02	12.650 km	3 m	Located on the northern side of the rail corridor at the end of Coleman Street, Mascot. The adjacent single track was curved with a radius of approximately 240 m.
V03	12.170 km	8 m	Located on the northern side of the rail corridor approximately 250 m east of O'Riordan Street, Mascot. The adjacent single track was straight for at least 300 m either side of the measurement location and had no identified nearby features such as turnouts, crossings, etc.
V04	11.200 km	8 m	Located on the northern side of the rail track near the rail corridor access gate on McBurney Avenue, Mascot. The adjacent single track was curved with a radius of approximately 280 m.
V05	10.800 km	18 m	Located on the southern side of the rail corridor, opposite Eastlake golf course. The adjacent single track was slightly curved with a radius of approximately 780 m.
V06	10.280 km	19 m	Located to the south west of the rail corridor at the end of Myrtle Street, Mascot. The adjacent single track was curved with a radius of approximately 390 m.
V07	10.060 km	12 m	Located on the western side of the rail corridor approximately 50 m south of the Ellis Street and Bay Street intersection in Botany. The adjacent single track was straight for at least 160 m either side of the measurement location and had no identified localised noise producing features.

A summary of the measured train pass-by noise levels is provided in **Table 5**. The measurements were completed over a period of around seven days at each location and include all representative trains pass-bys that were not influenced by extraneous sources of noise. Around 60 trains were deemed representative during the survey.

Table 5 Summary of Measured Train Passby Noise Levels

Location	Distance from Near Track	Measured Noise Level (dBA)	
		L_{AE}[1]	L_{Amax}[2]
V01	7 m	102	104
V02	3 m	109	115
V03	8 m	98	96
V04	8 m	102	104
V05	18 m	94	91
V06	19 m	96	98
V07	12 m	96	93

Note 1: Logarithmic average sound exposure level. The L_{AE} is the measured noise level of an event normalised to one second and is used to compare **noise** events with different time durations.

Note 2: Represents the 95% LAmax percentile of the measured trains. This represents the repeatable maximum noise level measured during train passbys.

3 Policy Context

This section summarises the guidelines and/or policies referred to in the assessment.

3.1 Relevant Policies and Guidelines

3.1.1 Construction Noise and Vibration Guidelines

The guidelines used to assess construction impacts from the project are listed in **Table 6**. The guidelines aim to protect the community and environment from excessive adverse noise and vibration impacts as projects are constructed.

Table 6 Construction Noise and Vibration Guidelines

Guideline/Policy Name	Where Guideline Used
Interim Construction Noise Guideline (DECC, 2009) (ICNG)	Assessment of airborne noise and ground-borne noise impacts on sensitive receivers
Assessing Vibration: a technical guideline (DEC, 2006)	Assessment of vibration impacts on sensitive receivers
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces
Road Noise Policy (DECCW, 2011) (RNP)	Assessment of construction traffic impacts
BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993	Assessment of vibration impacts (structural damage) to non-heritage sensitive structures
DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999	Screening assessment of vibration impacts (structural damage) to heritage sensitive structures, where the structure is found to be unsound

3.1.1.1 Interim Construction Noise Guideline

The NSW *Interim Construction Noise Guideline* (DECC, 2009) (ICNG) is used to assess and manage impacts from construction noise on residences and other sensitive land uses in NSW.

The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers based on the existing background noise in the area. 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.

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

Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in **Table 7**.

Table 7 ICNG NMLs for Residential Receivers

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

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

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

Note 1: The RBL is the Rating Background Level and the ICNG refers to the calculation procedures in the NSW *Industrial Noise Policy* (INP). The INP has been superseded by the NSW EPA *Noise Policy for Industry* (NPfI).

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

Sleep Disturbance

Major infrastructure projects in urban areas often require certain works to be completed during the night-time due to a range of constraints. Where night works are located close to residential receivers there is potential for sleep disturbance.

The ICNG lists five categories of works that might be undertaken outside of Standard Construction Hours:

- The **delivery of oversized equipment or structures** that require special arrangements to transport on public roads
- **Emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
- **Maintenance and repair of public infrastructure** where disruption to essential services or considerations of worker safety do not allow work within standard hours

- **Public infrastructure works** that shorten the length of the project and are supported by the affected community
- Works where a proponent demonstrates and justifies **a need to operate outside the recommended standard hours**.

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

A method for assessing sleep disturbance is contained in the NPfI. Although the NPfI sleep disturbance criteria relates to industrial noise, they are considered relevant for reviewing potential impacts from construction noise as a screening criteria to identify the need for further assessment. The NPfI defines external sleep disturbance criteria as being:

- 52 dBA L_{AFmax} or the prevailing background level plus 15 dB, whichever is the greater.

For this assessment, the existing background level plus 15 dB approach has been used. As per the NPfI, the assessment should consider several factors contributing to sleep disturbance including the number of times the criterion is exceeded, the distribution of high noise events across the night-time period and early-morning shoulder periods.

Summary of Residential NMLs

The residential NMLs for the project are determined using the results from the unattended ambient noise monitoring (see **Section 2**) and are shown in **Table 8**.

Table 8 Residential Receiver Construction Noise Management Levels

NCA	Representative Background Monitoring Location	NML ($L_{Aeq(15minute)}$ – dBA)				Sleep Disturbance Screening Criteria (RBL +15 dB)
		Standard Construction (RBL +10 dB)	Out of Hours (RBL +5 dB)			
		Daytime	Daytime[1]	Evening	Night-time	
NCA01	L01[2]	70	65	61	55	65
NCA02[3]	-	-	-	-	-	-
NCA03	L03	64	59	56	50	60
NCA04	L04	67	62	59	53	63
NCA05[3]	-	-	-	-	-	-
NCA06[3]	-	-	-	-	-	-
NCA07	L07	56	51	51	48	58
NCA08	L06	49	44	44	42	52

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

Note 2: NCA01 has two noise monitoring locations – L01 and L02. L01 has been used to set the NMLs for the catchment as it has lower background levels and results in more stringent criteria.

Note 3: NCA has no residential receivers.

The noise monitoring locations were selected to measure background noise levels at front row receivers in each NCA. These locations would likely be most affected during construction of the project and whilst background noise levels may reduce for receivers which are further back from the works (due to increased distance from the nearest roads and local shielding effects), construction noise reduces at a quicker rate than background noise level (from general transportation noise) with increasing distance. Worst-case noise impacts are therefore generally at the closest receivers and normally control the mitigation requirements for the project.

Other Sensitive Land Uses and Commercial Receivers

A number of non-residential land uses have been identified in the project site and some of these 'other sensitive' uses are considered sensitive to potential noise impacts. These include educational institutes, medical facilities, outdoor recreational areas, and commercial properties. The ICNG NMLs for 'other sensitive' receivers are shown in **Table 9**.

Table 9 ICNG NMLs for Other Sensitive Receivers

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (Applied when the property is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dBA[1]
Hospital wards and operating theatres	Internal noise level 45 dBA[1]
Places of Worship	Internal noise level 45 dBA[1]
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion)	External noise level 60 dBA
Community centres	Refer to the recommended 'maximum' internal levels in AS 2107 for specific uses
Commercial	External noise level 70 dBA

Note 1: The criteria is specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are 10 dB higher than the corresponding internal level, which is representative of windows being partially open to provide ventilation. Hospital wards are assumed to have fixed windows with 20 dB higher external levels.

The ICNG references *AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors* for criteria for 'other sensitive' receivers which are not listed in the guideline. The AS2107 NMLs for 'other sensitive' receivers which have been identified in the study area (see **Table 2**) are shown in **Table 10**.

Table 10 AS2107 NMLs for Other Sensitive Receivers

Use	Period	AS2107 Classification	Noise Management Level $L_{Aeq(15minute)}$
Hotel	Daytime and evening	Bars and lounges	Internal noise level 50 dBA[1]
	Night-time	Sleeping Areas: - Hotels near major road	Internal noise level 40 dBA[1]
Library	When in use	Reading areas	Internal noise level 45 dBA[1]

Note 1: These receivers are assumed to have fixed windows with a conservative 20 dB reduction for external to internal noise levels.

3.1.1.2 Construction Traffic Noise Guidelines

The potential impacts from construction traffic on public roads are assessed under the NSW *Road Noise Policy* (EPA, 2011) (RNP).

An initial screening test is first applied to evaluate if noise levels due to construction traffic are expected to increase by more than 2 dB. Where this is considered likely, further assessment of the impacts on potentially affected receivers is required using the RNP base criteria shown in **Table 11**.

Table 11 RNP Criteria for Assessing Construction Traffic on Public Roads

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

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

3.1.1.3 Construction Ground-borne Noise Guidelines

Construction works can cause ground-borne noise impacts in nearby buildings when vibration generating equipment is in use. Vibration can be transmitted through the ground and into the structure of nearby buildings, which can then create audible noise impacts inside the building. The ICNG provides evening and night-time ground-borne noise NMLs for residences to protect the amenity and sleep of residents. The internal ground-borne noise NMLs are:

- Evening $L_{Aeq(15minute)}$ 40 dBA
- Night-time $L_{Aeq(15minute)}$ 35 dBA

The NMLs only apply where internal ground-borne noise levels are higher than noise transmitted through the air. This situation can occur where buildings near to construction works have high performing facades which attenuate the airborne component, or where sensitive internal areas do not have facades which face the construction works.

For this project, the majority of receivers are likely to be sufficiently distant from the works for ground-borne noise impacts to be minimal.

3.1.1.4 Construction Vibration Guidelines

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

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

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

Human Comfort Vibration

People can sometimes perceive vibration impacts when vibration generating construction works are located close to occupied buildings.

Vibration from construction works tends to be intermittent in nature and the EPA's *Assessing Vibration: a technical guideline* (EPA, 2006) provides criteria for intermittent vibration based on the Vibration Dose Value (VDV). The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in **Table 12**.

Table 12 Vibration Dose Values for Intermittent Vibration

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

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

Effects on Building Contents

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

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes, is located in buildings near to construction works. Criteria for vibration sensitive equipment are discussed in **Section 3.1.1.5**.

Structural and Cosmetic Damage Vibration

If vibration from construction works is sufficiently high it can cause damage to structural elements of affected buildings. The levels of vibration required to cause cosmetic damage tend to be at least an order of magnitude (10 times) higher than those at which people can perceive vibration.

Examples of damage that can occur includes cracks or loosening of drywall surfaces, cracks in supporting columns and loosening of joints. Structural damage vibration limits are contained in British Standard BS 7385 and German Standard DIN 4150.

BS 7385

British Standard BS 7385 recommends vibration limits for transient vibration which are judged to give a minimal risk of vibration induced damage to effected buildings. The limits for residential and industrial buildings are shown in **Table 13**.

Table 13 BS 7385 Transient Vibration Values for Minimal Risk of Damage

Group	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Note 1: Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values may need to be reduced by up to 50%.

For heritage buildings, the standard states that *"a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive"*. Assessment of potential impacts to heritage buildings from construction vibration is further discussed below.

DIN 4150

German Standard DIN 4150 also provides guideline vibration limits for different buildings and buried pipework. Damage is not expected to occur where the values are complied with and the values are generally recognised to be conservative. The DIN 4150 values for buildings and structures are shown in **Table 14** with values for buried pipework in **Table 15**.

Table 14 DIN 4150 Guideline Values for Short-term[1] Vibration on Structures

Group	Type of Structure	Guideline Values Vibration Velocity (mm/s)				
		Foundation, All Directions at a Frequency of			Topmost Floor, Horizontal	Floor Slabs, Vertical
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified as Group 1 or 2 **and** are of great intrinsic value (eg heritage listed buildings)	3	3 to 8	8 to 10	8	20[2]

Note 1: Short-term is defined in DIN 4150 as vibration that does not occur often enough to cause material fatigue and whose development over time and duration is not suitable for producing a significant increase in vibration due to resonance in the particular structure.

Note 2: It may be necessary to lower the relevant guideline value markedly to prevent minor damage.

Table 15 DIN 4150 Guideline Values for Short-term Vibration on Buried Pipework

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

Heritage Items

Heritage buildings and structures should be considered on a case-by-case basis but as noted in BS 7385 should not be assumed to be more sensitive to vibration, unless structurally unsound. Where a heritage building is deemed to be sensitive following investigation by a structural engineer, the more stringent DIN 4150 Group 3 guideline values in **Table 14** can be applied.

3.1.1.5 Sensitive Scientific and Medical Equipment

Some scientific equipment, such as electron microscopes and microelectronics manufacturing equipment, can require stringent vibration goals (as set by the manufacturer). Other equipment used for various business requirements as well as medical equipment may also have specific vibration goals. Vibration sensitive equipment is however often housed in rooms specifically designed and constructed for such items.

Where vibration sensitive equipment is potentially affected by construction works, vibration limits for the operation of the equipment should be taken from manufacturer's data. Where this is not available, generic Vibration Criterion (VC) curves can be used. These VC curves are shown in **Table 16**.

Table 16 VC Curves for Vibration Sensitive Equipment

Criterion Curve	Max Level (µm/sec, rms)[1]	Detail Size (microns)[2]	Description of Use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

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

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

3.1.1.6 Minimum Working Distances for Vibration Intensive Works

Construction vibration has the potential to result in cosmetic damage and human comfort impacts when works are completed near to receivers. Minimum working distances for typical vibration intensive construction equipment are provided **Table 17**. The minimum working distances are for both cosmetic damage (from BS 7385 and DIN 4150) and human comfort (from the NSW *Assessing Vibration: a technical guideline* (DEC, 2006)) and are based on empirical data which suggests that where works are further from receivers than the quoted minimum distances then impacts are not considered likely.

Table 17 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant Item	Rating/Description	Minimum Distance		
		Cosmetic Damage		Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1-2 tonne)	5 m	11 m	15 m to 20 m
	<100 kN (2-4 tonne)	6 m	13 m	20 m
	<200 kN (4-6 tonne)	12 m	15 m	40 m
	<300 kN (7-13 tonne)	15 m	31 m	100 m
	>300 kN (13-18 tonne)	20 m	40 m	100 m
	>300 kN (>18 tonne)	25 m	50 m	100 m
Small Hydraulic Hammer	300 kg (5 to 12 t excavator)	2 m	5 m	7 m
Medium Hydraulic Hammer	900 kg (12 to 18 t excavator)	7 m	15 m	23 m
Large Hydraulic Hammer	1,600 kg (18 to 34 t excavator)	22 m	44 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	5 m to 40 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	5 m	n/a
Jackhammer	Hand held	1 m (nominal)	3 m	Avoid contact with structure

Note: The minimum working distances have been referenced from the Transport for NSW *Construction Noise and Vibration Strategy* (CNVS).

Where works are within the minimum working distances and considered likely to exceed the cosmetic damage objectives, construction works should not proceed unless:

- A different construction method with lower source vibration levels is used, where feasible
- Attended vibration measurements are undertaken at the start of the works to determine the risk of exceeding of the vibration objectives.

The minimum working distances are indicative and will vary depending on the particular item of equipment and local geotechnical conditions.

3.1.2 Operational Rail Noise and Vibration Guidelines

The guidelines used for assessing the potential operational rail impacts from the project are listed in **Table 18**. The guidelines aim to protect the community and environment from excessive noise and vibration impacts from the long-term operation of the project.

Table 18 Operational Rail Noise and Vibration Guidelines

Guideline/Policy Name	When Guideline is Used
Rail Infrastructure Noise Guideline (EPA, 2013) (RING)	Assessment of operational airborne and ground-borne noise impacts on sensitive receivers.
Noise Prediction and Mitigation Guideline (ARTC, 2018)	Provides guidance on the assessment and design of mitigation for ARTC rail projects. This is an ARTC internal document that forms part of the ARTC Environmental Management System.
Assessing Vibration: a technical guideline (DEC, 2006)	Assessment of vibration impacts on sensitive receivers.
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces.

3.1.2.1 Airborne Noise – Rail Infrastructure Noise Guideline

The NSW *Rail Infrastructure Noise Guideline* (EPA, 2013) (RING) is used to assess and manage potential airborne noise impact from new and redeveloped railway projects. The guideline provides non-mandatory 'trigger levels' for residential and other sensitive land uses.

Where a project results in rail noise levels which are predicted to be above the trigger levels, the project should investigate feasible and reasonable noise mitigation measures to minimise the impacts.

The RING uses the following scenarios to assess the impacts from rail projects:

- **'Without project'** – the assessment scenario used to predict noise levels if the project were not to go ahead
- '**With project**' – the assessment scenario used to predict noise levels with the project.

The difference between the 'Without project' and the 'With project' noise levels is used to determine the noise level increase from the project.

Residential Receivers

The project is a redevelopment of an existing rail line and the relevant airborne noise trigger levels for residential receivers are shown in **Table 19**.

Table 19 RING Airborne Rail Noise Trigger Levels for Residential Receivers

Sensitive Land Use	Noise Trigger Level (dBA)	
	Daytime	Night-time
Residential	Development increases existing $L_{Aeq(period)}$[1] rail noise levels by 2 dB or more, or existing L_{Amax} rail noise levels by 3 dB or more ***and*** predicted rail noise levels exceed:	
	65 $L_{Aeq(15hour)}$ or 85 L_{Amax}[2]	60 $L_{Aeq(9hour)}$ or 85 L_{Amax}[2]

Note 1: $L_{Aeq(period)}$ refers to average noise level in the period. $L_{Aeq(15hour)}$ is the daytime and $L_{Aeq(9hour)}$ is the night-time.

Note 2: L_{Amax} refers to the maximum noise level not exceeded for 95% of rail pass-by events.

The L_{Aeq} noise trigger levels are lower for the night-time due to the greater sensitivity of communities to noise impacts during this period.

The RING requires noise to be assessed at project opening and for a future design year which is representative of the design capacity for the project and is typically ten years after opening. For this project, the opening year is 2024 and the design year is 2034.

Other Sensitive Land Uses

A number of 'other sensitive' non-residential land uses have been identified in the study area. The noise trigger levels for these receivers are shown in **Table 20**. The RING does not consider commercial and industrial receivers as being sensitive to operational airborne rail noise impacts.

Table 20 RING Airborne Rail Noise Trigger Levels for Other Sensitive Receivers

Sensitive Land Use	Noise Trigger Level (dBA) (when in use)
Schools, educational institutions and child care centres	45 $L_{Aeq(1hour)}$ Internal[1]
Places of worship	45 $L_{Aeq(1hour)}$ Internal[1]
Hospital wards	40 $L_{Aeq(1hour)}$ Internal[1]
Hospital other uses	65 $L_{Aeq(1hour)}$
Open space – passive use (eg parkland, bush reserves)	65 $L_{Aeq(15hour)}$
Open space – active use (eg sports field, golf course)	65 $L_{Aeq(15hour)}$

Note 1: The criteria is specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are 10 dB higher than the corresponding internal level, which is representative of windows being partially open to provide ventilation.

A number of hotels are located close to the rail corridor in the study area. The RING does not provide specific criteria for this receiver type. Certain hotels may have people who reside permanently on site and the RING residential criteria has therefore conservatively been applied to these receivers, noting that only areas of permanent residence require assessment. Other areas of hotels that are not used as a permanent residence are considered commercial, which the RING does not provide operational noise criteria for.

3.1.3 Operational Ground-borne Noise and Vibration Guidelines

3.1.3.1 Ground-borne Noise

Ground-borne vibration from passing trains can cause perceptible vibration impacts to occupants of nearby buildings. Ground-borne vibration can also result in audible impacts inside buildings in the form of a low frequency rumble if the vibration is sufficient to cause floors or walls of the structure to vibrate. The integrity of building structures are unlikely to be comprised by passing trains.

The RING provides operational ground-borne noise and vibration criteria for rail infrastructure projects which apply only where internal ground-borne noise levels are higher than noise transmitted through the air. The ground-borne noise trigger levels for residential and 'other sensitive' receivers are shown in **Table 21**.

Table 21 RING Ground-borne Noise Trigger Levels

Sensitive Land Use	Time of Day	Internal Noise Trigger Level (dBA)
		Development increases existing rail noise levels by 3 dBA or more ***and*** resulting rail noise levels exceed:
Residential	Day (7am to 10pm)	40 L_{ASmax}
	Night (10pm to 7am)	35 L_{ASmax}
Schools, educational institutions, places of worship	When in use	40 - 45 L_{ASmax}

The RING does not specify criteria for hotels so residential criteria have conservatively been applied in this assessment on the assumption that they may have staff who reside permanently on site, noting that only areas of permanent residence require assessment.

3.1.3.2 Ground-borne Vibration

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

The RING refers to the EPA's *Assessing Vibration: a technical guideline* (EPA, 2006) for vibration criteria for rail projects, which are sources of intermittent vibration. The 'preferred' and 'maximum' VDVs for human comfort are shown in **Table 22**.

Table 22 Vibration Dose Values for Intermittent Vibration

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

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

The guideline states *"activities should be designed to meet the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the maximum range may be used if they can be justified"*

3.2 Secretary's Environmental Assessment Requirements

The SEARs relevant to noise and vibration, together with a reference to where they are addressed in this report, are outlined in **Table 23**.

Table 23 SEARs Relevant to this Assessment

Requirement	Where Addressed in this Report
Assessment of Key Issues	
2. For each key issue the Proponent must:	-
(a) describe the biophysical and socio-economic environment, as far as it is relevant to that issue;	**Section 2**
(b) describe the legislative and policy context, as far as it is relevant to the issue;	**Section 3**
(c) identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts;	**Section 4, 5, 6** and **7**
(d) demonstrate how options within the project potentially affect the impacts relevant to the issue;	Chapter 5 of the EIS
(e) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies);	**Section 4, 8**
(f) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant); and	**Section 8**
(g) detail how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.	**Section 8**

Requirement	Where Addressed in this Report
Noise and Vibration – Amenity	
1. The Proponent must assess typical and realistic construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must take into consideration impacts to sensitive receivers and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	**Section 4, 5** and **6**
2. An assessment of construction noise and vibration impacts which must address:	
(a) the nature of construction activities (including transport and redistribution of traffic (including local feeder roads), tonal or impulsive noise-generating works, as relevant);	**Section 4.1.1**
(b) the intensity and duration of noise (both air and ground borne) and vibration impacts. This must include consideration of extended construction impacts associated with ancillary facilities (and the like) and construction fatigue;	**Section 4.1.1** **Section 5** and **7.2**
(c) the identification of receivers, existing and likely, during the construction period;	**Section 2.1** and **2.2**
(d) the nature, sensitivity and impact to receivers;	**Section 5**
(e) the need to balance timely conclusion of noise and vibration generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	**Section 8.2**
(f) noise impacts of out-of-hours works and proposed activities including utility works, estimation of the number of out-of-hours activities required, timeframes and justification for these activities in terms of the Interim Construction Noise Guideline (DECCW, 2009);	**Section 4.1.1.1, 5.1** and **5.2**
(g) a cumulative noise and vibration assessment inclusive of impacts from the project (including concurrent project construction activities);	**Section 7.1.1** and **7.2**
(h) a cumulative noise and vibration assessment of the impacts from the project and the construction of other relevant development in the vicinity of the proposal;	**Section 7.1.2**
(i) details and analysis of the effectiveness of mitigation measures to adequately manage identified impacts, including cumulative impacts as identified in (g) and (h) and a clear identification of residual noise and vibration following application of mitigation measures; and	**Section 8.2**
(j) a description of how community preferences have been taken into account in the design of mitigation measures and consider tailored mitigation, management and communication strategies for vulnerable community members.	**Section 8.1**
3. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	n/a – no blasting
4. The operational noise and vibration assessment must include consideration of operational plant and equipment and increases in freight rail movements.	**Section 4.4.2** and **6**
Noise and Vibration – Structural	
1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	**Section 3, 5, 5.7.3** and **6**
2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	n/a – no blasting

4 Methodology

This section describes the methodology used to undertake the noise and vibration assessment for the project.

4.1 Construction Airborne Noise Assessment Methodology

A noise model of the study area has been used to predict noise levels from the proposed construction works to all surrounding receivers. The model uses ISO 9613 algorithms in SoundPLAN software.

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

4.1.1 Works Description

Representative scenarios have been developed to assess the likely impacts from the various construction phases of the project. These scenarios are shown in **Table 24** together with a high-level description of each works activity. The location of the various work scenarios are shown in **Figure 4**.

The assessment uses 'realistic worst-case' scenarios to determine the impacts from the noisiest 15-minute period that is likely to occur for each work scenario, as required by the ICNG. The impacts represent construction noise levels without mitigation applied.

The assessment is generally considered conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

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

Table 24 Construction Scenario Descriptions

ID	Scenario	Description
1a	Enabling Works - Billboard Demolition	Enabling works would be required early on in the project to allow the main construction activities to occur. These works are expected to include: • Billboard removal – several existing billboards on Qantas Drive and Joyce Drive would likely be impacted by the project and would require removal • Utility relocation/protection – ground works to adjust, relocate or protect existing services • Vegetation clearing and property adjustment – works required to remove existing vegetation and adjust property boundaries before starting the main works. Works using noise intensive equipment would be required at certain times and would include the use of concrete saws during billboard removal and utility works, and chain saws and chippers during vegetation removal.
1b	Enabling Works - Utilities	
1c	Enabling Works – Vegetation Clearing & Property Adjustments	

ID	Scenario	Description
2a	Compounds - Establishment	The main compounds would be near the level crossing off General Holmes Drive, which is an existing compound for the Roads and Maritime Service's Airport East project, and off Banksia Street located within the existing rail corridor. The main compounds would include site offices, worker amenities and workforce parking. Smaller satellite compounds would be located along the alignment and would have limited worker amenities. Ground works would be required to establish the compounds. Operation of the compounds would last throughout construction and would include deliveries, storage of equipment and materials, and typical worker activities. Compound operation generally has no requirement for noise intensive equipment.
2b	Compounds - Operations	
3a	Bridge Works - Demolition (inc. breaker)	There are four bridge locations in the project site – Mill Stream bridge, Southern Cross bridge, O'Riordan Street bridge and Robey Street bridge. New bridge structures would be required at each location and demolition and replacement of the existing bridge would be required at O'Riordan Street and Robey Street. Works using noise intensive equipment would be required at certain times during bridge demolition and would include the use of concrete saws or rockbreakers.
3b	Bridge Works - Construction	
4a	Retaining Walls - Construction	Retaining wall works would be required where the alignment is on embankment. Retaining wall works would include: • Excavate and prepare foundations • Piling works, including construction of piling platforms • Install panels and reinforcement
5a	Track Works - Peak	The track works would involve the construction of new track, the upgrading of existing track and installation of new crossovers, turnouts and catchpoints. The works would vary depending on location but could include: • Ground works to excavate, backfill and compact formation layer • Installing concrete sleepers, rail and fastenings • Ballast placing and tamping track to final height • Cutting and welding rails. The works have been categorised into 'Peak' and 'Typical' works. Examples of 'Peak' work includes the use of noise intensive equipment for shorter durations along the project site. These can include concrete saws or track machines including a ballast tamper or ballast regulator. 'Typical' works are representative of noise levels outside of the worst-case when noise intensive equipment isn't being used.
5b	Track Works - Typical	
6a	Signalling (inc. CSR)	The existing Combined Services Route (CSR) would require adjustment and relocation due to the new track alignment. New signalling equipment would also be required in certain locations. Signalling and CSR works would include: • Ground excavation • Install conduit and cable pulling • Excavation and installation of pits • Install equipment. Signalling works generally have no requirement for noise intensive equipment.

ID	Scenario	Description
6b	Testing, Commissioning & Finishing	Testing and commissioning works are required for the new track and signalling equipment prior to operation. Finishing works would include: • Removal of temporary fencing • Landscape activities • Removal of ancillary compounds. Testing, commissioning and finishing works generally have no requirement for noise intensive equipment.

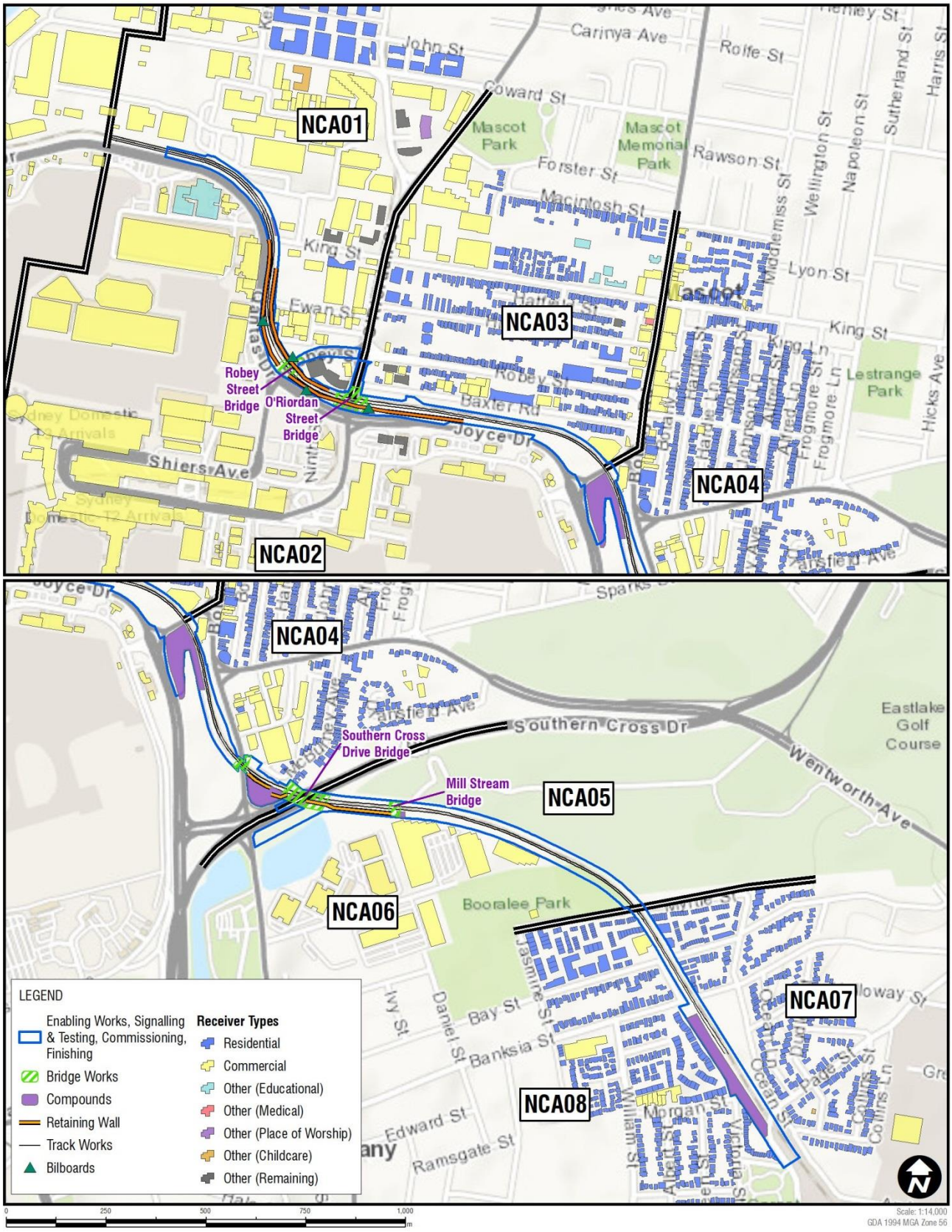
Note: Equipment lists for each scenario and sound power level data are provided in **Appendix C**.

The assessment in **Section 5** presents a summary of the predicted impacts from the above construction scenarios. To gain an understanding of the potential impacts from the project, detailed results are also provided for:

- The scenario with the predicted **worst-case impacts** (ie the highest predicted NML exceedances and most number of receivers affected)
- The scenario with the **longest duration**.

The assessment presents the impacts from the various construction scenarios assuming works are occurring at all locations at the same time. In reality, works would occur at discreet locations before moving on to the next area, which would limit the extent of impacts to nearby receivers.

Figure 4 Construction Works Locations



4.1.1.1 Working Hours

Construction of the project would be carried out during Standard Construction Hours where possible. Standard Construction Hours are defined in the ICNG and shown in **Table 25.**

Table 25 Standard Construction Hours

Hour commencing	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
Monday																								
Tuesday																								
Wednesday									Standard										OOH[3]					
Thursday	OOH								Construction Hours[2]										Period 1					
Friday	Period 2																		Evening					
Saturday																								
Sunday									OOH[3] Period 1										OOH[3]					
Public Holiday									Day										Period 2					

Note 1: Taken from the TfNSW *Construction Noise and Vibration Strategy*.

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

Note 3: OOH = Out of Hours (ie not during Standard Construction Hours).

However, the project specific constraints mean evening and night-time work would be required at certain times to minimise impacts on road, rail and air traffic, and for safety reasons. Works outside of Standard Construction Hours would include:

- Delivery of materials and equipment required by authorities for safety reasons.
- Work required to be undertaken during 48-hour track possessions when freight trains are not operating. The approximate times would be 2 am Saturday morning to 2 am Monday morning. There are typically four track possessions per year.
- Work required to be undertaken when safeworking protection is required to control freight trains. This would result from communication with Network Control to block access to a designated area of track through placement of red signals either end, typically undertaken during low demand periods such as early morning.
- Work required to be undertaken at night-time with a road occupancy license (ROL) to minimise traffic disruptions and ensure pedestrian and cyclist safety. It is anticipated that ROLs would generally be used between 10 pm and 4 am, although around 10 major road closures of about 48 hrs would be required for works at the Robey Street and O'Riordan Street bridges (around five per road).
- Work to be completed outside of Sydney Airport operational hours due to encroachment of the Sydney Airport obstacle limitation surface (OLS), where work would be done in the 11 pm to 5 am aircraft curfew period.
- Work required to be programmed to coincide with non-peak traffic times due to restrictions placed at access gates at some worksites in order to manage potential traffic impacts.

The periods in which the construction works would be required are shown in **Table 26**. At this early stage in the project, Out of Hours Works (OOHWs) have been included in the assessment for all construction scenarios as they would all likely require periods of works outside of Standard Construction Hours at some point in the construction. The anticipated duration of each activity is also provided in the table, noting that noisy activities would not occur at full capacity for the entire duration and would not be undertaken every day.

Table 26 Construction Scenarios – Working Hours and Indicative Durations

ID	Scenario	Activity	Indicative Duration	Hours of Works								
				Normal Works		Weekend Possessions				Other Possessions		
				Day	Day OOH[1]	Day	Day OOH[1]	Evening	Night-time	Morning Works (4am to 9am)	Night –time outside of peak due to lane closures (10pm to 6am)	Night-time during Sydney Airport curfew (10pm to 5am)
1a	Enabling Works	Billboard Demolition	3 months	✓	✓	✓	✓	✓	✓	✓	✓	-
1b		Utilities	12 months	✓	✓	✓	✓	✓	✓	✓	✓	✓
1c		Vegetation Clearing & Property Adjustments	12 months	✓	✓	✓	✓	✓	✓	✓	-	✓
2a	Compounds	Establishment	3months	✓	✓	-	-	-	-	✓	-	-
2b		Operations	37months	✓	✓	✓	✓	✓	✓	✓	✓	✓
3a	Bridge Works	Demolition (inc. breaker)	2 months	✓	✓	✓	✓	✓	✓	✓	✓	-
3b		Construction	17 months +11 months	✓	✓	✓	✓	✓	✓	✓	✓	✓
4a	Retaining Walls	Construction	24 months	✓	✓	✓	✓	✓	✓	✓	✓	✓
5a	Track Works	Peak	2 months (x2)	✓	✓	✓	✓	✓	✓	✓	✓	✓
5b		Typical	21 month	✓	✓	✓	✓	✓	✓	✓	✓	✓
6a	Signalling (inc. CSR)		29 months	✓	✓	✓	✓	✓	✓	✓	-	✓
7a	Testing, Commissioning & Finishing		2 months	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note 1: OOH = out of hours.

The key constraints which affect the construction of the project and result in the need for certain works to be completed outside of Standard Construction Hours are shown in **Figure 5**.

Figure 5 Key Project Constraints affecting Working Hours

The Robey/O'Riordan bridge works are significantly affected by rail (safety and operations) and road (safety and access) constraints. The Mill Stream bridge works are also significantly affected by a combination of rail, road and airspace constraints.

Construction works in the rail corridor that are carried out within the danger zone (within 3 m of the centreline of the rail track) are also affected by rail safety constraints, as works are only able to be carried out when trains are not operating. This may occur during weekend possession periods or during controlled signal blocks (typically during low demand periods such as early morning).

As a result of these constraints, works outside of Standard Construction Hours would be required at times for the full duration of construction and have therefore been included in the assessment for all construction scenarios shown in **Table 26**.

Some of the construction scenarios are progressive (would move along the alignment and would not impact the same receivers for the full duration of works) and some are fixed works (works that would remain in one place and may impact the same receivers for the project duration). The type of works are shown in **Table 27**.

Table 27 Construction Scenarios – Type of Works

ID	Scenario	Activity	Type of Works
1a	Enabling Works	Billboard Demolition	Fixed
1b		Utilities	Progressive
1c		Vegetation Clearing & Property Adjustments	Progressive
2a	Compounds	Establishment	Fixed
2b		Operations	Fixed
3a	Bridge Works	Demolition (inc. breaker)	Fixed
3b		Construction	Fixed
4a	Retaining Walls	Construction	Progressive
5a	Track Works	Peak	Progressive
5b		Typical	Progressive
6a	Signalling (inc. CSR)		Progressive
7a	Testing, Commissioning & Finishing		Progressive

4.1.1.1.1 Possessions/Closedown Periods Required for Construction

The Botany Line would remain operational during construction of the project. ARTC currently schedules routine maintenance possessions on four weekends each calendar year and the shutdowns start at around 2 am on Saturday and end at 2 am on Monday.

Subject to detailed construction planning, these scheduled maintenance possessions would be used to carry out construction works that cannot be done when the line is in operation. Work during possessions would be undertaken on a 24 hour basis continuously for the duration of each possession.

In addition to 48-hour possessions, it is anticipated that other types of worksite protection would be used where the operation of trains on the Botany Line is controlled to allow construction works to progress.

4.1.2 Works Schedule

Subject to planning approval, construction of the project is planned to start in the last quarter of 2020, with completion expected by mid-2024 (including commissioning). The indicative construction program for the project is shown in **Table 28**.

Table 28 Indicative Construction Schedule

Work Phase	2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Enabling Works																								
Bridge works:																								
- Mill Stream bridge																								
- Southern Cross bridge																								
- Robey bridge																								
- O'Riordan bridge																								
Civil works																								
Track work																								
Signalling																								
Testing and Commissioning																								
- Down Botany Line																								
- Up Botany Line																								
Demobilisation and Finishing																								

4.2 Construction Vibration Assessment

The potential impacts during vibration intensive works have been assessed using the nominated minimum working distances for cosmetic damage and human response shown in **Table 17**. The assessment identifies structures which are within the minimum working distances assuming a 13-18 tonne vibratory roller or a large rockbreaker are used during construction (see **Figure 4** and **Appendix C**).

4.3 Construction Mitigation

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

The results of the construction noise assessment have been used to determine project specific mitigation measures that should be applied where feasible and reasonable. These are summarised in **Section 8.1**.

4.4 Operational Noise Modelling Methodology

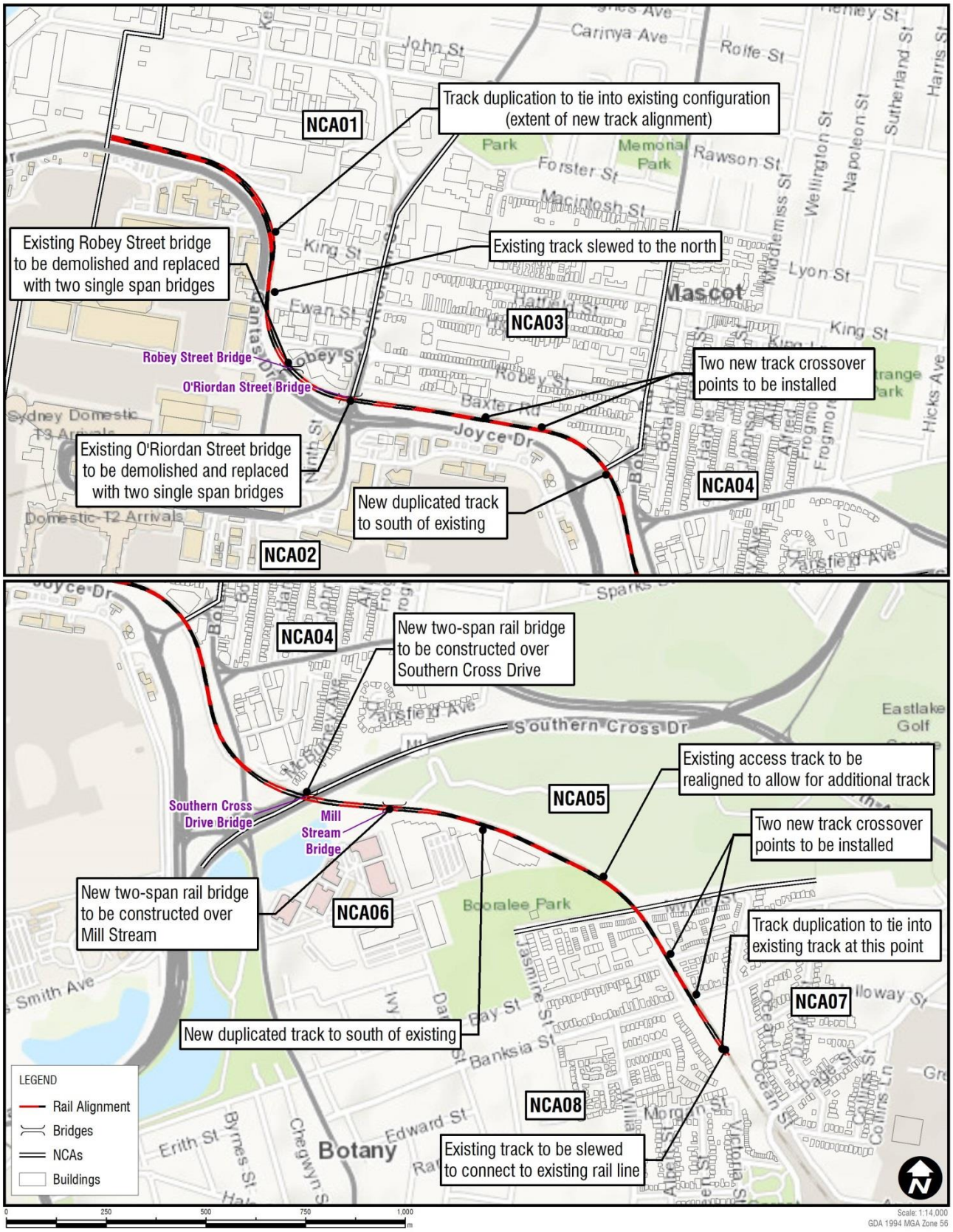
4.4.1 Key Features of Project

The key features of the project that have the potential to change noise impacts in the study area include:

- Duplication of the existing single bi-directional track, with the new track being to the south of the existing track. The new track is generally around 5 metres from the existing track.
- Slewing of the existing track in certain sections to make room for the new track.
- An increase in average freight train speeds.
- An increase in number of trains per day.
- New track crossovers near Bay Street in Botany and Baxter Road in Mascot to allow freight trains to cross between the existing and new tracks.
- Removal of the need for freight trains to stop and idle in passing loops and at either end of the existing single line.

The key features of the project are shown in **Figure 6**.

Figure 6 Key Features of the Project



4.4.2 Noise Model

A noise model of the study area has been used to predict noise levels from the operation of the project to all surrounding receivers. The model uses the Nordic Rail Traffic Noise Prediction Method (Kilde 1984) algorithms in SoundPLAN software.

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

The '**Without project**' scenarios use the existing track alignment, existing track features such as crossovers, bridges and level crossings, and existing operational features such as train speeds.

The '**With project**' scenarios use the proposed design of the project which includes all new works, bridges, proposed track modifications, and changes to civil structures such as cuttings and embankments. This scenario also includes the proposed operational changes such as increased train speeds and volumes.

Source Noise Levels

The source noise levels used in the modelling have been taken from the NSW rail noise database and are shown in **Table 29**.

Table 29 Source Noise Levels

Train Type	Reference Conditions	Source Noise Level (dBA)[1]	
		L_{AE}[2]	L_{Amax}[3]
Freight wagon rolling noise	1000 m of wagons	88	94
Freight locomotive rolling noise	1 locomotive, 20 m long	88	94
Freight locomotive engine and exhaust noise	1 locomotive, 20 m long	100	90

Note 1: Referenced to a train speed of 80 km/h and where rail roughness is in accordance with ISO 3095. The reference measurement location is 15m from the track centre and at a height of 1.5 m above top of rail.

Note 2: Logarithmic average sound exposure level.

Note 3: Represents the maximum noise level not exceeded for 95% of trains.

The source noise levels assume track in good condition and the running surface of the rail head is free of defects. Wheel tread condition is also assumed to be in good to fair condition. The maximum source noise levels are representative of locomotives operating in high notch.

The source noise levels and modelling methodology have been validated against the measured rail noise levels in the study area (see **Table 4**) in **Section 4.4.3**.

Track Feature Corrections

Impact noise from rail discontinuities such as turnouts, expansion joints or rail defects can increase noise levels from trains and are heard as impulsive noise as each train wheel passes over the discontinuity.

In areas where the track has tight radius curves, flanging noise and/or curve squeal is often heard and can increase noise levels at nearby receivers. The noise level corrections used in the modelling of track features are shown in **Table 30**.

Table 30 Track Feature Corrections

Feature	Noise Correction (dB)[1]	
	L_{Aeq}	L_{Amax}
Radius greater than 500m	+0	+0
Radius 400m to 500m	+8	+21
Radius 300m to 400m	+8	+21
Radius less than 300m	+9	+23
Turnouts	+6	+6
Level crossing	+3	+3

Note 1: Corrections taken from the NSW Rail Noise Database and the ARTC *Noise Modelling and Mitigation Guideline*.

Bridge Noise

Certain types of rail bridges can produce structure-radiated noise when trains pass over them. The corrections applied to the rail bridges in the study area are shown in **Table 31**.

Table 31 Rail Bridge Locations and Corrections

Bridge	Track[1]	Chainage	Bridge Details		
			Construction	Trackform	Correction[2]
Alexandria Canal Bridge	Existing Up Track	13.940 -14.020	Steel span and deck	Concrete sleepers on steel web	+8 dB
	Existing Down Track	13.940 -14.020			
Robey Street Bridge	New Up Track	12.600 - 12.570	Concrete span and deck	Ballast track	0 dB
	New Down Track	12.570 - 12.600			
O'Riordan Street Bridge	New Up Track	12.420 - 12.390	Concrete span and deck	Ballast track	0 dB
	New Down Track	12.390 - 12.420			
Wentworth Avenue Bridge	Existing Up and down Track	11.540 - 11.470	Concrete span and deck	Ballast track	0 dB
Botany Road Bridge	Existing Up Track	11.350 - 11.320	Steel span and deck	Direct Fix	+8 dB
	Existing Down Track	11.320 - 11.350			
Southern Cross Drive Bridge	Existing Up Track	11.200 - 11.110	Concrete span and deck	Ballast track	0 dB
	New Down Track	11.110 - 11.200	Precast concrete span, concrete deck		
Mill Stream Bridge	Existing Up Track	10.950 - 10.920	Concrete span and deck	Ballast track	0 dB
	New Down Track	10.910 - 10.940	Precast concrete span, concrete deck		

Note 1: Up is towards Port Botany and Down is away from Port Botany.

Note 2: Corrections taken from the NSW *Rail Noise Database* and the ARTC *Noise Modelling and Mitigation Guideline*.

Speed Profile

The existing and future speed profile for the Botany Line provided by the project team is shown below in **Figure 7** and **Figure 8**.

Figure 7 Speed Profile – Without Project

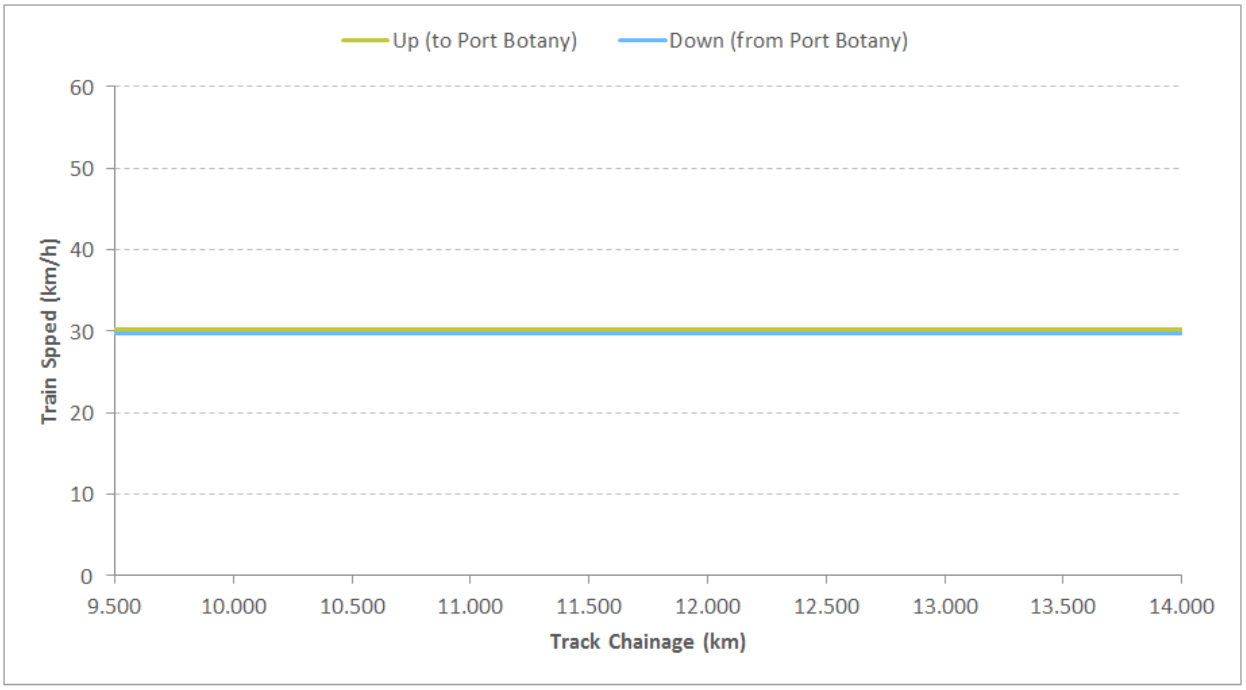
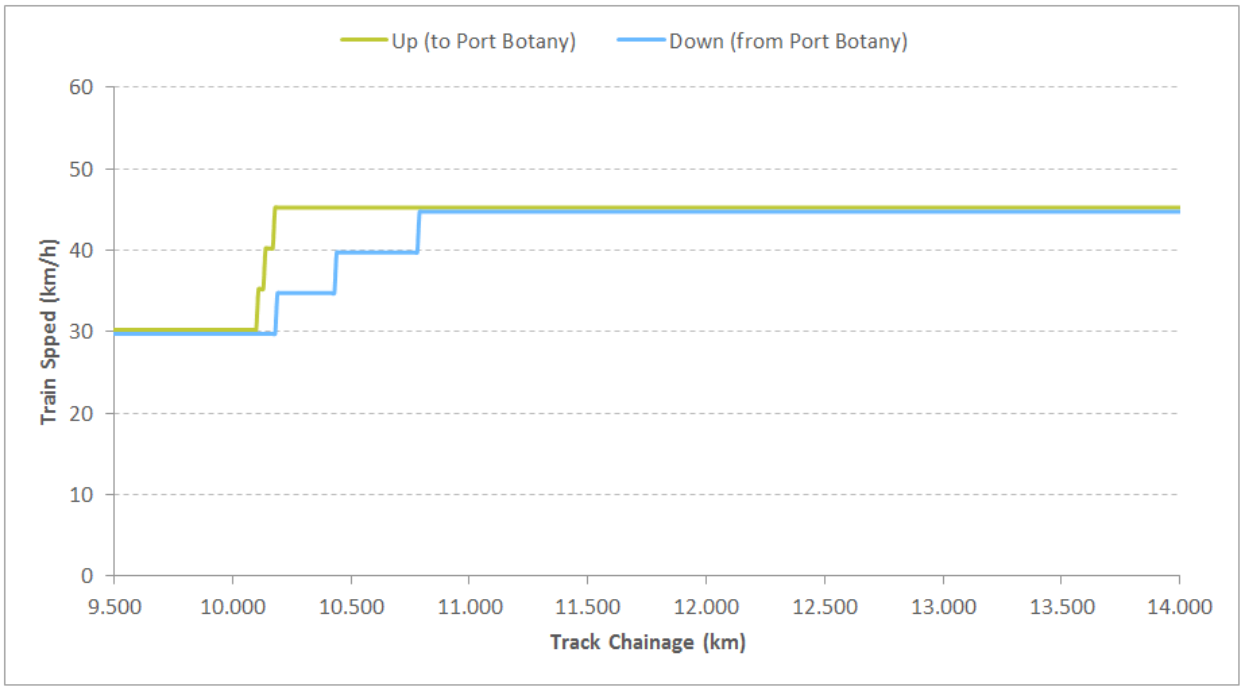


Figure 8 Speed Profile – With Project



Typical maximum train speeds in the study area are currently 30 kilometres per hour (km/h). The project would increase train speeds to up to 45 km/h for the track to the north of Myrtle Street in Botany.

Rail Traffic Data

The rail traffic data used in the noise modelling for the year of opening and the 10-year design year is shown in **Table 32**.

Table 32 Rail Traffic Data

Year	Scenario	Train Movements			
		Daytime		Night-time	
		To Port Botany	From Port Botany	To Port Botany	From Port Botany
2024 At Opening	Without project	24	24	14	14
	With project	24	24	14	14
2034 Future Design	Without project	28	28	17	17
	With project	35	35	21	21

4.4.3 Noise Model Validation

To validate the operational rail noise model, the 2018 existing scenario was modelled and compared to measurements of existing noise levels in the study area (see **Section 2.5**). The noise levels are predicted using the measured noise data (see **Table 5**) and the number of trains in a 24 hour period.

The validation measurement sites are shown in **Figure 3** and a summary of the noise model validation is provided in **Table 33**.

Table 33 Comparison of Measured versus Predicted Noise Levels

Location	Noise Level (dBA)					
	$L_{Aeq(24hour)}$			L_{Amax}		
	Measured	Predicted	Difference[1]	Measured	Predicted	Difference[1]
V01	72	70	-2.0	104	107	+2.4
V02	78	77	-1.4	115	111	-4.1
V03	67	66	-0.9	96	95	-1.6
V04	71	71	+0.0	104	105	+0.5
V05	64	62	-1.2	91	90	-0.7
V06	65	67	+2.1	98	99	+1.4
V07	65	64	-0.5	93	92	-0.2
		Median	**-0.9**		**Median**	**-0.2**

Note 1: Difference is Predicted minus Measured. A negative difference indicates the predicted level of rail noise is lower than the measured data, a positive difference indicates the predicted level is higher.

The above shows that the difference between the measured and predicted noise levels is generally within the acceptable range of ±2 dB at most locations. The only exception is location V02, where the noise model under predicts the maximum noise level by 4.1 dB. This location was adjacent to a particularly tight curve and a small number of trains were observed to result in very high levels of wheel squeal in comparison to other curves in the study area.

On this basis, the model is considered to be performing as expected and is valid for predicting rail noise levels for the project.

4.4.4 Noise Mitigation

The RING provides guidance in managing and controlling impacts from rail noise projects and describes the principles to be applied when reviewing noise mitigation.

Where a project is likely to result in impacts which exceed the identified trigger levels, then feasible and reasonable mitigation should be considered to reduce noise towards the relevant absolute trigger level. The guideline notes that it is not mandatory to achieve the trigger levels, but the assessment should provide justification where they cannot be met.

A noise mitigation measure is feasible if it can be engineered and is practical to build, given project constraints such as safety and maintenance requirements. Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measures.

The RING requires mitigation measures to be considered in the following order of preference:

- Source control – controlling noise and vibration at the point where the noise is generated
- Path control – controlling the transmission of noise and vibration from the source to noise sensitive receivers, such as through the use of noise barriers
- Receiver control – once source and transmission controls are exhausted, mitigation measures at the noise sensitive receivers are to be considered, such as at-property treatments.

4.5 Operational Vibration and Ground-borne Noise Modelling

A model developed in-house has been used to predict vibration levels from the operation of the project to all surrounding sensitive receivers. The model accounts for variables such as train speed, distance from source to receiver, vibration attenuation due to geometric spreading, material damping, angle of view and coupling losses from the ground into affected buildings.

The prediction of vibration uses many of the same modelling parameters discussed earlier in **Section 4.4** for the airborne noise assessment, with the addition of the items discussed below.

Source Vibration Levels

The source vibration levels reference the general assessment approach described in the U.S. Department of Transportation Federal Transit Administration (FTA) *Transit Noise and Vibration Impact Assessment*, and are shown in **Table 34**.

The maximum measured vibration levels on the existing Botany Line generally correspond to the FTA source vibration levels, with most trains measured during the survey observed to result in lower vibration levels than the reference level.

Table 34 Reference Freight Train Vibration Spectrum at 80 km/h and 7.5 m from Track Centreline

Track Type	Vibration Levels (dB_V re 1 nm/s) in 1/3 Octave Bands (Hz) – $L_{max,slow,95\%}$														Overall Level
	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	
Ballast	85	93	102	107	111	111	110	108	107	106	100	93	90	85	118

Note: Data referenced from measurements on the Botany Line as part of other projects.

The source vibration levels assume track in good condition and that the running surface of the rail head is free of defects. Wheel tread condition is also assumed to be in good to fair condition.

4.5.2 Conversion of Vibration Predictions to Ground-borne Noise

The ground-borne vibration predictions have been used to predict ground-borne noise levels from the project using industry standard corrections (see *Measurement and Assessment of Ground-borne Noise and Vibration*, Association of Noise Consultants, 2012). The predictions are representative of the ground-borne noise level that would be expected to be apparent within a room of the affected receivers.

5 Construction Impact Assessment

The potential noise and vibration impacts during project construction have been predicted for all identified sensitive receivers in the study area and the impacts are discussed in the following sections. Additional information relating to the construction assessment is provided in **Appendix C**.

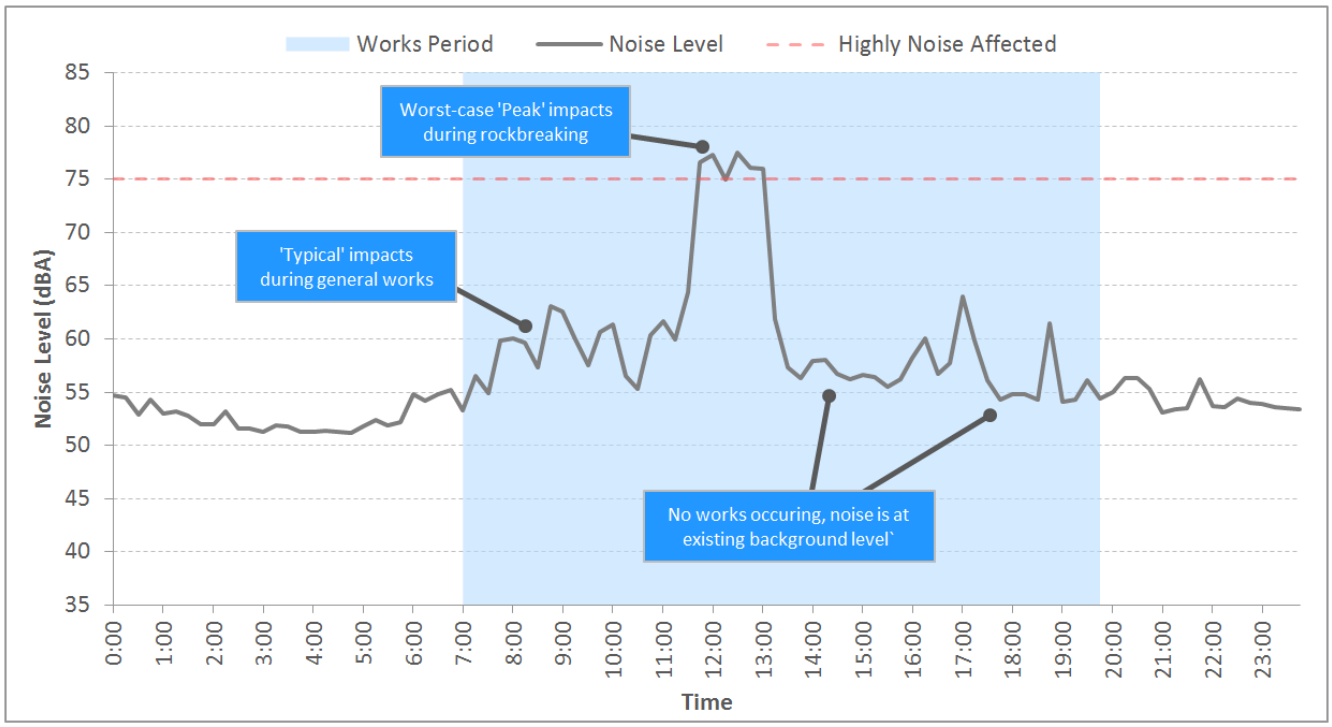
The methodology and various inputs to the construction assessment are outlined in **Section 4.1**.

5.1 Overview of Construction Impacts on Residential Receivers

The following summary is based on the predicted noise impacts on the most affected receivers in each NCA and is representative of the worst-case situation where construction equipment is at the closest point to each receiver.

For most works, the construction noise impacts would frequently be lower than predicted as the worst-case situation is typically only apparent for a relatively short period when noisy equipment is in use nearby. This concept is illustrated in **Figure 9** which shows noise levels measured next to major construction works during a period of rockbreaking and shows how construction noise levels can vary over the works period.

Figure 9 Example of Indicative Construction Noise Levels during Rockbreaking



Note: The measurement location was around 40 metres away from the works.

In the above example, whilst the worst-case levels result in Highly Noise Affected impacts, these only last for part of the works period and the noise levels during less noisy activities are much lower. There are also periods when no works are occurring and noise levels are at the existing ambient noise level (eg road traffic and general urban hum).

The following assessment shows the predicted noise impacts based on the exceedance of the NML, as per the three categories in **Table 35**. The likely subjective response of people affected by the impacts is also shown in the table, noting that the subjective response would vary and depends on the period in which the impacts occur (ie people are generally less sensitive to impacts during the daytime and more sensitive in the evening and night-time).

Table 35 NML Exceedance Bands and Corresponding Qualitative Response to Impacts

Exceedance of NML	Symbol	Likely Subjective Response
Compliance	·	Barely noticeable
1 to 10 dB	●	Marginal to minor
11 dB to 20 dB	◆	Moderate
>20 dB	■	High

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

A summary of the predicted construction noise impacts in each NCA for residential receivers is shown in **Table 36**. Detailed noise level predictions and summaries of the number of receivers predicted to have 'minor', 'moderate' and 'high' impacts in each NCA are provided in **Appendix C**.

Where impacts are predicted, the methods for controlling the impacts through the use of mitigation measures and management techniques are discussed in more detail in **Section 8.1**.

Table 36 Predicted Construction Noise Exceedances – Residential Receivers

Period	ID	Scenario	Activity	NCA01	NCA02	NCA03	NCA04	NCA05	NCA06	NCA07	NCA08
Daytime	1a	Enabling Works	Billboard Demolition	·	·	●	·	·	·	·	·
	1b		Utilities	·	·	◆	◆	·	·	■	■
	1c		Veg. Clearing & Property Adjust.	·	·	◆	◆	·	·	■	■
	2a	Compounds	Establishment	·	·	·	·	·	·	●	■
	2b		Operations	·	·	·	·	·	·	·	◆
	3a	Bridge Works	Demolition (inc. breaker)	·	·	●	◆	·	·	·	●
	3b		Construction	·	·	·	●	·	·	·	·
	4a	Retaining	Construction	·	·	·	●	·	·	·	·
	5a	Track Works	Peak	·	·	◆	◆	·	·	■	■
	5b		Typical	·	·	·	·	·	·	●	◆
	6a	Signalling (inc. CSR)		·	·	●	●	·	·	◆	■
	6b	Testing, Commissioning & Finishing		·	·	●	●	·	·	◆	■
Evening	1a	Enabling Works	Billboard Demolition	·	·	●	·	·	·	·	·
	1b		Utilities	●	·	■	◆	·	·	■	■
	1c		Veg. Clearing & Property Adjust.	●	·	■	■	·	·	■	■
	2a	Compounds	Establishment	·	·	·	·	·	·	●	■
	2b		Operations	·	·	·	·	·	·	·	◆
	3a	Bridge Works	Demolition (inc. breaker)	·	·	◆	■	·	·	·	●
	3b		Construction	·	·	●	◆	·	·	·	·
	4a	Retaining	Construction	·	·	●	◆	·	·	·	·
	5a	Track Works	Peak	●	·	■	■	·	·	■	■
	5b		Typical	·	·	●	●	·	·	◆	◆
	6a	Signalling (inc. CSR)		·	·	◆	●	·	·	■	■
	6b	Testing, Commissioning & Finishing		·	·	◆	◆	·	·	■	■
Night-time	1a	Enabling Works	Billboard Demolition	·	·	◆	·	·	·	·	·
	1b		Utilities	●	·	■	■	·	·	■	■
	1c		Veg. Clearing & Property Adjust.	◆	·	■	■	·	·	■	■
	2a	Compounds	Establishment	·	·	●	●	·	·	◆	■
	2b		Operations	·	·	·	·	·	·	●	■
	3a	Bridge Works	Demolition (inc. breaker)	●	·	◆	■	·	·	●	●
	3b		Construction	·	·	◆	■	·	·	·	●
	4a	Retaining	Construction	●	·	◆	◆	·	·	·	●
	5a	Track Works	Peak	●	·	■	■	·	·	■	■
	5b		Typical	·	·	●	●	·	·	◆	■
	6a	Signalling (inc. CSR)		·	·	◆	◆	·	·	■	■
	6b	Testing, Commissioning & Finishing		·	·	◆	◆	·	·	■	■

Key to Impacts ● Marginal to minor (1 to 10 dB) ◆ Moderate (11 dB to 20 dB) ■ High (>20 dB)

Note: Cells with no coloured shape represent noise levels are either compliant or there are no residential receivers in the catchment.

The above assessment for residential receivers shows that:

- The highest impact is generally seen in scenarios which use of noise intensive equipment such as rockbreakers, concrete saws or ballast tampers. For most scenarios, these noise intensive works would however only be required for a relatively short period. Noise levels and impacts during the works that do not required noise intensive equipment are significantly lower.
- The highest impacts on residential receivers are at predicted in NCA07 and NCA08 (to the south of Eastlake golf course in Botany and Pagewood) due to the proximity of receivers in this area. 'High' impacts (see **Table 35** for impact category definitions) are also predicted in NCA03 and NCA04 (in Mascot near to Joyce Drive and Botany Road). Residential receivers are not typically located in the other areas of the project.
- During the daytime, 'high' impacts are seen in the noisiest scenarios at the most affected receivers in NCA07 and NCA08, with 'moderate' impacts NCA03 and NCA04. During the night-time, 'high' impacts are in NCA03, NCA04, NCA07 and NCA08, with 'minor' or 'moderate' impacts in NCA01.
- The worst-case impacts are typically in the following scenarios:
  - *Scenario 1b, Enabling Works – Utilities*
  - *Scenario 1c, Enabling Works – Vegetation Clearing & Property Adjustment*
  - *Scenario 2a, Compounds – Establishment*
  - *Scenario 5a, Track Works – Peak*
  - *Scenario 6a, Signalling (inc. CSR)*
  - *Scenario 6b, Testing, Commissioning & Finishing.*
- Works that do not require noise intensive equipment generally result in considerably lower impacts.

5.2 Detailed Construction Noise Impacts – All Receiver Types

The predicted construction noise impacts from each works scenario are provided in assessment tables in **Appendix C** for each NCA. The following sections provide a detailed discussion of the key construction impacts at all receivers which are associated with:

- *Enabling Works – Vegetation Clearing & Property Adjustment*, which is the scenario with the predicted **worst-case impacts** due to highest predicted noise levels
- *Compounds – Operation*, which is the scenario with the **longest duration**.

5.2.1 Worst-case Scenario

5.2.1.1 Site Establishment – All Locations

The worst-case construction impacts are predicted during Enabling Works when noise intensive equipment like concrete saws are in use. The predicted night-time impacts during Enabling Works are shown in:

- **Figure 10** – *Scenario 1c, Enabling Works – Vegetation Clearing & Property Adjustment*, when noise intensive equipment is being used as part of these works
- **Figure 11** – *Scenario 1a, Enabling Works – Billboard Demolition*, for works which are more localised and are not required in the full project site.

Noise intensive equipment would be required for the Enabling Works with concrete saws being used at times during the night-time as certain aspects of the works can only take place during:

- 48-hour track possessions during which works would occur throughout the possession period
- During road closures which would be at night to minimise the impact on the surrounding roads.

Figure 10 Predicted Impacts 'Scenario 1c, Enabling Works – Clearing and Adjust.' in All Locations (Night-time)

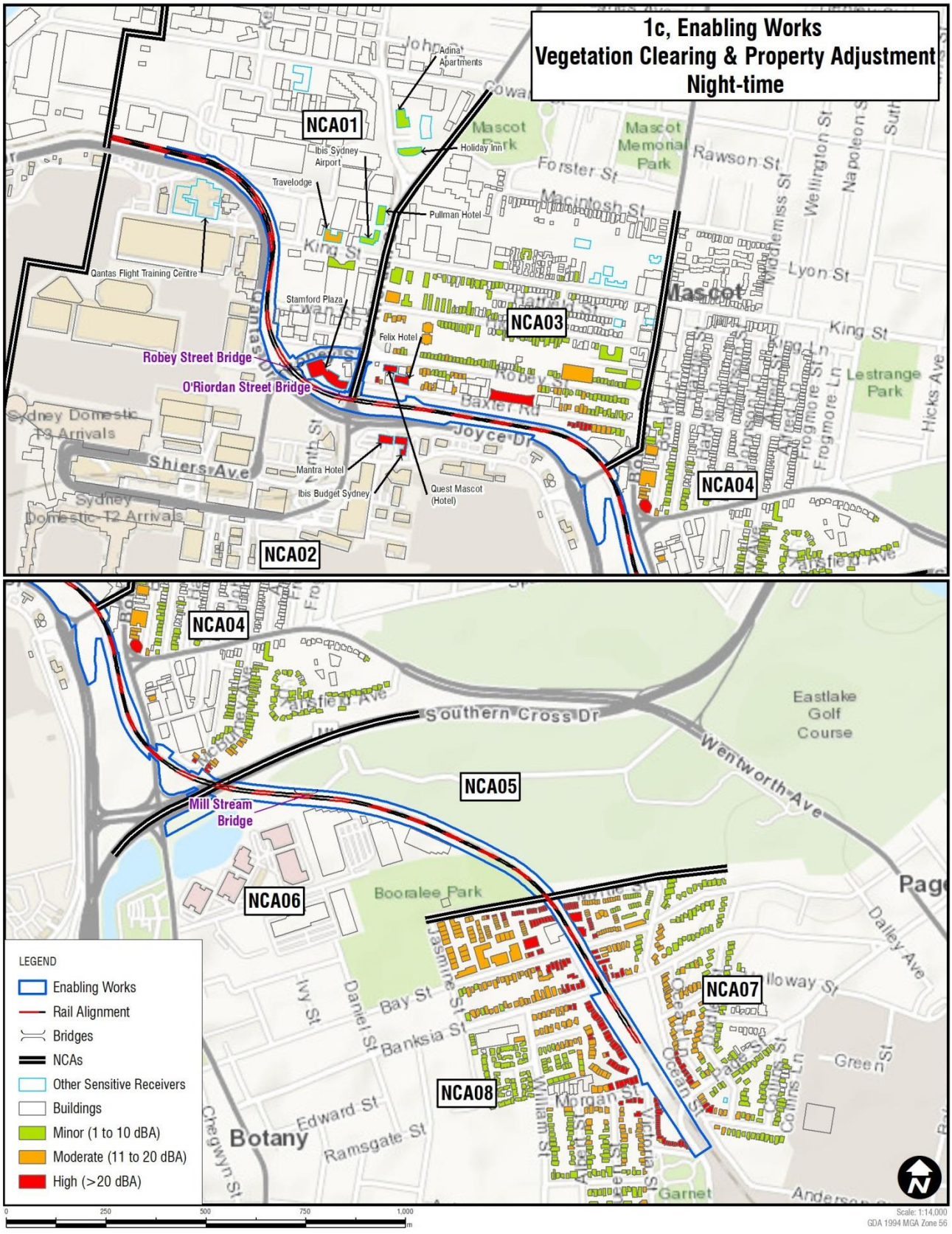
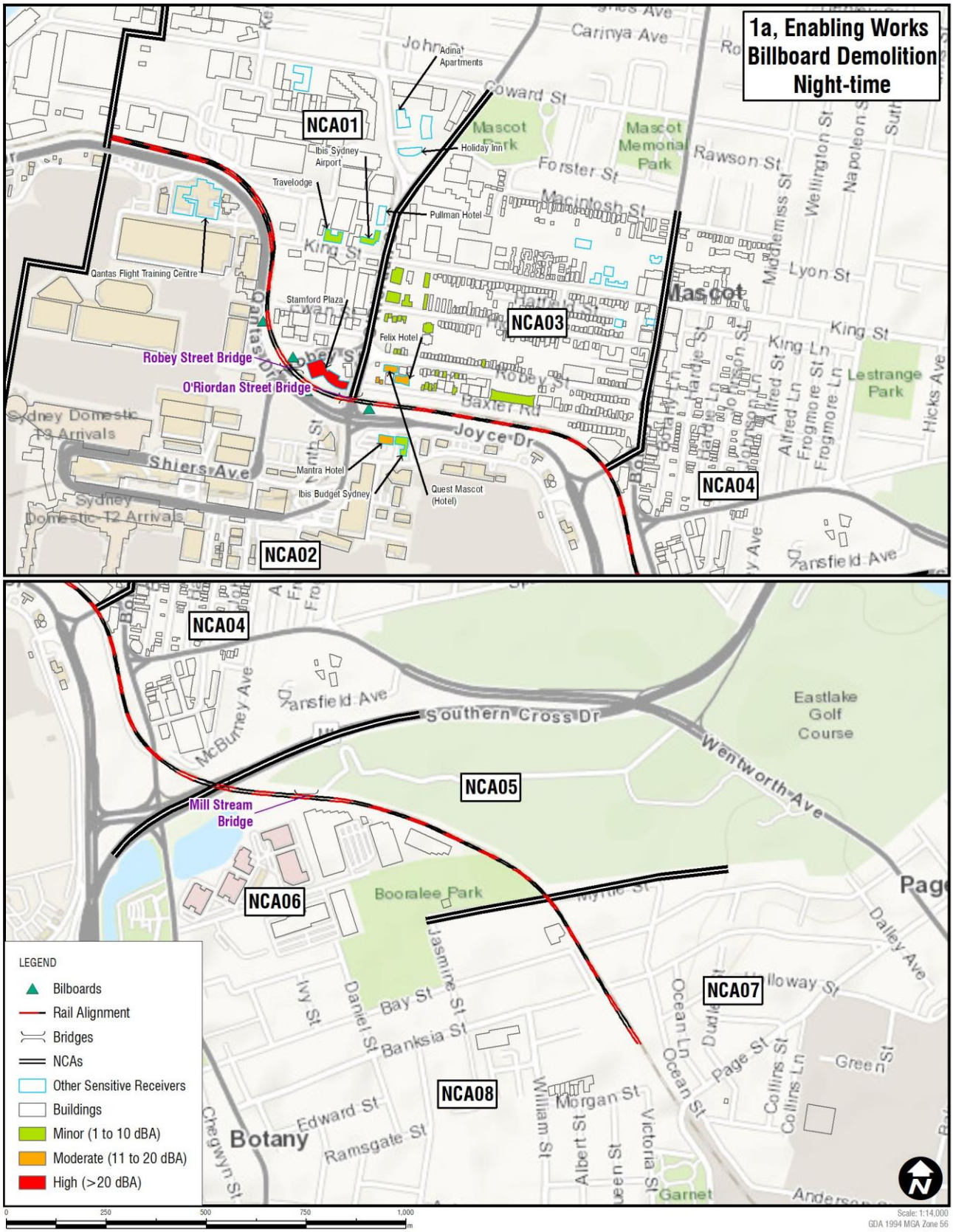


Figure 11 Predicted Impacts 'Scenario 1a, Enabling Works – Billboard Demolition' in All Locations (Night-time)



The above assessment shows that during the use of noise intensive equipment in *Enabling Works – Vegetation Clearing & Property Adjustment*, 'high' impacts are likely at the nearest receivers to the works in most NCAs. The worst-case impacts would however only occur when the noisiest equipment such as concrete saws are in use. When noise intensive equipment is not being used, the noise levels would be substantially lower.

The worst-case impacts during *Scenario 1a, Enabling Works – Billboard Demolition* are less widespread, with the nearest receivers generally being subject to 'moderate' impacts.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur. The impacts would also be lower than predicted when works are occurring in distant parts of the project site or where they are screened from view of the nearest receivers.

5.2.2 Longest Duration Scenario

The longest duration works scenario is related to operation of the Compounds. During the initial establishment of the compounds, noisy works would occur during activities such as ground preparation.

The operation of the compounds includes activities such as deliveries, and storage of equipment and material. Compound operation would generally not require the use of noise intensive equipment.

The predicted night-time impacts during Compounds are shown in:

- **Figure 12** – *Scenario 2a, Compounds – Establishment*, when noisy ground preparation works are being completed
- **Figure 13** – *Scenario 2b, Compounds – Operations*, for works associated with general operation of the compounds. These works would not require the use of noise intensive equipment.

Figure 12 Predicted Impacts 'Scenario 2a, Compounds – Establishment' in All Locations (Night-time)

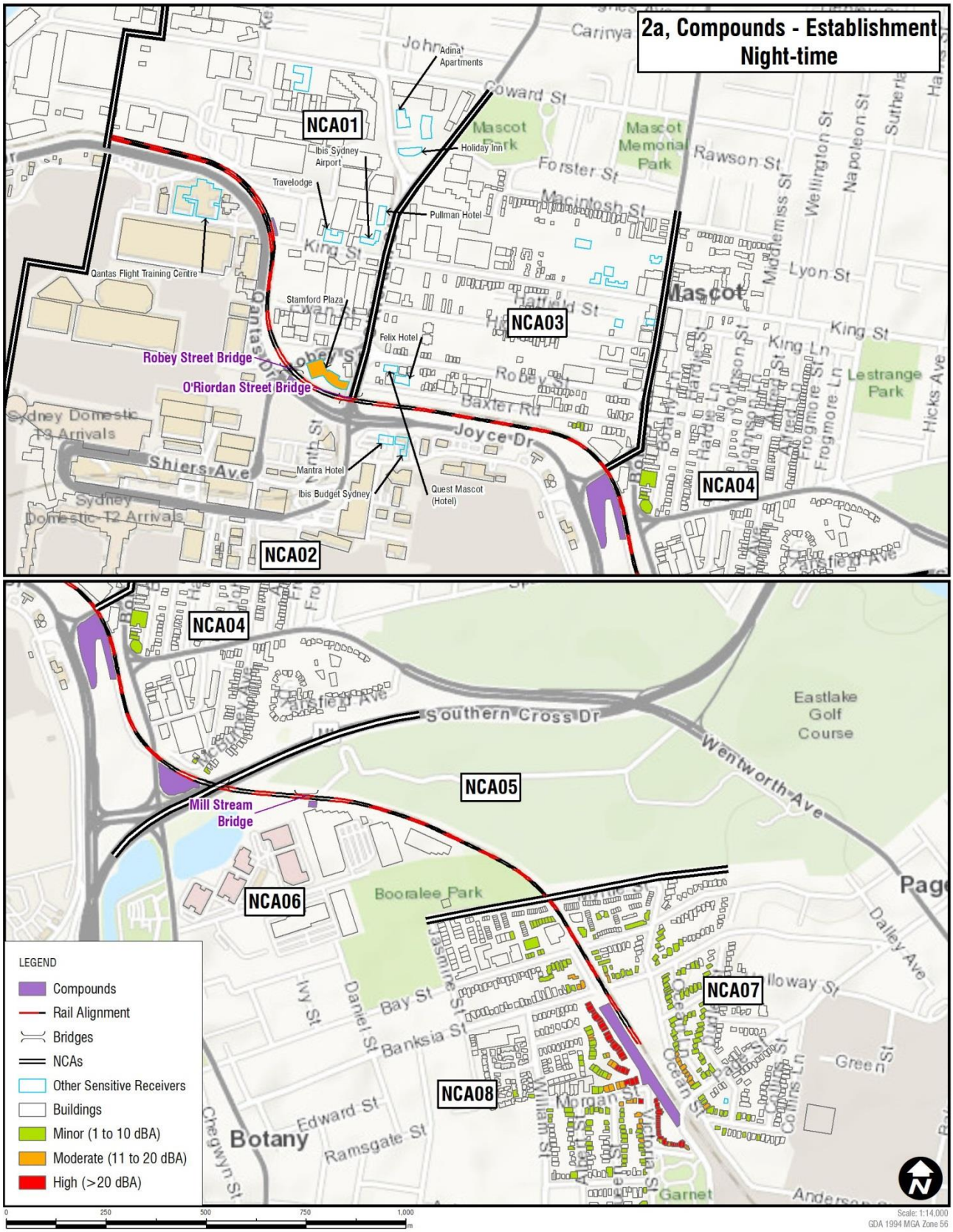
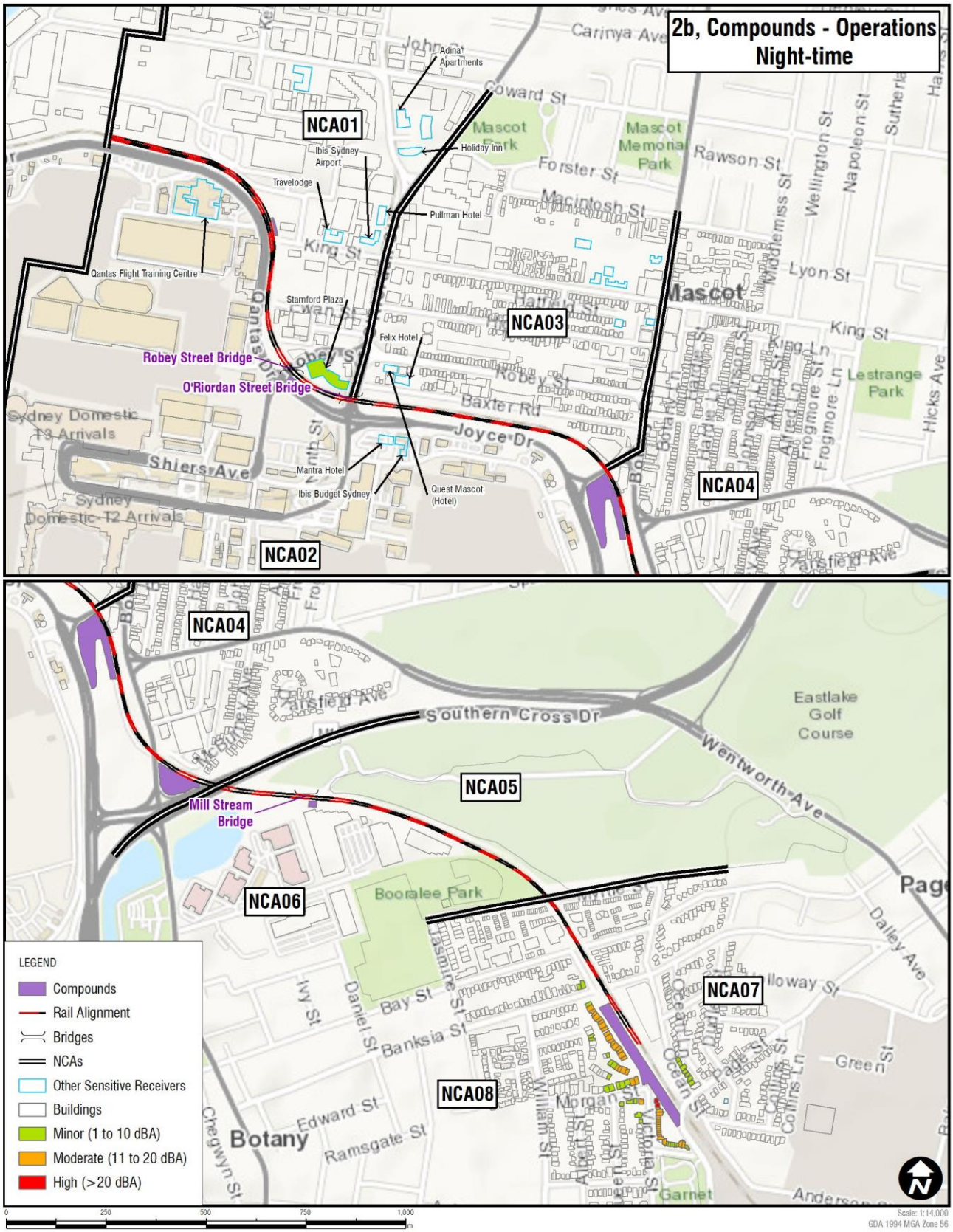


Figure 13 Predicted Impacts 'Scenario 2b, Compounds – Operations' in All Locations (Night-time)



The above assessment shows during use of noise intensive equipment in *Compound – Establishment*, 'high' impacts are likely at the nearest receivers to the works in NCA07 and NCA08. 'Moderate' and 'minor' impacts are seen at the nearest receivers in other areas of the project. The noisiest equipment such as chainsaws would likely only be required for short periods at the start of the works and when noise intensive equipment is not being used, the noise levels would be substantially lower.

The worst-case impacts during *Compound – Operation* are substantially lower. 'Moderate' and 'minor' impacts affect the nearest several rows of receivers near the compound between Banksia Street and Stephen Road in NCA07 and NCA08. Receivers in other parts of the study area are generally predicted to not be impacted by operation of the compounds during the night-time.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur. The impacts would also be lower than predicted when works are occurring in distant parts of the project site or where they are screened from view of the nearest receivers.

5.3 Highly Noise Affected Residential Receivers

Residential receivers that are subject to noise levels of 75 dBA or greater are considered Highly Noise Affected by the ICNG. Receivers can be Highly Noise Affected when noisy works are occurring close to residents.

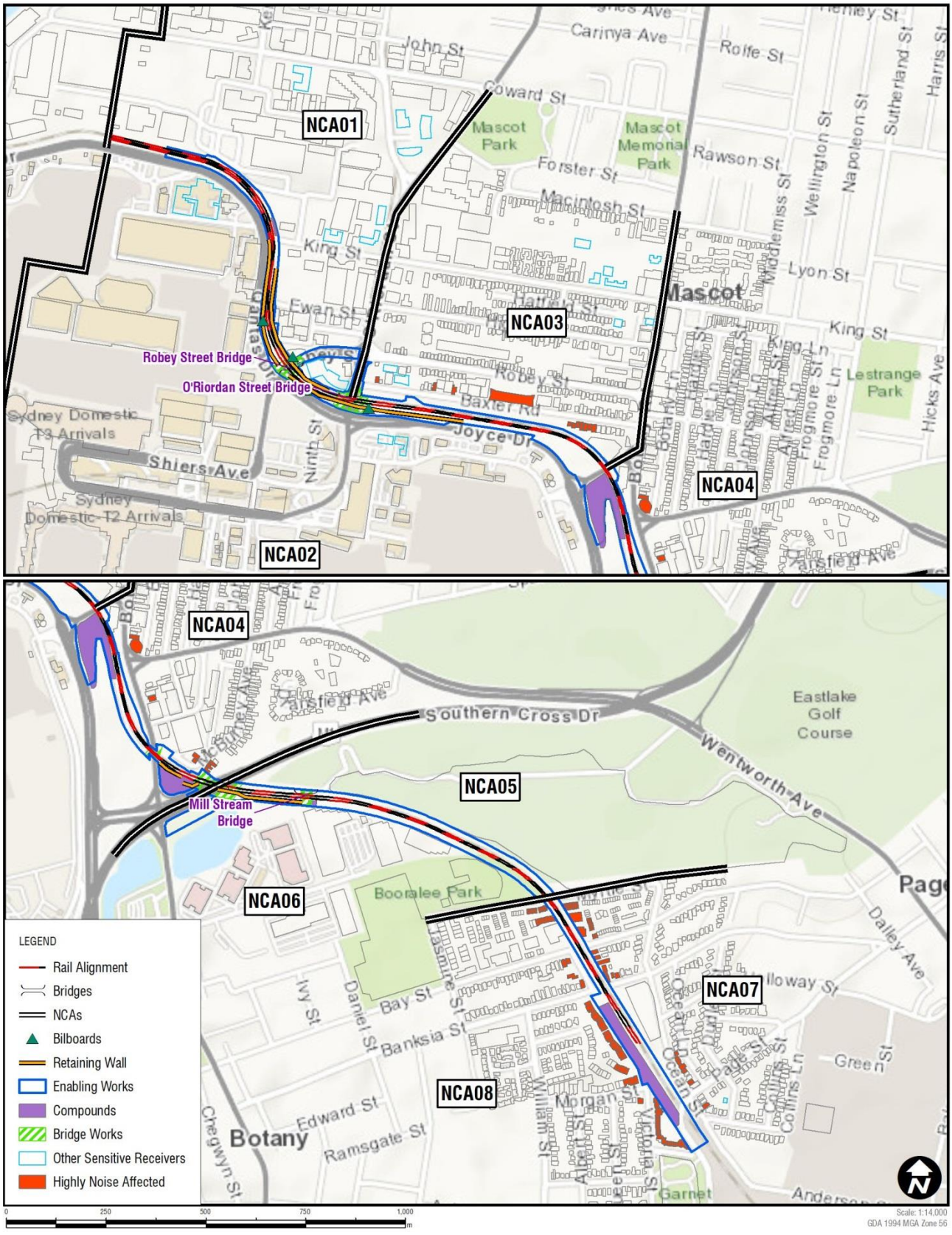
The receivers which could potentially be Highly Noise Affected during the worst-case impacts from the project are summarised in **Table 37** and shown in **Figure 14**.

The predictions assume the worst-case scenarios are occurring at all locations and therefore present all Highly Noise Affected receivers in one assessment. In reality, work would occur in isolated locations and the number of Highly Noise Affected receivers during any single works period would be less than shown.

Table 37 Predicted Number of Highly Noise Affected Residential Receivers

ID	Scenario	Activity	NCA01	NCA02	NCA03	NCA04	NCA05	NCA06	NCA07	NCA08
1a	Enabling Works	Billboard Demolition	-	-	-	-	-	-	-	-
1b		Utilities	-	-	3	3	-	-	13	39
1c		Veg. Clearing & Property Adjust.	-	-	11	8	-	-	32	72
2a	Compounds	Establishment	-	-	-	-	-	-	-	-
2b		Operations	-	-	-	-	-	-	-	-
3a	Bridge Works	Demolition (inc. breaker)	-	-	-	2	-	-	-	-
3b		Construction	-	-	-	1	-	-	-	-
4a	Retaining Walls	Construction	-	-	-	-	-	-	-	-
5a	Track Works	Peak	-	-	7	4	-	-	21	40
5b		Typical	-	-	-	-	-	-	-	-
6a	Signalling (inc. CSR)		-	-	-	-	-	-	-	-
6b	Testing, Commissioning & Finishing		-	-	-	-	-	-	1	-

Figure 14 Highly Noise Affected Residential Receivers (All Works)



The scenarios with the most Highly Noise Affected receivers are:

- *Scenario 1b, Enabling Works – Utilities*
- *Scenario 1c, Enabling Works – Vegetation Clearing & Property Adjustment*
- *Scenario 5a, Track Works – Peak*

The most impacted receivers are typically dwellings which are close to the project and have direct line of sight to the nearest works. Whilst certain receivers are predicted to be Highly Noise Affected, this would only occur when works using noise intensive equipment are being carried out near to particular residential receivers and would only be apparent for relatively short periods.

5.4 Other Sensitive Receivers

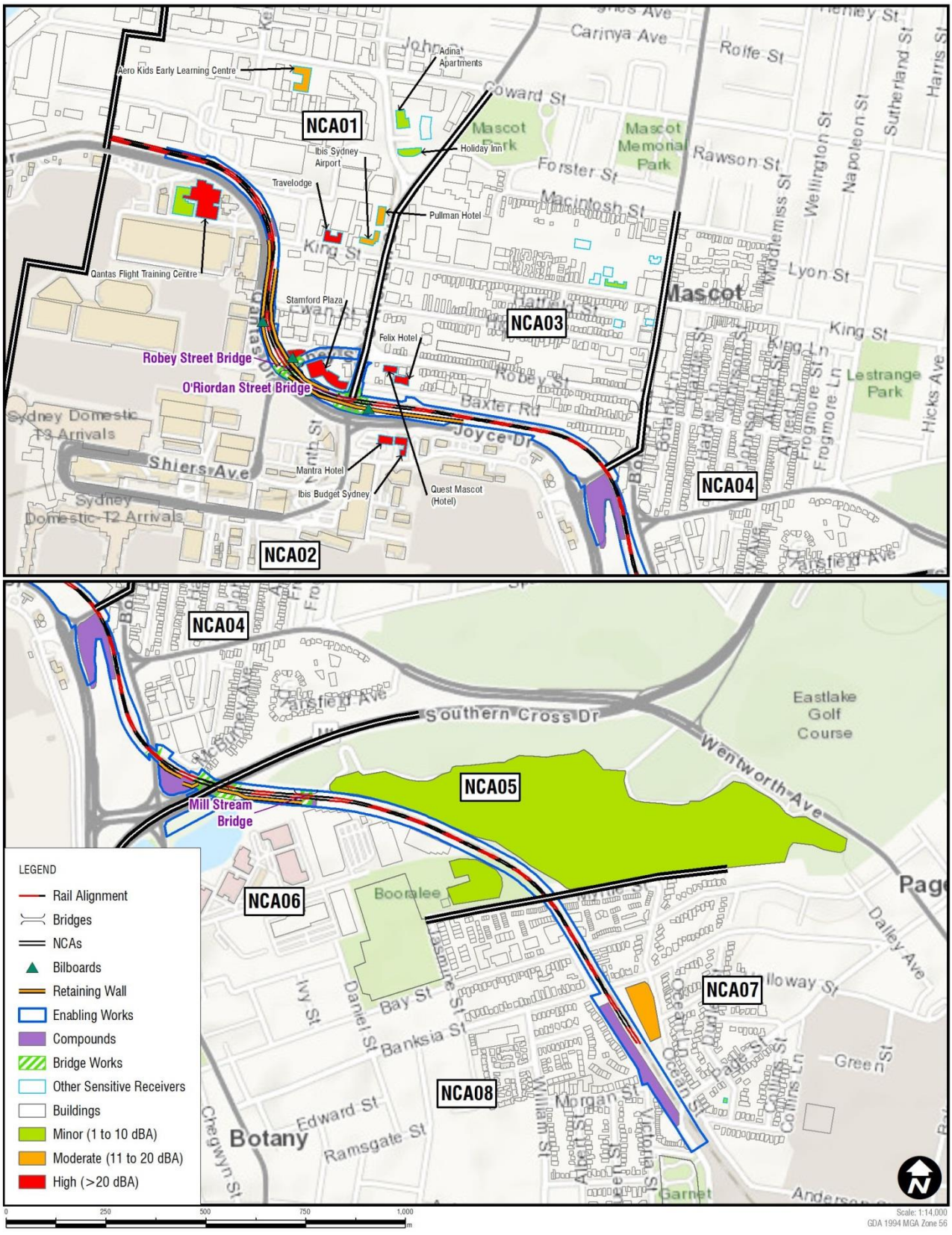
There are several categories of 'other sensitive' receivers in the project site, including educational facilities, places of worship, child care centres and hotels.

The predicted NML exceedances for 'other sensitive' receivers are summarised in **Table 38**. The summary is for all NCAs and shows the impacts in bands of 10 dB above the corresponding NML, separately by receiver type. The predicted worst-case impacts on 'other sensitive' receivers are also shown in **Figure 15**.

Table 38 Overview of 'Other Sensitive' Receiver NML Exceedances

ID	Scenario	Activity	Number of Receivers																								
			Education-al			Medical			Place of Worship			Child Care			Library			Outdoor Active			Outdoor Passive			Hotels – Daytime			Hotels – Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
1a	Enabling Works	Billboard Demolition	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	1	-	3	3	1
1b		Utilities	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	2	-	-	1	1	-	1	4	1	4	1	5
1c		Clearing & Property Adjust.	1	-	1	-	-	-	-	-	-	1	1	-	-	-	-	2	-	-	-	1	1	2	5	1	2	2	6
2a	Compounds	Establishment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-
2b		Operations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
3a	Bridge Works	Demolition (inc. breaker)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	3	-	4	2	3
3b		Construction	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	-	-	1	4	-
4a	Retaining Walls	Construction	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	1	-	3	4	1
5a	Track Works	Peak	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-	2	-	1	4	1	4	1	5
5b		Typical	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	1	-
6a	Signalling (inc. CSR)		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	-	-	2	4	-
6b	Testing, Commissioning & Finishing		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	4	1	-	1	4	1
	Key to Impacts		● Marginal to minor (1 to 10 dB)									◆ Moderate (11 dB to 20 dB)									■ High (>20 dB)								

Figure 15 Predicted Worst-case Noise Impacts – Other Sensitive Receivers



The above assessment shows the following:

- The worst-case impacts are seen in scenarios which use noise intensive equipment. The predicted noise levels and NML exceedances during less noisy works are significantly lower.
- The closest hotels are likely to be subject to 'high' impacts during the worst-case scenarios. The hotels are:
  - Stamford Plaza Hotel and Travelodge in NCA01
  - Mantra Hotel and Ibis Budget Sydney Airport in NCA02
  - Quest Hotel and Felix Hotel in NCA03.

  The more distant hotels are predicted to be subject to 'moderate' or 'minor' worst-case impacts.

  Certain construction works would at times be required to be completed near to hotels during the night-time. The most affected hotels are however likely to have high performance facades and glazing due to high existing noise levels near the airport which could potentially reduce construction noise impacts to acceptable internal levels for many of the construction works.

  Similar to the assessment of residential impacts, the worst-case noise levels and impacts would only be apparent for relatively short durations of the works.

  Further investigation of the potential impacts on hotels near to the construction works should be completed during detailed design. Appropriate criteria should be set which takes into account the existing facade performance of the affected hotels, noting that most of the hotels are of recent construction and are likely to have high performance facades.
- The Qantas Flight Training Centre is predicted to be subject to 'high' impacts during the worst-case scenarios when noise intensive equipment is being used nearby.
  - The centre provides flight training for pilots and cabin crew and operates 24 hours a day, seven days a week. It has several specialist flight simulators that are required to be kept operational to meet training needs and the simulators are highly sensitive to noise impacts as they simulate aircraft warning sounds and events which need to be easily discernible by pilots during training.

    It is noted that Qantas are proposing to relocate the centre to King Street in Mascot, which is around 150 m to the east of the existing centre. Impacts on the proposed future developments are discussed in **Section 5.9**.
- Two child care centres and three outdoor areas are predicted to experience 'moderate' or 'minor' impacts. These are:
  - Aero Kids Early Learning Centre in NCA01
  - Eastlake golf course in NCA05
  - Booralee Park in NCA06
  - Pagewood Kindergarten and Gaiarine Gardens in NCA07.
- The remaining 'other sensitive' receivers identified in the study area are not expected to be impacted by construction of the project.

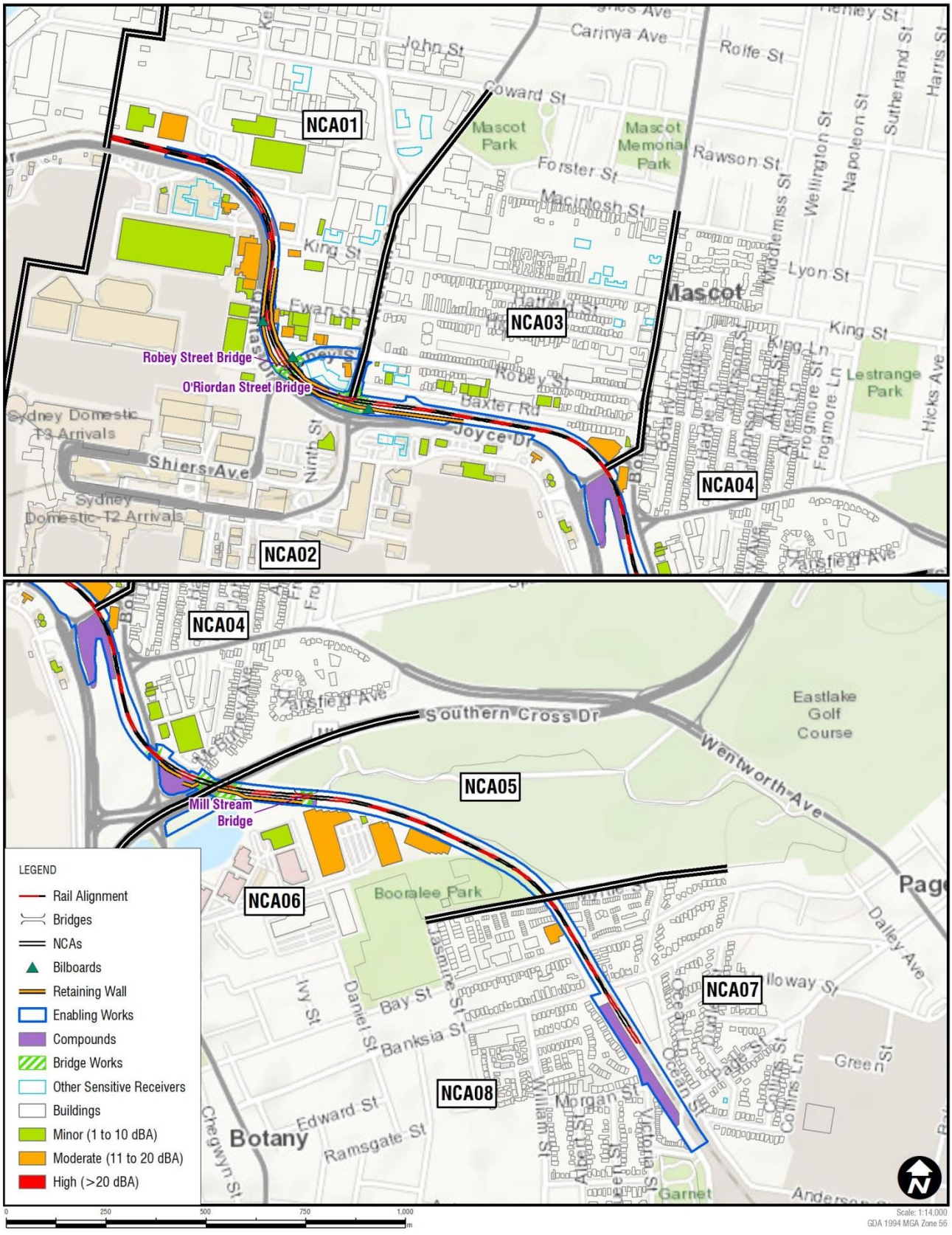
5.5 Commercial Receivers

A summary of the predicted construction noise impacts in each NCA for commercial receivers is presented in **Table 39** and shown in **Figure 16**. Noise level predictions are provided in **Appendix C**.

Table 39 Predicted Construction Noise Exceedances – Commercial Receivers

Period	ID	Scenario	Activity	NCA01	NCA02	NCA03	NCA04	NCA05	NCA06	NCA07	NCA08
When in Use	1a	Enabling Works	Billboard Demolition	●	·	·	·	·	·	·	·
	1b		Utilities	●	●	◆	◆	·	●	·	◆
	1c		Veg. Clearing & Property Adjust.	◆	◆	◆	◆	·	◆	·	◆
	2a	Compounds	Establishment	·	·	·	·	·	●	·	·
	2b		Operations	·	·	·	·	·	·	·	·
	3a	Bridge Works	Demolition (inc. breaker)	●	·	·	●	·	◆	·	·
	3b		Construction	·	·	·	·	·	●	·	·
	4a	Retaining Walls	Construction	●	●	·	·	·	·	·	·
	5a	Track Works	Peak	◆	◆	◆	◆	·	◆	·	◆
	5b		Typical	·	·	·	·	·	·	·	·
	6a	Signalling (inc. CSR)		·	·	●	●	·	·	·	●
	6b	Testing, Commissioning		●	·	●	●	·	·	·	●
Key to Impacts		● Marginal to minor (1 to 10 dB)		◆ Moderate (11 dB to 20 dB)				■ High (>20 dB)			

Figure 16 Predicted Worst-case Impacts on Commercial Receivers



The above assessment shows that for commercial receivers:

- Moderate impacts are seen in several areas of the project during:
  - *Scenario 1b, Enabling Works – Utilities*
  - *Scenario 1c, Enabling Works – Vegetation Clearing & Property Adjustment*
  - *Scenario 3a, Bridge Works – Demolition (inc. breaker)*
  - *Scenario 5a, Track Works – Peak*
- The worst-case impacts are seen in scenarios which use noise intensive equipment. Noise levels and exceedances during the less noisy works are significantly lower.
- No commercial receivers are predicted to have high impacts.

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

5.6 Sleep Disturbance

A sleep disturbance screening assessment has been undertaken for the construction works and is contained in the assessment tables in **Appendix C**. Review of the predictions shows that the sleep disturbance screening criterion is likely to be exceeded when night works are occurring near to residential receivers. The receivers which would potentially be affected by sleep disturbance impacts are generally the same receivers where 'high' night-time impacts have been predicted (see **Section 5.1** and **5.2**).

There are a number of key activities which would require consecutive days of works out of hours which could result in sleep disturbance impacts at nearby receivers. These include key activities such as:

- During bridge construction at Southern Cross Drive, such as piling and construction of piers, where major road closures are only allowed as consecutive nights during a week. For example, subject to relevant approvals these works may include four nights from 11 pm to 5 am per week for three weeks.
- Where works are required immediately adjacent to the active rail line, such as during construction of the retaining wall, track formation, track slewing and construction of CSR (utilities). These would likely be undertaken during morning rail possessions which typically moves progressively along the alignment. For example, subject to approval of morning possessions, works would occur between 4 am and 9 am. The works would move along the alignment and would typically take around three months to complete about 200 m.
- Preparation for bridge demolition at Robey and O'Riordan Streets in the lead up to major weekend road closures. For example, this would require around one week of night works where works are near to trafficable lanes and there is a need for lane closures.

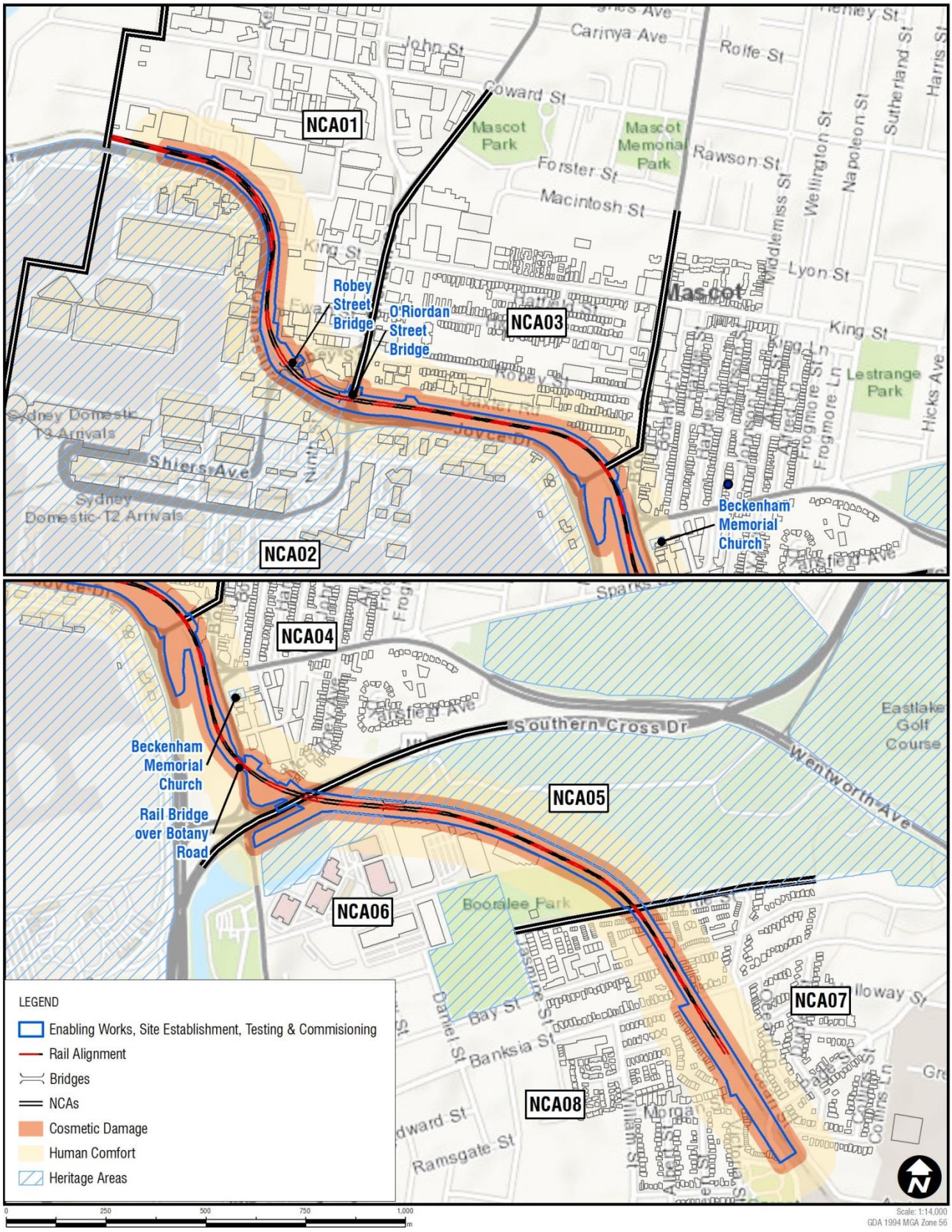
The requirements for night-time works would be confirmed as the project progresses and detailed construction planning information becomes available. Construction mitigation and management measures are discussed further in **Section 8.1**.

5.7 Construction Vibration Assessment

The main potential sources of vibration from the construction works are vibratory rollers and rockbreakers.

Vibration offset distances have been estimated from the recommended minimum working distances for cosmetic damage and human response in **Table 17**. The assessment assumes that a large rockbreaker is required in the project site and the assessment is summarised in **Figure 17**.

Figure 17 Construction Vibration Assessment (including Heritage Items)



5.7.1 Cosmetic Damage Assessment Summary

The above assessment shows that the distance between the construction works and the nearest sensitive receivers is generally sufficient for most buildings to be unlikely to suffer cosmetic damage.

Some buildings are however within the recommended minimum working distance, particularly in the eastern section of the project where residential receivers in NCA07 and NCA08 (near Myrtle Street, Ellis Street and Banksia Street in Botany) are located close to the works.

5.7.2 Human Comfort Vibration Assessment

Certain receivers which are adjacent to the construction areas are within the human comfort minimum working distance shown in **Figure 17** and occupants of affected buildings may be able to perceive vibration impacts at times when vibration generating equipment is in use.

Where impacts are perceptible, they would likely only be apparent for relatively short durations when equipment such as rockbreakers or vibratory rollers are in use nearby.

5.7.3 Heritage Structures

Heritage buildings and structures that have been identified in the study area are shown in **Figure 17**. The heritage items which are within the cosmetic damage minimum working distance are shown in the figure and also listed in **Table 40**.

Table 40 Heritage Items Identified within Cosmetic Damage Minimum Working Distance

NCA	Item	Location
NCA01	Mascot (Robey Street) Underbridge	Extends over Robey Street, Mascot
	Mascot (O'Riordan Street) Underbridge	Extends over O'Riordan Street, Mascot
NCA02	Sydney (Kingsford Smith) Airport Group	Part Lot 8, DP 1050923
	Commonwealth Water Pumping and Sewerage Pumping Station	General Holmes Drive (within the boundary of Sydney Airport)
NCA04	Railway Bridge over Botany Road	Extends over Botany Road, Botany
NCA05 & NCA06	Botany Water Reserves (also known as Botany Wetlands or Botany Swamps)	About 200ha between Mascot and Botany, including Eastlake golf course and Mill and Engine Ponds

BS 7385 states that *"a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive"* and therefore building or structures should not be assumed to be sensitive to vibration on the basis of being a heritage item alone.

The above assessment has identified six heritage items which are within the cosmetic damage minimum working distance. It is noted that three of the heritage items are rail bridges and are not expected to be overly sensitive to potential vibration impacts from nearby construction works.

5.7.4 Pipelines

There are several pipelines in the project site. Vibration intensive activities, such as rockbreaking or vibratory rolling, may occur near to these pipelines at certain times during construction of the project.

Vibration criteria for buried pipework range from 50 mm/s to 100 mm/s (see **Table 15**) depending on the pipe material. At this early stage in the project it is unclear as to the condition of the various pipes and it may be necessary to reduce the criteria to prevent minor damage. Vibration from construction equipment may exceed the criteria depending on the distance of the works to the pipelines, the type of equipment used and the intervening ground conditions.

Where impacts are considered likely, the susceptibility of the various assets to vibration levels and appropriate monitoring and management protocols should be developed in consultation with the relevant owners during detailed design.

5.7.5 Vibration Mitigation

Based on experience with other similar infrastructure projects in Sydney, it is expected that vibration impacts would be able to be controlled to avoid cosmetic damage to all buildings and structures.

Where works are within the minimum working distances and considered likely to exceed the cosmetic damage objectives:

- Different construction methods with lower source vibration levels should be investigated and implemented, where feasible
- Attended vibration measurements should be undertaken at the start of the works to determine the actual vibration levels at the nearest receivers or structures. Work should cease if the monitoring indicates vibration levels are likely to exceed the relevant criteria.

Condition surveys should be completed before and after the works for all structures, including heritage items, within the cosmetic damage minimum working distances. Appropriate criteria should be confirmed before the works begin on the basis of the surveys.

The potential for cosmetic damage and human comfort impacts from construction vibration should be reviewed during detailed design when finalised information regarding the works is available.

Construction mitigation measures are discussed in more detail in **Section 8.1**.

5.8 Construction Ground-borne Noise

Construction works can cause ground-borne noise impacts in nearby buildings when vibration generating equipment is in use. Ground-borne noise impacts should be considered where the ground-borne noise levels are higher than noise transmitted through the air, such as where buildings near to construction works have high performing facades which attenuate the airborne component.

The majority of receivers are sufficiently distant from the works for ground-borne noise impacts to be minimal. Where residential receivers are located near to construction works, airborne noise levels would typically be dominant over the ground-borne component, however, several hotels are located close to the project and due to their existing high facade and glazing performance, would potentially be affected by ground-borne noise when vibration intensive equipment, such as rockbreakers, are in use nearby.

The extent of the impacts would be dependent on the requirement for vibration generating works in areas near to hotels, the location of sensitive uses inside the building relative to the works and the existing facade performance in the potentially affected locations.

Prior to construction, all hotels within 50 m of the project area should be consulted and assessed to determine their sensitivity to ground-borne noise impacts, existing facade performance and to allow appropriate criteria and mitigation to be determined.

5.9 Future Developments

There are a number of future developments within the study area which could potentially be affected by construction of the project depending on when they are completed. These include:

- **Qantas Flight Training Centre**. Qantas are proposing to relocate their existing facility to King Street in Mascot. The project is currently in the planning process and has not been approved. The new facility would be around 40 metres from the Botany Line and could potentially be subject to noise and vibration impacts during construction for the Botany Rail Duplication, assuming the facility is operational prior to works beginning.

  The potential construction noise impacts on the new centre could be 'high' when noise intensive equipment is being used nearby. However, given the proposed location, it is anticipated that the centre would be constructed with appropriate facades to manage the high existing noise levels near to the existing Botany Line and Sydney Airport, which would also mitigate the potential construction noise impacts from the Botany Rail Duplication.

  Whilst the worst-case impacts could be 'high' at certain times, works which use less noise intensive equipment or works that are further away from the facility would result in much lower impacts.

  Works at this location would also be undertaken during possessions, which would limit the impacts to discrete periods. It should also be noted that the works in this location, which are predominantly related to realigning the existing tracks to align with the new duplicated track south of this location, would be similar to typical maintenance activities of the existing Botany Line.

- **Future Airport Hotel**. A new hotel on Qantas Drive, between Seventh and Ninth Street, is proposed as part of the Sydney Airport T2/T3 Ground Access Solutions and Hotel project. Details on the design of the hotel are not currently available. The site is around 60 metres to the south of the project and is a similar distance away as the Mantra Hotel and Ibis Budget hotel, in NCA02.

  If the hotel were in use during Botany Rail Duplication construction works, the potential impacts on the future hotel would be expected to be comparable to the impacts predicted for the Mantra Hotel and Ibis Budget hotel, with 'high' impacts likely when works that use noise intensive equipment such are nearby.

  It is however noted that the facades of the hotel would also be high performing due to high existing noise levels near the airport, which would likely mitigate the potential airborne noise impacts to some degree.

- **Holiday Inn**. A new hotel is currently being constructed on Sarah Street in Mascot. The site is to the north of the Stamford Plaza hotel.

  The potential impacts at the hotel would be expected to be comparable to the impacts predicted for the Quest Mascot, with 'high' impacts likely when works that use noise intensive equipment such as rockbreakers or concrete saws are nearby (see **Section 5.4**).

It is however noted that the facades of the hotel would also be high performing due to high existing noise levels near the airport, which would likely mitigate the potential airborne noise impacts to some degree.

- **Sydney Airport Master Plan**

  Part of the project site is located within Sydney Airport and is therefore subject to the Sydney Airport Master Plan 2039 (SACL 2018)). This land is zoned for business development and Airport Terminal and Support Services.

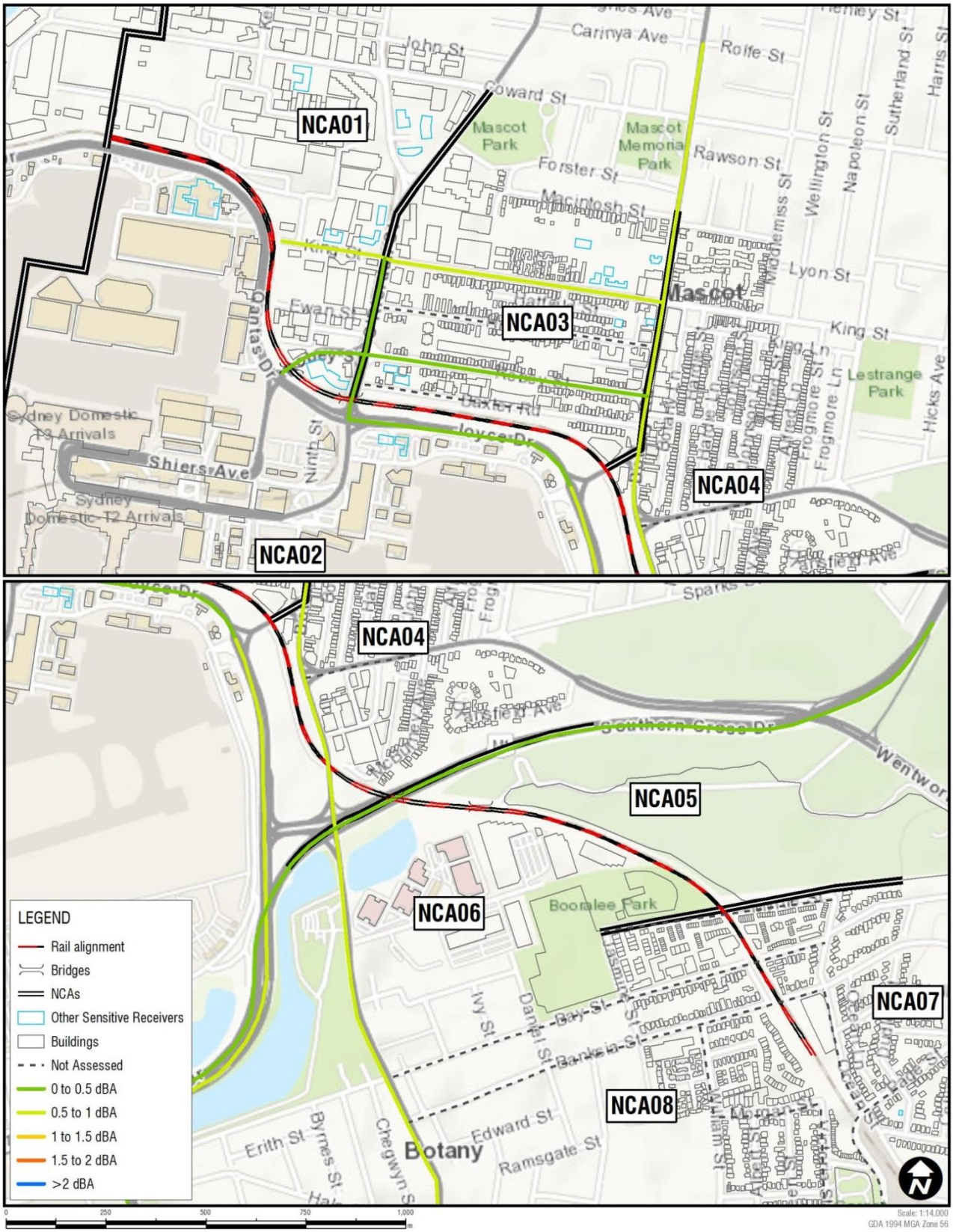
  No specific noise or vibration sensitive proposals are identified for these areas, other than the Future Airport Hotel discussed above.

5.10 Construction Traffic Noise Assessment

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

The existing and forecast construction traffic volumes in the study area have been used to determine where potentially noticeable increases in road traffic noise (ie a greater than 2.0 dB increase over the existing noise level) is likely. The results of the assessment are summarised in **Figure 18**.

Figure 18 Construction Traffic Assessment – Predicted Change in Noise Level



Note: The presented levels are the highest of the daytime and night-time predictions.

The above assessment indicates that for the assessed routes, construction traffic is unlikely to result in a noticeable increase in noise levels where vehicles use major roads. This results from the high volumes of traffic that currently use these routes.

A number of the proposed construction traffic routes are however along smaller local roads and existing volumes on these roads are currently unknown, these are shown in **Figure 18** as 'not assessed'. These roads include:

- Baxter Road and High Street in NCA03.
- Myrtle Street, Bay Street, Banksia Street, William Street, Morgan Street, Page Street, Stephen Street and Ocean Street in NCA07/NCA08.

Existing volumes are likely to be relatively low on these local roads, meaning noticeable increases in road traffic noise may be apparent if they are used as construction haulage routes.

Mitigation and management measures for construction traffic are discussed in **Section 8.1**.

5.10.1 Construction Detour Routes

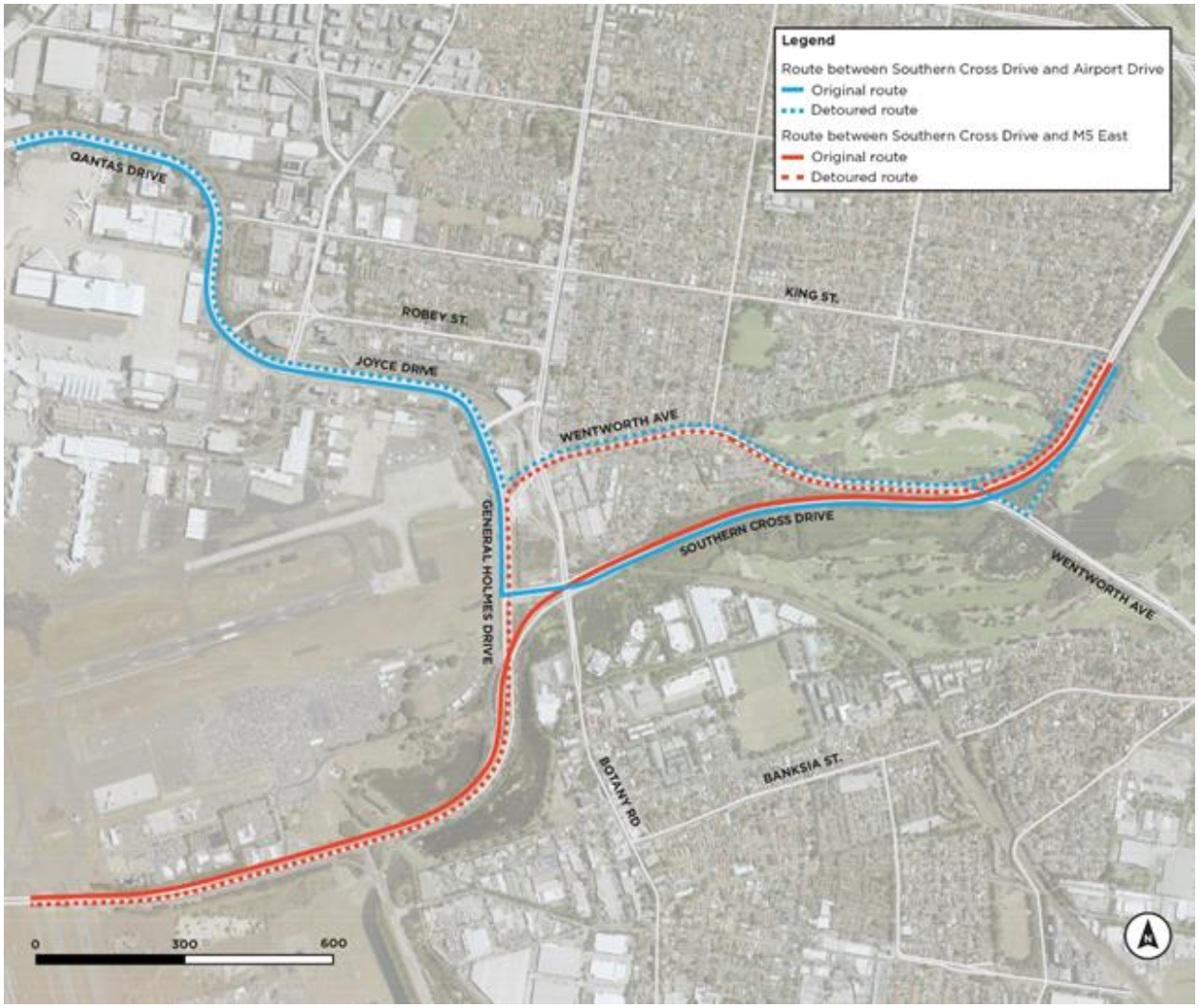
There would potentially be a requirement to close certain roads during construction to allow works to be completed in a safe manner and to ease space constraints. The following closures would likely be required:

- **Robey Street** or **O'Riordan Street** – closure of these roads near the project area would be required to complete construction activities, ensure worker and general public safety, and ease space constraints (for activities such as moving and erecting new and demolishing redundant bridge structures). A 54-hour weekend closure (from 11 pm Friday to 5 am Monday) would be required to avoid impacts to weekday peak period traffic. The proposed scope of works would require around 10 weekend road closures (to either Robey Street or O'Riordan Street) over the construction period. Only one of the roads would be closed at one time. The proposed detour routes are shown in **Figure 19** and **Figure 20**.
- **Southern Cross Drive** – there are three potential road closure arrangements for Southern Cross Drive which correspond to the types of works required at the rail overpass. Closure of the carriageway in one direction is generally proposed, with an additional lane closure in the opposite direction. Full closure is not currently anticipated. The road closures would be between 11 pm to 5 am, to align with the airport curfew and around six closures are anticipated. The proposed detour routes are shown in **Figure 21**.

Figure 19 Detour Routes for Robey Street Closure

Figure 20 Detour Routes for O'Riordan Street Closure

Figure 21 Detour Routes for Southern Cross Drive Closure



Potential Impacts

The potential impacts have been evaluated qualitatively and are summarised in **Table 41**.

Table 41 Qualitative Noise Impacts from Detours

Closure	Roads used for Detour	Potential Impacts
Robey Street or O'Riordan Street	Joyce Drive, General Holmes Drive, Wentworth Avenue, Botany Road, Robey Street	The majority of the proposed detour routes are busy arterial roads with high existing traffic volumes and few adjacent sensitive receivers, meaning the potential noise impacts are likely to be relatively minor. An exception to this is Robey Street, which has a much lower volume of existing traffic and residential receivers in close proximity. Road traffic noise levels on Robey Street would potentially be increased by >2.0 dB during detour periods.
Southern Cross Drive	Wentworth Avenue, General Holmes Drive, Joyce Drive, Qantas Drive	The majority of the proposed detour routes are busy arterial roads with high existing traffic volumes and few adjacent sensitive receivers. Wentworth Avenue does have adjacent residential receivers, however, existing volumes on this road are generally high. The potential noise impacts during detours of Southern Cross Drive are likely to be relatively minor.

The potential road traffic noise impacts from detours should be quantitatively determined when detailed traffic volume data is available.

Mitigation and management measures for detours during construction are discussed in **Section 8.1**.

6 Impacts during Operation

Operational rail noise impacts have been predicted for all identified sensitive receivers in the study area. The operational impacts are discussed in the following sections. Operational rail noise contours are provided in **Appendix D**.

The methodology and various inputs to the operational assessment are outlined in **Section 4.4**.

6.1 Residential Receivers

The predicted rail noise levels at residential receivers are summarised in **Table 42** for the 2024 at-opening and 2034 future design scenarios. The tables show the highest noise levels in each NCA, which is typically at receivers nearest to the alignment. Details on the number of triggered receivers in each NCA is also provided.

The impacts from the project are predicted to be greatest in the 2034 future design scenario due to this timeframe generally having more trains than in 2024 at project opening. Receivers are generally most affected by the project in the night-time in 2034 and this scenario is considered to control the assessment in terms of determining the worst-case impacts and requirements for mitigation.

The predicted noise levels for each receiver are also shown in scatter graphs in **Figure 22**, **Figure 23** and **Figure 24** which show the predicted daytime, night-time and maximum noise levels respectively. The graphs present the predicted noise levels from the project together with the change in noise corresponding to the controlling 2034 scenario. Receivers which are above the RING trigger levels are coloured on each of the scatter graphs, noting that for a receiver to be triggered it needs to have impacts which are above both the RING noise level criteria and the increase criteria (see **Table 19**).

The residential and 'other sensitive' receivers which are above the RING trigger levels are shown in **Figure 25**.

Table 42 Summary of the Predicted Operational Rail Noise Levels at Residential Receivers in each NCA

NCA	Side	Predicted Noise Level (dBA)[1]												Number of Receivers (2034)						
		Daytime $L_{Aeq(15hour)}$				Night-time $L_{Aeq(9hour)}$				Maximum L_{Amax}[2]				Above RING Absolute Trigger Level			Above Ring Increase Trigger Level			Total Triggers[3]
		At Opening (2024)		Design Year (2034)		At Opening (2024)		Design Year (2034)		At Opening (2024)		Design Year (2034)								
		Without project	With project	Without project	With project	Without project	With project	Without project	With project	Without project	With project	Without project	With project	Day	Night	Max.	Day	Night	Max.	
Criteria[4]		*65*	*65*	*65*	*65*	*60*	*60*	*60*	*60*	*85*	*85*	*85*	*85*	*65*	*60*	*85*	*2.0*	*2.0*	*3.0*	-
NCA01	Up	62	64	62	65	61	64	62	66	90	95	90	95	-	1	1	22	22	22	**1**
NCA02[5]	Down	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
NCA03	Up	70	72	71	73	70	72	71	73	99	104	99	104	19	37	57	268	276	274	**43**
NCA04	Up	67	68	67	70	68	69	69	71	100	106	100	106	11	29	52	420	433	457	**52**
NCA05[5]	Up	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
NCA06[5]	Down	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
NCA07	Up	65	66	65	67	69	70	70	72	101	106	101	106	30	98	107	16	39	105	**39**
NCA08	Down	71	73	72	74	71	73	72	75	99	105	99	105	49	106	127	30	38	134	**47**
																			TOTAL	**182**

Note 1: The results are for the receiver with the highest predicted noise level in the controlling 2034 'with project' scenario in each NCA for the daytime, night-time and maximum noise levels. As such the daytime, night-time and maximum results may be for a different receiver in the same NCA. The receiver with the highest predicted 2034 'with project' noise level may not be subject to the largest increase in noise from the project in that NCA. The predicted increases are discussed in the following sections.

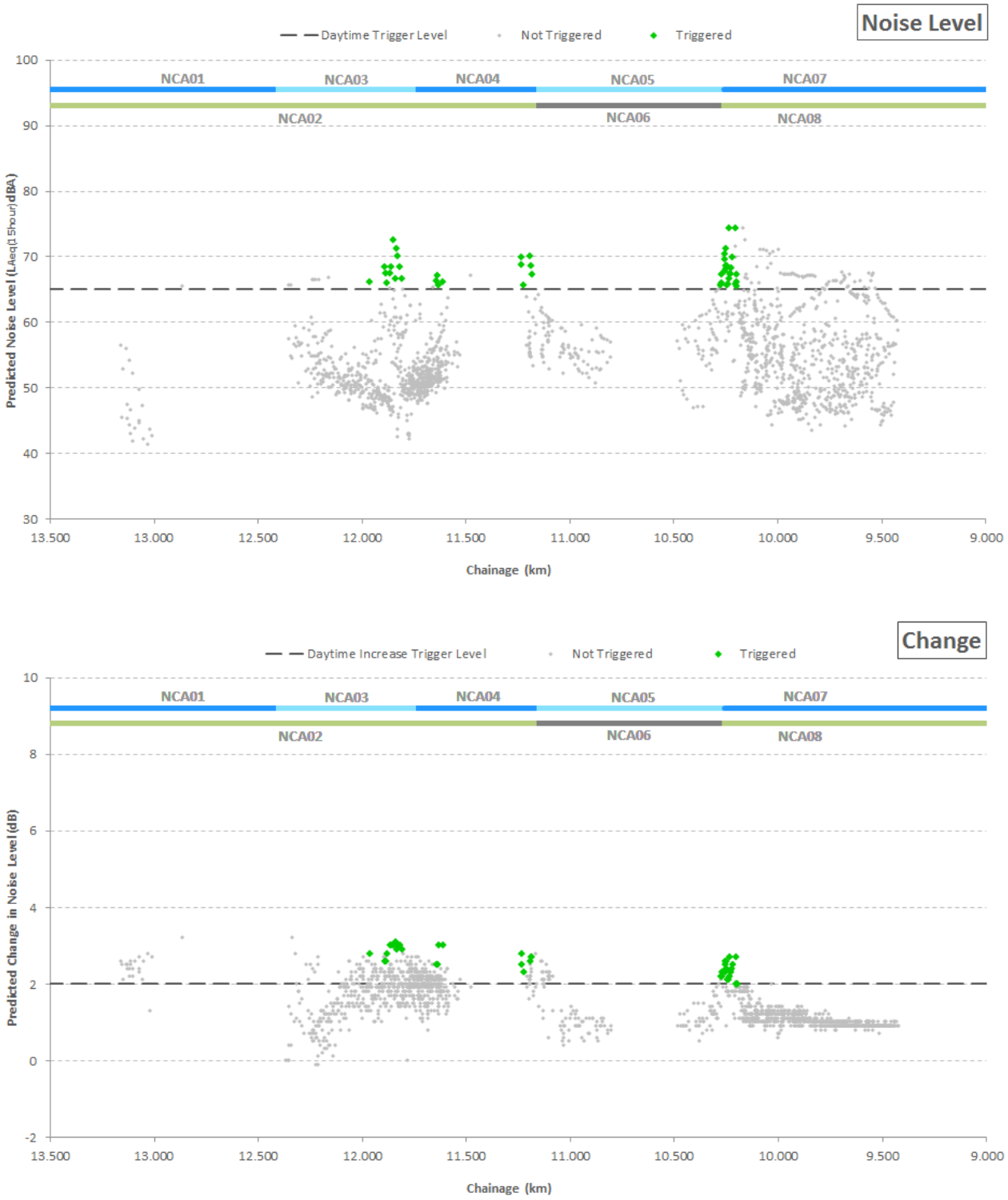
Note 2: Maximum refers to the L_{Amax} noise level and applies to both the daytime and night-time.

Note 3: Mitigation measures should be investigated for receivers that are predicted to experience noise levels above both the RING absolute and increase trigger levels.

Note 4: RING residential noise trigger level criteria for redeveloped rail projects.

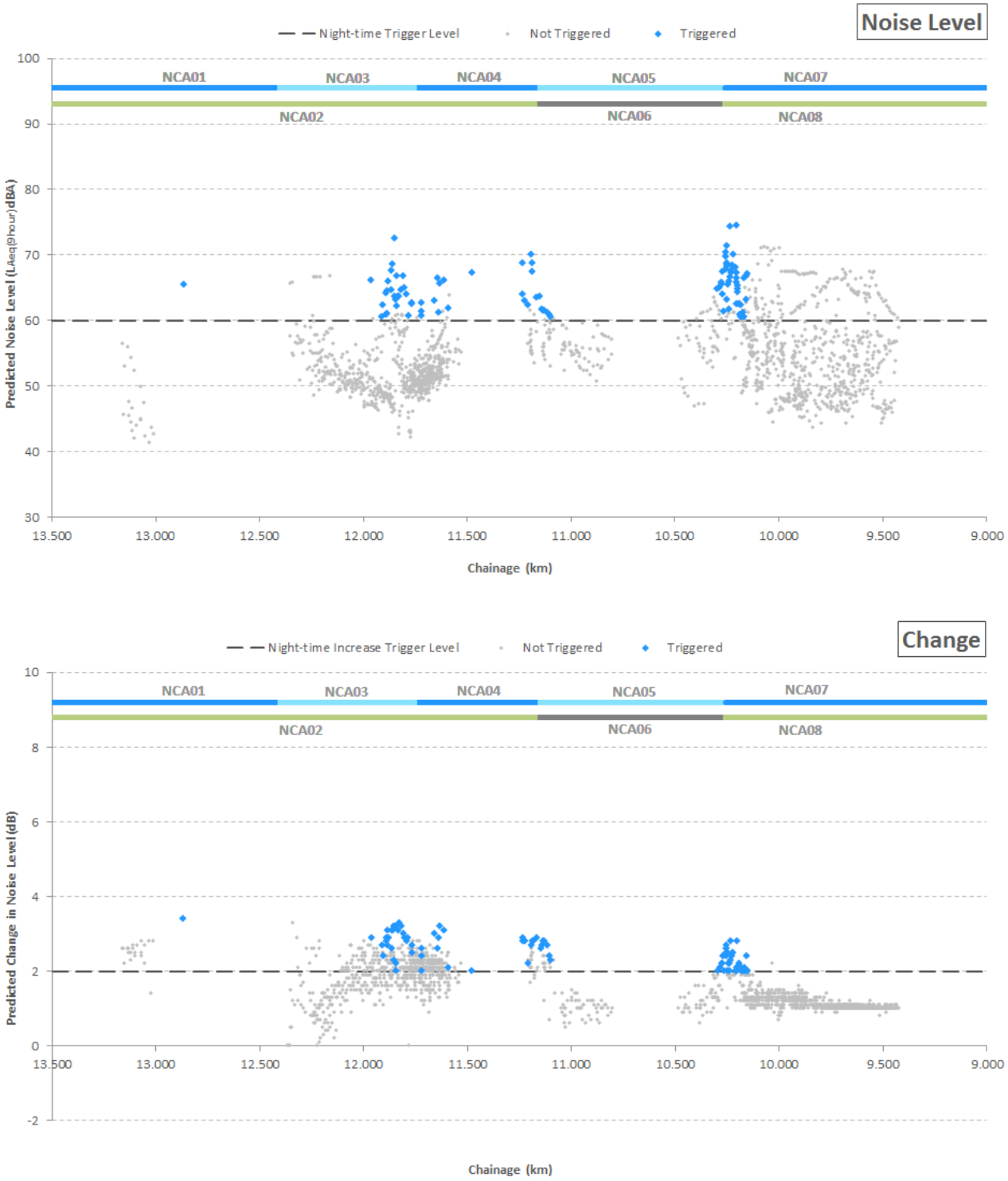
Note 5: NCA does not contain residential receivers.

Figure 22 Predicted Operational Noise Impacts – Residential Receivers 2034 Daytime



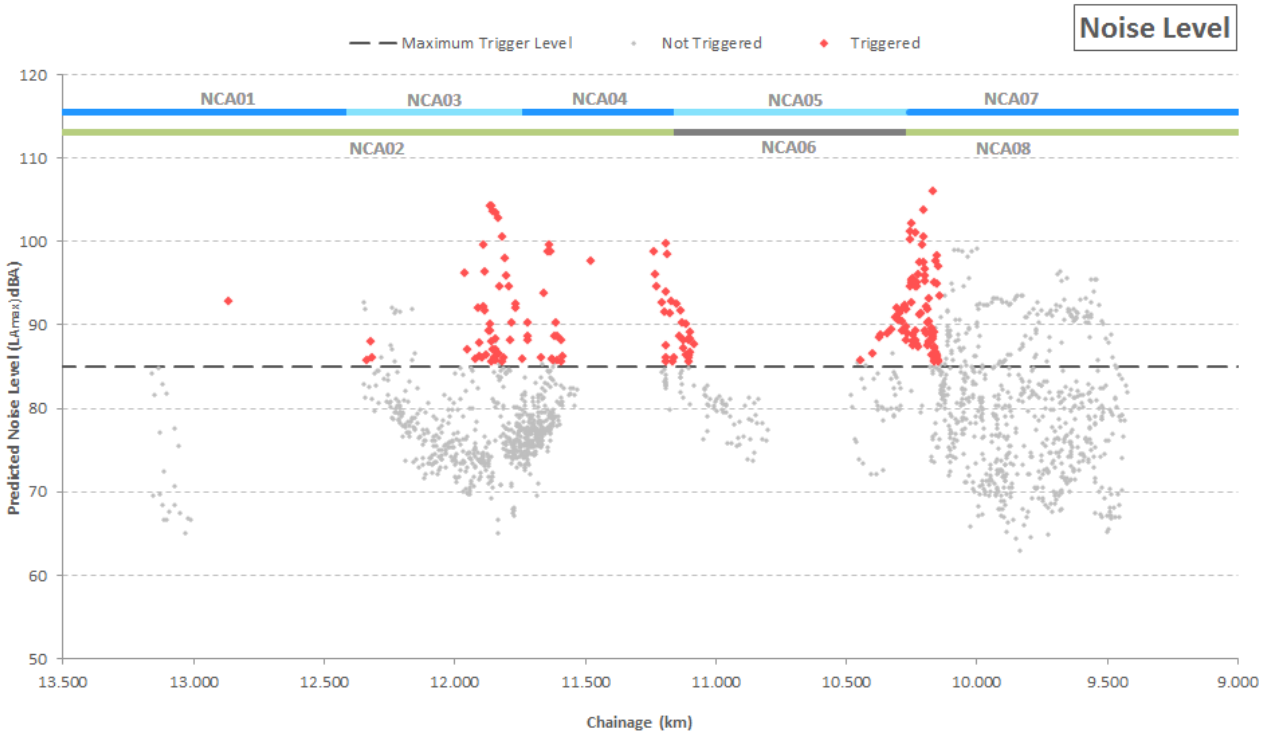
Note 1: For a receiver to be triggered it must be above both the RING daytime *and* the increase trigger levels.

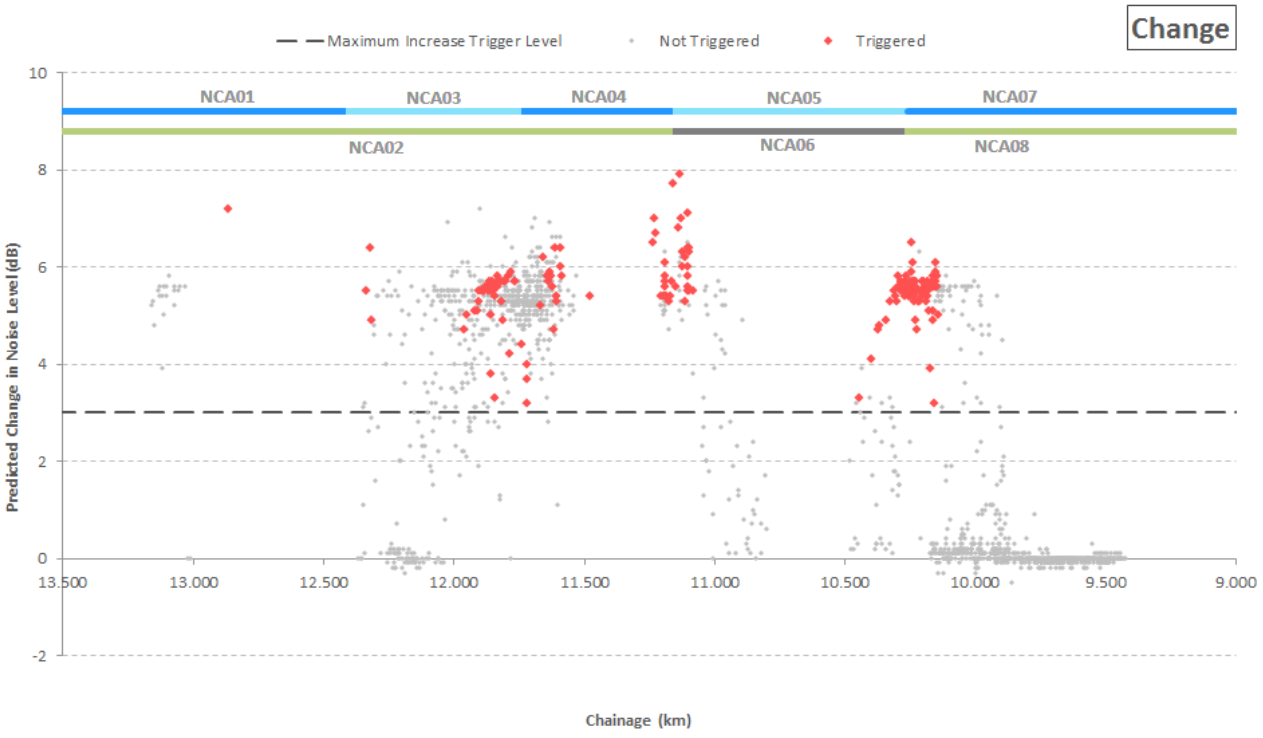
Figure 23 Predicted Operational Noise Impacts – Residential Receivers 2034 Night-time



Note 1: For a receiver to be triggered it must be above both the RING night-time *and* the increase trigger levels.

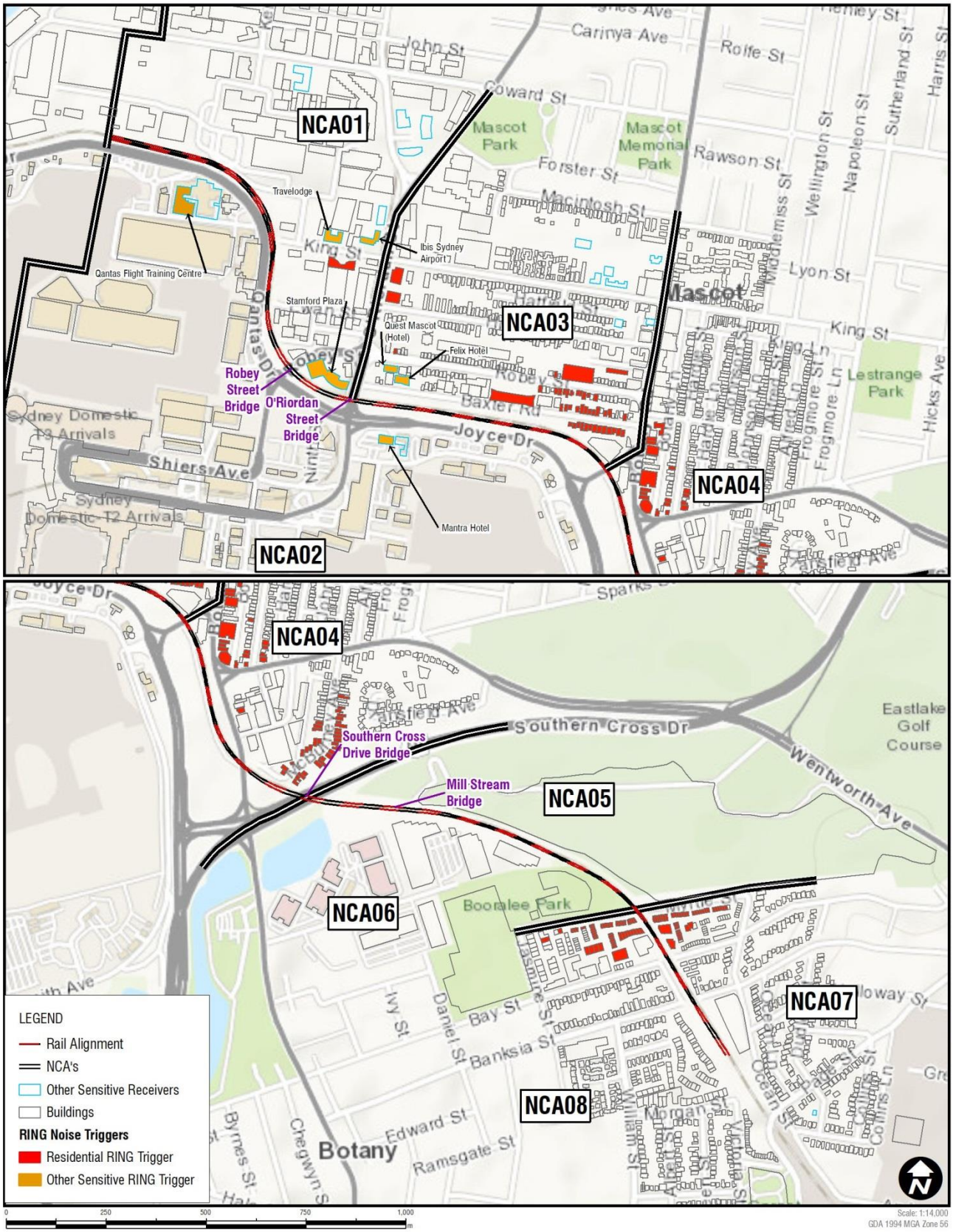
Figure 24 Predicted Operational Noise Impacts – Residential Receivers 2034 Maximum Noise Levels





Note 1: For a receiver to be triggered it must be above both the RING maximum *and* the increase trigger levels.

Figure 25 Locations of Predicted RING Noise Triggered Level Exceedances



The results above show the following:

- Existing rail noise levels in the study area are already high where receivers are close to the tracks.
- The project is predicted to increase rail noise levels in the study area which results in receivers above the trigger levels in all NCAs that contain residential receivers. Worst-case increases of around 8 dB are predicted for maximum noise levels, with daytime and night-time L_{Aeq} noise levels predicted to increase by around 3 dB. The increases are due to a combination of:
  - Increased train speeds through the project site (see **Section 4.5**), which increases rail noise levels adjacent to the project and also increases the occurrence and noise level of curving noise[1]
  - A higher volume of trains with the project (see **Section 4.5**)
  - The new track being closer to certain receivers. This is generally limited to receivers to the south of the alignment in NCA08, near Myrtle Street in Botany.
- The majority of residential RING trigger level exceedances occur in NCA03, NC04, NCA07 and NCA08. In these catchments, residential receivers are closely grouped and located adjacent to curved track.
- The residential RING triggers are most influenced by increased maximum noise levels adjacent to curved track sections, and less so by increased L_{Aeq} daytime and night-time noise levels.
- L_{Aeq} daytime and night-time noise levels increase by a greater degree for the 2034 scenario which is due to more trains in this timeframe.
- In total, 182 residential receivers exceed the RING trigger levels based on the current design of the project.

6.2 Other Sensitive Receivers

'Other sensitive' receivers that are predicted to have exceedances of the noise trigger levels are shown in **Table 43** for the controlling 2034 scenario. The location of the triggered 'other sensitive' receivers are shown in **Figure 25**.

[1] *Railway Noise and Vibration - Mechanics, Modelling and Means of Control, D.Thompson (2009)*

Table 43 Other Sensitive Receiver Triggers – 2034

NCA	Receiver	Noise Level (dBA)[1]					
		Predicted Level			Change in Noise		
		Day	Night	Max	Day	Night	Max
Hotels							
Criteria – Redeveloped[2]		***65***	***60***	***85***	***2.0***	***2.0***	***3.0***
NCA01	Ibis Sydney Airport	57	57	87	2.9	3.0	6.4
	Travelodge Sydney Airport	66	63	93	3.2	3.7	6.8
	Stamford Plaza Hotel	71	71	107	3.0	3.1	5.1
NCA02	Mantra Hotel	65	63	87	1.6	2.5	5.6
NCA03	Quest Mascot	64	63	86	1.3	2.2	6.4
	Felix Hotel	66	66	86	0.9	1.0	5.4
Educational							
Criteria – Redeveloped[1]		***55***	***55***	n/a	***2.0***	***2.0***	n/a
NCA02	Qantas Flight Training Centre	67	67	n/a	2.1	1.9	n/a

Note 1: The results represent the facade of the receiver with the highest noise level increase.

Note 2: Criteria is the corresponding external level.

The results above show the following:

- Noise levels are predicted to exceed the noise trigger levels at a number of hotels in the study area. Hotels have been conservatively assessed against residential criteria (see **Section 3.1.2.1**) on the assumption that they may have people who reside permanently on site. It is noted that only areas of permanent residence require assessment and other hotel areas are considered commercial, which the RING does not provide operational noise criteria for.
- The existing Qantas Flight Training Centre, which has been assessed as an educational receiver, is also predicted to be above the trigger levels.
- Noise level triggers for hotels are primarily controlled by exceedances of the maximum noise level criteria. Increases in maximum noise levels are a result of the project increasing train speeds.
- Increases in daytime and night-time L_{Aeq} noise levels are also apparent to a lesser degree, and are influenced by increased train speeds and increased in train volumes.

6.3 Summary of Triggered Receivers

A summary of the sensitive receivers which are predicted to exceed the noise trigger levels is provided in **Table 44**.

Table 44 Summary of Triggered Receivers

NCA	Side	Number of Exceedances of RING Noise Trigger Levels				Comments
		2024		2034		
		Residential	Other Sensitive	Residential	Other Sensitive	
NCA01	Up	1	3	1	3	RING triggers predicted at an approved (not yet built) apartment building on King Street, and three hotels including the Ibis Hotel, Travelodge Sydney Airport and Stamford Plaza Hotel. Only areas of permanent residence in hotels require consideration of mitigation. Noise impacts on these receivers are primarily controlled by exceedances of the maximum noise level criteria, however night-time L_{Aeq} exceedances are also predicted for most of these receivers. Noise levels in this NCA are influenced by curving noise (wheel squeal and flanging noise).
NCA02	Down	-	2	-	2	Triggers predicted at the Mantra Hotel and at the Qantas Flight Training Centre.
NCA03	Up	43	2	43	2	In this catchment, 43 residential receivers are triggered and primarily controlled by exceedances in maximum noise levels. Two hotels, the Quest Hotel and Felix Hotel, are also triggered. Noise levels are influenced by curving noise and new crossovers.
NCA04	Up	52	-	52	-	Triggers include 18 residential buildings between Wentworth Avenue and Hollingshed Street, one residential building adjacent the Wentworth Avenue underpass, and 33 residential buildings on McBurney Avenue. The exceedances are influenced by curving noise.
NCA05	Up	-	-	-	-	-
NCA06	Down	-	-	-	-	-
NCA07[1]	Up	39	-	39	-	Triggers predicted on both sides of the track between Bay Street and Myrtle Street in NCA07 and NCA08. All of these residential buildings are multistorey apartment or townhouse buildings. Noise levels in these NCAs are influenced by curving noise from trains operating on the curved track to the north of Myrtle Street and new crossovers.
NCA08[1]	Down	47	-	47	-	
Sub Total		**182**	**7**	**182**	**7**	
TOTAL		**189**		**189**		

Note 1: Buildings have been split into individual town houses where appropriate.

6.4 Noise from Idling Locomotives

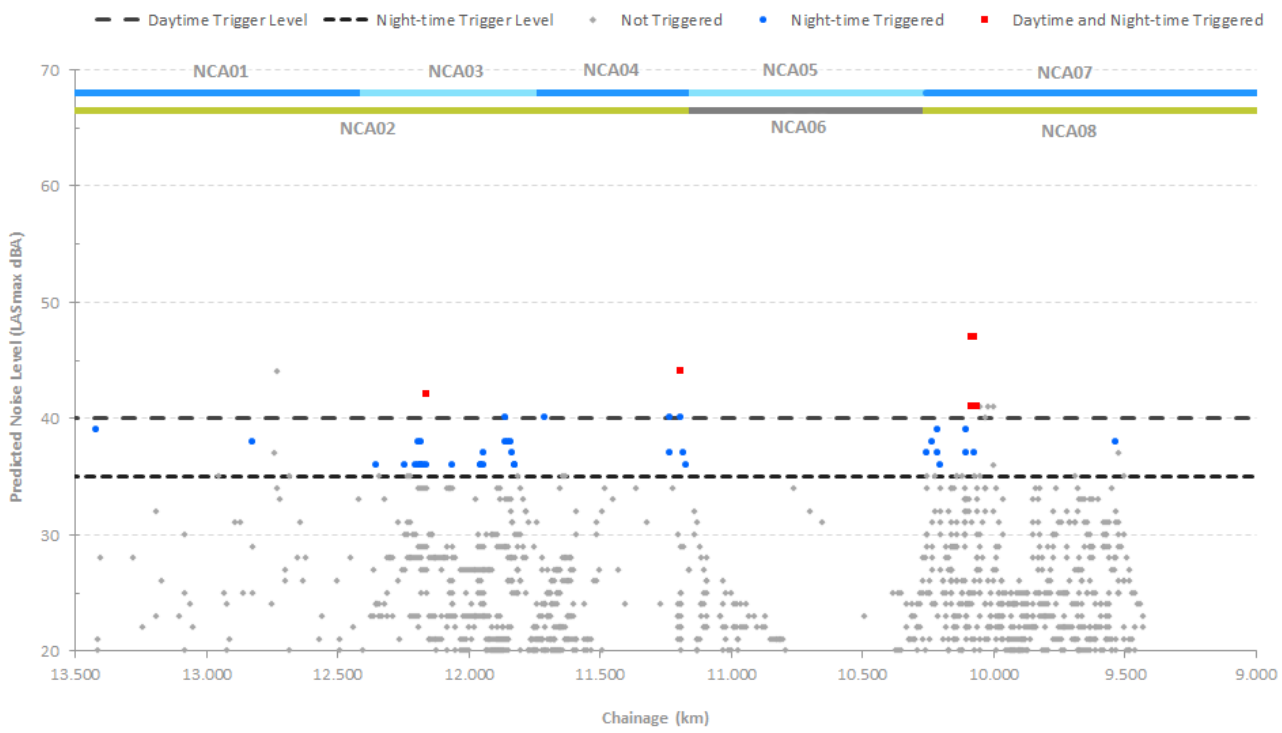
In situations where a freight train has insufficient margin to stay ahead of another train service, freight trains may need to briefly stop to allow for overtaking. Freight trains leave their engines idling while waiting to be passed, resulting in the generation of noise from the stationary locomotive.

The project reduces the requirement for trains to stop and idle while other trains use the existing single-track section of the Botany Line within the project site.

6.5 Operational Ground-borne Noise Assessment

The predicted ground-borne noise levels at residential receivers adjacent to the project are shown in **Figure 26**.

Figure 26 Predicted Ground-borne Noise Levels



The above figure shows the following:

- 45 residential receivers in the study area are predicted to exceed the night-time ground-borne noise trigger level of 35 dBA, by up to 5dB.
- The triggered receivers are generally either adjacent to where the project would install new rail crossovers or where receivers are close to the rail track (ie within 10 to 20 m).

A summary of the predicted internal ground-borne noise levels and the corresponding external airborne noise levels is presented in **Table 45** for the most affected receivers in catchments where ground-borne noise exceedances have been predicted.

Table 45 Internal Ground-borne Noise Levels in Comparison to External Airborne Noise Levels

NCA	Predicted Noise Level (dBA)	
	Ground-borne Noise Level (L_{ASmax})	External Noise Level (L_{AFmax})
CRITERIA	***35***[1]	***85***[2]
NCA03	42	> 100
NCA04	44	96
NCA07	47	99
NCA08	39	> 100

Note 1: RING night-time internal ground-borne noise trigger level.

Note 2: RING external maximum noise trigger level.

The results above show that receivers which are predicted to have ground-borne noise exceedances would also be subject to relatively high external airborne noise levels. For these receivers, external airborne noise levels would be expected to dominate noise inside the building unless parts of the dwelling are acoustically isolated from airborne rail noise, such as rooms that do not have windows which face the rail corridor.

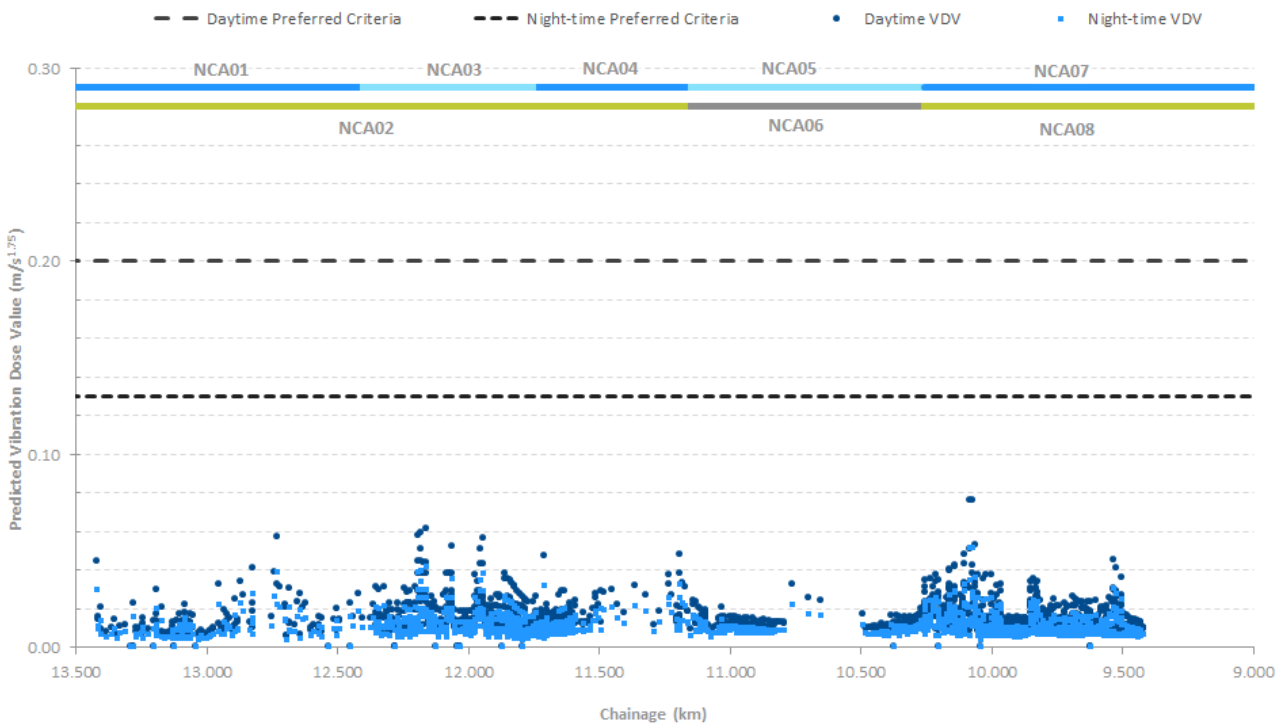
The RING notes that the ground-borne noise criteria only apply where ground-borne noise is dominant.

Further consideration of potential ground-borne noise impacts should be investigated during detailed design when the extent of airborne rail noise mitigation, train speeds, and the position of track turnouts is finalised.

6.6 Operational Vibration Assessment

A summary of the predicted 2034 VDV levels for residential receivers adjacent to the project is provided in **Figure 27**.

Figure 27 Predicted Vibration Dose Values – Residential Receivers, 2034



The above results show that vibration from the project is predicted to comply with the preferred daytime and night-time VDV criteria for residential receivers, and consideration of specific vibration mitigation measures for the project is not required.

People can perceive floor vibration at levels well below those likely to cause damage to buildings or their contents. As vibration from the project is predicted to comply with the human comfort vibration criteria, cosmetic damage impacts to buildings near the alignment are not anticipated.

6.7 Future Developments

There are a number of future developments within the study area which could potentially be affected by the operation of the project. These include:

- **Qantas Flight Training Centre**. Qantas are proposing to relocate their existing facility to King Street in Mascot. The project is currently in the planning process and has not been approved. The new facility would be around 40 metres from the project.

  Operational airborne noise levels could be influenced by curving noise (wheel squeal and flanging noise) from trains operating on the compound curves between Lancastrian Road and O'Riordan Street. Daytime and night-time L_{Aeq} noise levels of around 75 dBA and maximum noise levels of over 100 dBA are predicted at the future site.

The facades of the future centre would however be required to be acoustically high performing to control the high existing noise levels near to the existing Botany Line and Sydney Airport, which would assist in mitigating the airborne noise impacts.

High performance acoustic facades could however reduce external airborne noise levels to a point where ground-borne noise impacts (which are caused by ground vibration) potentially occur inside the centre, due to the close proximity of the site to rail corridor.

- **Future Airport Hotel**. A new hotel on Qantas Drive, between Seventh and Ninth Street, is proposed as part of the Sydney Airport T2/T3 Ground Access Solutions and Hotel redevelopment. Details on the design of the hotel are not currently available. The site is around 60 m to the south of the project and is a similar distance away as the Mantra Hotel and Ibis Budget hotel, in NCA02. The site is already affected by existing rail noise level from the Botany Line.

  Operational rail noise impacts on the future hotel would be expected to be similar in nature to the nearby Stamford Hotel due to its position adjacent curved rail track with high existing curve noise levels. Daytime and night-time L_{Aeq} noise levels of around 70 dBA and maximum noise levels of above 100 dBA are predicted at the future building.

- **Holiday Inn**. A new hotel is currently being constructed on Sarah Street in Mascot. The site is to the north of the Stamford Plaza hotel.

  The potential operational rail noise impacts at the hotel would be expected to be comparable to the impacts predicted for the Quest Mascot (see **Table 43**). However, only areas of permanent residence in hotels require consideration of noise mitigation.

- **Sydney Airport Master Plan**

  Part of the project site is located within Sydney Airport and is therefore subject to the Sydney Airport Master Plan 2039 (SACL 2018)). This land is zoned for business development and Airport Terminal and Support Services.

  No specific noise or vibration sensitive proposals are identified for these areas, other than the Future Airport Hotel discussed above.

7 Cumulative Impacts

7.1 Cumulative Construction Noise Impacts

7.1.1 Botany Rail Duplication Construction Works

Cumulative construction noise impacts can occur where multiple works are being completed near to a particular receiver. The indicative construction program in **Table 28** shows a number of overlapping work phases meaning cumulative impacts may happen at certain times during the project.

Since the construction scenarios generally require similar items of equipment, concurrent construction works being completed in an area of the project could theoretically increase the worst-case noise levels in this report by around 3 dB (ie a logarithmic adding of two sources of noise at the same level).

The likelihood of worst-case noise levels being generated by two different works at the same time is however considered low and rather than increase construction noise levels, the impact of concurrent works would generally be a potential increase in the duration, and annoyance, of noise impacts on the affected receivers.

In practice, construction noise levels in any one location would vary and would be frequently much lower than worst-case due to construction phasing moving works around and in many cases only a few items of equipment being used at any one time.

7.1.2 Works from other Major Projects

A number of other major projects are currently under construction or planned for construction within or near to the study area. Cumulative construction noise impacts may occur if construction on these projects is carried at the same time as Botany Rail Duplication works.

7.1.2.1 Sydney Gateway road project

Sydney Gateway road project is a new road that connects St Peters interchange to Sydney Airport, and is currently in the planning phase. The indicative location of Sydney Gateway road project in relation to the Botany Rail Duplication study area is shown in **Figure 28**.

The study area for Sydney Gateway road project overlaps with the western section of the Botany Rail Duplication study area, near to Qantas Drive and O'Riordan Street in NCA01 and NCA02. Whilst most of the receivers in this location are of commercial use, there are several hotels near the intersection of Qantas Drive and O'Riordan Street, including Stamford Plaza Sydney Airport, Quest Mascot, Felix Hotel, Ibis Budget Sydney Airport and Mantra Hotel, along with areas of residential receivers further to the east in NCA03.

Details on the construction methodology for Sydney Gateway road project are not yet available, however it is likely to be similar to the construction scenarios assessed in this report. Where Sydney Gateway road project works are operating concurrently with Botany Rail Duplication works near to receivers, the increase could be the same as described above for cumulative Botany Rail Duplication works, ie a theoretical increase of around 3 dB for most locations.

However, the outcome would likely be a potential increase in the duration of the noise impacts (ie more periods with impacts from either project) than an increase in worst-case noise level.

7.1.2.2 WestConnex – St Peters Interchange

St Peters interchange connects WestConnex New M5 and WestConnex M4-M5 Link to Mascot and Sydney Gateway road project at the site of the old Alexandria landfill. Construction works began in late 2016 and are due for completion in 2023. St Peters interchange is shown in **Figure 28**.

Concurrent construction works may occur at St Peters interchange and on the Botany Rail Duplication, and residential apartments are located in between both projects in the area of Kent Road in NCA01. These receivers are however over 600 metres away from St Peters interchange and 400 metres from the Botany Rail Duplication, and given the high existing noise levels in this area would only be minimally affected by construction noise from either project.

Given the significant distance from these receivers to St Peters interchange, cumulative impacts from works on both projects are considered unlikely to significantly increase the construction noise levels in this report. Additionally, the impacts from the Botany Rail Duplication alone at these receivers are predicted to be minimal.

7.1.2.3 Qantas Flight Training Centre

Qantas are proposing to relocate their Flight Training Centre. The existing centre is to the south of Qantas Drive and the proposed location is around 150 metres to the east, on King Street. The location of the existing and proposed sites are shown in **Figure 28**.

The project is in the early planning stages, however construction is programmed to commence in 2020 meaning concurrent construction works may occur for the new centre and the Botany Rail Duplication.

The receivers near to the proposed site are generally commercial, however Travelodge hotel and King Apartments (an approved residential development but not built yet) are nearby.

Construction works at the proposed site of the new Qantas Flight Training Centre would be much closer to these receivers than Botany Rail Duplication works, meaning that if concurrent works were to occur on both projects, the noise levels from construction of the new Qantas Flight Training Centre would likely be dominant over the noise levels from the Botany Rail Duplication.

As such, the mitigation measures used to control the impacts from the construction of the new centre would likely be sufficient and the effect of cumulative impacts in this location are considered minimal.

7.1.2.4 Airport North

Airport North includes reconfiguring and widening of Robey Street and O'Riordan Street to improve access to Sydney Airport. Early works started in July 2018 and main works are likely to be finished in 2019. The Airport North study area is shown in **Figure 28**.

The Airport North study area also overlaps the western section of the Botany Rail Duplication in NCA01, NCA02 and NCA03, near to the Sydney Airport Terminal 2/3 entrance. Whilst NCA01 is generally commercial, Airport North works would likely affect residential receivers and hotels near to O'Riordan Street, Baxter Road and Joyce Drive.

Airport North works are likely to be completed prior to Botany Rail Duplication works starting and are not expected to result in cumulative impacts with the Botany Rail Duplication.

7.1.2.5 Airport East

Airport East includes upgrading roads east of Sydney Airport and removing the General Holmes Drive rail level crossing by constructing a new road underpass. Construction began in 2016 and is scheduled to be complete in 2019. The Airport East study area is shown in **Figure 28**.

The Airport East study area overlaps the central section of the Botany Rail Duplication in NCA02, NCA03 and NCA04, along General Holmes Drive.

Airport East works are likely to be completed prior to Botany Rail Duplication works starting and are not expected to result in cumulative impacts with the Botany Rail Duplication

7.1.2.6 F6 Extension – Stage 1

The F6 Extension involves the construction and operation of a new multi-lane link road between Westconnex New M5 at Arncliffe and President Avenue in Kogarah. The project is located around 4 kilometres to the south east of the Botany Rail Duplication study area and construction is proposed to start in 2020.

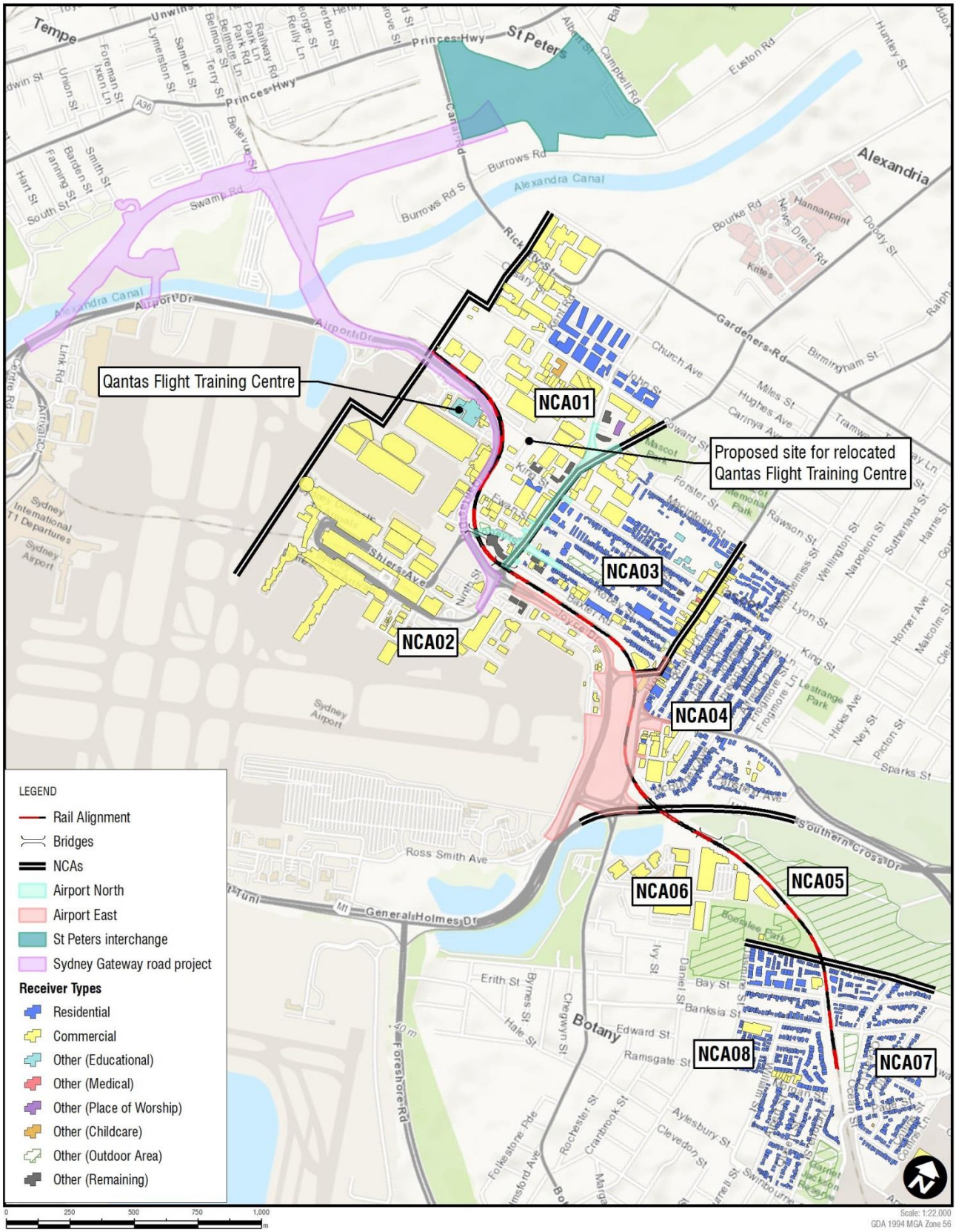
No cumulative impacts from are expected if the F6 Extension is built concurrently with the Botany Rail Duplication given the large distance between the two projects.

7.1.2.7 Summary

Based on the above discussion, the additional impacts from cumulative construction works are considered to be relatively minor. In most cases, the likelihood of worst-case noise levels being generated by two different works at the same time is considered low and rather than increase construction noise levels, the impact of concurrent works would be a potential increase in the duration, and annoyance, of the worst-case noise impacts. Periods of respite in-between works could also potentially be reduced.

Notwithstanding, the likelihood of cumulative construction noise impacts should be reviewed during detailed design when detailed construction schedules are available. The various projects should be scheduled with the aim of minimising concurrent works near to sensitive receivers, where practicable. However, it should be recognised that this may have the adverse effect of increasing the total duration of the impacts.

Figure 28 Other Major Construction Projects



7.2 Consecutive Construction Impacts

In addition to cumulative impacts, if more than one project occurs in the same area consecutively there may be a combined effect from the increased duration of impacts on nearby receivers. This effect is termed 'construction fatigue'.

Mitigation measures aimed at short-term construction works may be less effective where receivers are affected by longer duration impacts across several projects. Where receivers are affected by 'construction fatigue', it may be necessary to consider additional mitigation and management measures to minimise the impacts.

Construction works associated with road upgrades around Sydney Airport have been occurring in the study area since 2016. The projects include:

- **Airport East** – covering Wentworth Avenue, Botany Road, Mill Pond Road, Joyce Drive and General Holmes Drive, Mascot. Construction began in 2016 and is scheduled to be complete in 2019.
- **Airport North** – in the vicinity of O'Riordan Street, Mascot. Early works started in July 2018 and main works are likely to be finished in 2020.
- **WestConnex, New M5 –** at St Peters interchange. Construction currently underway and due for completion in 2020.
- **WestConnex, M4-M5 –** at St Peters interchange. Construction currently underway and due for completion in 2023.

As discussed previously, future projects in the study area include:

- **Sydney Gateway road project**
- Relocation of the **Qantas Flight Training Centre**.

The location of the above projects in relation to the Botany Rail Duplication study area are shown in **Figure 28** and indicative construction scheduling is shown in **Table 46**.

Table 46 Indicative Construction Schedule for Major Projects

Project and Work Phase	2016				2017				2018				2019				2020				2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Airport East																																				
Airport North																																				
WestConnex New M5																																				
WestConnex M4-M5																																				
Sydney Gateway road project[1]																																				
Qantas Flight Training Centre[1]																																				
Botany Rail Duplication																																				

Note 1: Timing of works is indicative.

7.2.1 Joyce Drive and O'Riordan Street Intersection

There is potential for consecutive impacts and 'construction fatigue' at receivers near the Joyce Drive and O'Riordan Street intersection. Receivers in this area, which include residential properties on Baxter Road and several hotels, are likely to have been impacted by construction works which began in 2016 for Airport East and would potentially be impacted for several more years by a number of successive projects, including:

- Airport North
- Sydney Gateway road project
- Qantas Flight Training Centre
- Botany Rail Duplication

7.2.2 St Peters interchange

Whilst multiple projects are occurring around the area of St Peters interchange, no impact from Botany Rail Duplication construction are predicted in this area meaning the project would not directly add to construction fatigue impacts for receivers near to St Peters interchange on the basis of noise.

However, given that several construction projects have occurred in the wider area over a number of years, the Botany Rail Duplication may add to the perception of the extended nature of construction works.

7.2.3 Consecutive Construction Impacts

The construction impacts discussed in **Section 5** of this report are based on the duration of the Botany Rail Duplication project in isolation, whereas as noted above, the potential impacts from the above projects may result in impacts over a longer timeframe.

Consecutive impacts may occur where the various projects overlap, with several hotels in NCA01 and NCA02 near the Joyce Drive and O-Riordan Street intersection being potentially affected, together with areas of residential receivers on Baxter Road in NCA03 and on Botany Road and McBurney Avenue in NCA04.

The potential consecutive impacts from the project and other major projects should be considered further in detailed design when detailed construction planning is developed. Specific management and mitigation measures to address potential consecutive impacts should be investigated and developed to minimise the impacts in consultation with the affected community.

7.3 Cumulative Operational Impacts

Operational rail noise impacts from the Botany Rail Duplication have been assessed against the requirements of the NSW EPA *Rail Infrastructure Noise Guideline* (see **Section 6**). Operational road traffic noise impacts from Sydney Gateway road project, and other nearby major road infrastructure projects, are assessed separately against the NSW EPA *Road Noise Policy* in the EIS for those projects.

Whilst receivers near to the Joyce Drive and O'Riordan Street intersection would potentially be affected by operational noise from the Botany Rail Duplication and Sydney Gateway road project, operational noise from different types of transportation (ie road and rail) have different characteristics and result in different annoyance responses from affected communities. This means a cumulative assessment of the combined operational impacts is not possible as the criteria for road and rail noise impacts are markedly different.

Where elements of both projects occur in the same location, there is potential for operational mitigation measures to be required for both projects at the same receivers. The final operational mitigation strategy for each project should consider the impacts from both the road and rail project with the aim of maximising the benefit provided by the mitigation in a pragmatic way.

8 Management of Impacts

8.1 Approach to Management of Impacts

ARTC commenced stakeholder and community consultation in 2018. Concerns raised have included:

- Construction noise
- Noise from construction workers
- Vibration during construction damaging buildings
- Noise at night
- Noise from existing trains including wheel screech, shunting and train horns
- Noise from maintenance machinery.

These issues raised by stakeholders, including vulnerable community members, have been considered as a part of this noise and vibration impact assessment and mitigation has been recommended to minimise potential impacts. Measures are detailed in **Section 8.2** and **8.3** include:

- Construction methodologies to minimise construction noise and noise from construction workers
- Out of hours protocol for works proposed for hours outside of standard construction hours including night works
- Vibration management measures
- Track lubrication to minimise wheel screech.

As described in the EIS Chapter 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has focused on avoiding and/or minimising the potential for environmental impacts during all key phases of the process. Measures taken to avoid or minimise impacts which relate to noise and vibration include:

- The construction access points and construction traffic routes have been directed away from sensitive areas. The surrounding land use has been considered when defining the use and operation of specific compounds.
- Construction compounds and other construction areas have been selected to be positioned within the existing rail corridor wherever possible.
- The current design for the project has adopted a risk-based approach to avoiding and/or minimising impacts associated with the relocation and/or adjustment of public utilities affected by the project in order to minimise impacts from utility works.

Mitigation measures for the project will be managed through the following:

- ARTC's Site Environmental Management Plans (EMPs) for enabling works
- Project specific Construction Environmental Management Plan (CEMP) for main construction works
- Community and stakeholder engagement plan
- ARTC's environmental management system for operation of the project.

8.2 Approach to Construction Impacts

The ICNG acknowledges that due to the nature of construction works it is inevitable that there will be impacts where construction is near to sensitive receivers. Examples of potential mitigation and management measures which could be applied to the project to minimise the impacts are provided below.

The need to efficiently undertake construction will need to be balanced against the communities' willingness to tolerate the level of noise predicted. Respite periods will help to alleviate the noise burden of some activities, noting the need to undertake specific works outside of Standard Construction Hours is partly due to the restrictions posed by aviation operations at Sydney Airport.

During the enabling works noise and vibration mitigation measures will be included in and managed through the site EMP.

During the main construction works, impacts would be managed through a Construction Noise and Vibration Management Plan (CNVMP) to the CEMP. This plan would include site specific Construction Noise and Vibration Impact Statements (CNVIS) prepared for all works outside Standard Construction Hours likely to exceed the relevant NMLs, activities likely to result in Highly Noise Affected receivers and/or activities likely to generate vibration levels at receivers in excess of the relevant criteria. These statements provide a detailed assessment of the potential impacts from the work and define the site specific mitigation and management measures to be used to control the impacts, particularly where evening or night-time works are required.

8.2.1 List of Construction Mitigation Measures

The assessment of the construction works predicts that impacts are likely during certain activities in some locations of the project where receivers are nearby. On the basis of the predicted impacts, **Table 47** lists the mitigation measures that will be incorporated into the relevant management plans to minimise the impacts from construction of the project. Items where further investigation has been recommended in later stages of the project are also listed.

Table 47 Construction Mitigation Measures

Item	Discussion and Recommendations
Project Specific Measures	
Preparation of site EMPs for Enabling works	**Construction Noise and Vibration Management** Site EMPs will be prepared before any enabling works begin. Specific to the activities proposed, these plans will include: • Identification of nearby sensitive receivers • Description of works, construction equipment and hours of work • Mitigation measures that apply to the works proposed • Criteria for the project and relevant licence and approval conditions • Requirements for noise and vibration monitoring • Details of how community consultation would be completed in accordance with the Stakeholder and Community Engagement Plan • Details on how respite would be applied where ongoing high impacts are seen at certain receivers.
	Out-of-hours work The requirement for enabling works out of hours would be described in the site EMP to be approved by the independent Environmental Representative (ER). The Site EMP would detail: • The proposed activities and predict the potential noise impact against the relevant noise and vibration criteria • The relevant mitigation measures included in this technical report including consideration of sleep disturbance and respite periods • The required community notification specific to the activities proposed.
Construction Noise and Vibration Management Plan	A CNVMP will be prepared as a sub plan to the CEMP before any main construction works begin. This will include: • Identification of nearby sensitive receivers • Description of works, construction equipment and hours of work • Criteria for the project and relevant licence and approval conditions • Requirements for noise and vibration monitoring • Details of how community consultation and notification would be completed • Procedures for handling complaints • Details on how respite would be applied where ongoing high impacts are seen at certain receivers. The CNVMP will also consider cumulative construction impacts and the likelihood for 'construction fatigue' from consecutive projects in the area and define a suitable management approach. Quantitative road traffic noise impacts from temporary detours during construction would also be evaluated, especially for local roads or roads with low existing volumes.

Item	Discussion and Recommendations
Noise impacts during out of hours work	Unless subject to an Environment Protection Licence, an Out-of-Hours Work Protocol would be prepared and be included as part of the CNVMP for main construction works. It will identify a process for the consideration, management and approval of works which are outside standard hours. The protocol would be prepared in consultation with the EPA and approved by the independent ER before the commencement of main construction works. The Protocol would include: • A process for the consideration of out of hours works against the relevant noise and vibration criteria • Provide a process for the identification of mitigation measures for residual impacts, including respite periods in consultation with the community at each affected location • Identify a process that considers the risk of activities, proposed mitigation, management, and coordination for works outside of standard hours to be approved by the independent ER.
Construction noise exceedances	The assessment has identified that high impacts are likely when noise intensive equipment such as rockbreakers, concrete saws and ballast tampers are in use, especially during evening and night-time periods. Residential receivers are predicted to be Highly Noise Affected in NCA03, NCA04, NCA07 and NCA08. Where noise intensive equipment is to be used near to sensitive receivers, the works will be scheduled for Standard Construction Hours, where possible. If it is not possible to restrict the works to daytime then they will be scheduled so noise intensive equipment is not used after 11:00 pm, where possible, noting that there is a requirement for many of the works to be completed during possessions and restrictions on working hours during these periods are generally not feasible.
Sleep disturbance	The need for consecutive night-time works and likelihood for sleep disturbance impacts will be reviewed during detailed design. Where impacts are considered likely, appropriate noise mitigation will be applied which takes into consideration factors such as the existing facade performance of affected residential receivers. Appropriate respite would be provided to affected receivers to limit impacts from night-time works in the same location, as required by the conditions of approval.
Compounds with long term works	Hoarding, or other shielding structures, will be used where receivers are near to compounds or worksites with long term works. To provide effective noise mitigation, the hoarding should break line-of-sight from the nearest receivers to the works, noting that some affected receivers are multi-storey, and be of solid construction with minimal gaps. Hoarding for construction sites is typically around 3 m in height.
Compound layout	Noise generating items in compounds will be positioned away from receivers where possible. Items such as sheds can also be used to shield receivers from noise generated in other parts of the compound.
Compound between Banksia Street and Stephen Road	Noise impacts are predicted for this compound site due to the proximity of the nearest receivers. The use of this compound site during out of hours works associated with the road closures at Robey Street and O'Riordan Street will be avoided as far as practicable.

Item	Discussion and Recommendations
Impacts on hotels	Several hotels are located close to the project and would potentially be impacted when noisy works are close by. Further investigation will be completed during detailed design to determine appropriate criteria which takes into account the existing facade performance of the affected hotels, noting that most of the hotels are of recent construction and are likely to have high performance facades Prior to construction, all hotels within 50 m of the project area would be consulted and assessed to determine their sensitivity to airborne and ground-borne noise impacts, existing facade performance and to allow appropriate criteria and mitigation to be determined.
Monitoring	Monitoring will be carried out at the start of noise and vibration intensive activities which are near to receivers to confirm that actual levels are consistent with the predictions. Where mitigation measures have been specified, the measurements should to confirm their effectiveness.
Vibration works within minimum working distance	Building condition surveys will be completed before and after the works where buildings or structures, including heritage items, are within the minimum working distances and considered likely to exceed the cosmetic damage criteria during the use of vibration intensive equipment. Appropriate criteria would be confirmed for each item before the works begin, based on the surveys.
	Where works are required within the minimum working distances and considered likely to exceed the cosmetic damage criteria: • Different construction methods with lower source vibration levels will be investigated and implemented, where feasible • Attended vibration measurements will be undertaken at the start of the works to determine actual vibration levels at the item. Works will be ceased if the monitoring indicates vibration levels are likely to, or do, exceed the relevant criteria.
	Certain receivers in the study area are within the human comfort minimum working distance and occupants of affected buildings may be able to perceive vibration impacts when vibration intensive equipment is in use. The potential human comfort impacts and requirement for vibration intensive works will be reviewed as the project progresses.. Where receivers are within the human comfort minimum working distances the impacts would be managed with the procedures defined in the CNVMP.
Vibration impacts on pipework	The project has the potential to impact a number of pipeline assets during construction. An assessment will be completed in detailed design which will: • Calculate the actual distance of the works from the structure • Assess ground conditions and the effect this will have on vibration. Where impacts are considered likely, the susceptibility of the various assets to vibration levels and appropriate monitoring and management protocols will be developed in consultation with the relevant owners. Condition surveys would be completed before and after the works where appropriate.
Heritage items	A number of heritage items have been identified as being within the cosmetic damage minimum working distances. The requirement for vibration intensive works near to heritage items will be reviewed during detailed construction planning. Where heritage items are considered potentially sensitive to vibration impacts, the more stringent DIN 4150 Group 3 guideline values should be applied and monitoring should be completed when vibration intensive works are in close proximity. Condition surveys will be completed before and after the works where heritage items are within the minimum working distances and considered likely to exceed the cosmetic damage criteria.

Item	Discussion and Recommendations
Construction traffic	A Construction Transport, Traffic and Access Management Plan will be prepared for the project to manage the haul routes and vehicle movements. Where construction routes are along local roads there is potential for impacts at the adjacent residential receivers, depending on the volume of construction traffic. The potential impacts will be managed using the following approaches: • Vehicle movements will be away from sensitive receivers and during less sensitive times, where possible • The speed of vehicles will be limited and will avoid the use of engine compression brakes • On-site storage capacity will be maximised to reduce the need for truck movements during sensitive times • Restriction of heavy vehicles idling near to residential receivers.
Detours during construction	The assessment indicates there is potential for noticeable increases in road traffic noise for some receivers along the detours routes, such as Robey Street. Detours using this road are planned for up to 10 weekends (for closures to either Robey Street or O'Riordan Street) during construction of the project. The potential impacts would be reviewed as the project progresses using detailed traffic volume data Where residential receivers are expected to be subject to a >2.0 dB night-time increase during detours, the project would: • Consider the use of different detour routes that do not put traffic during the night-time on roads with low existing volumes. Where this is not possible, the project would: • Apply appropriate mitigation measures to the affected residential receivers, as agreed with the independent Environmental Representative (ER), based on the expected magnitude of the exceedance and the total duration of night-time impacts from all detours during construction of the project.
Community preference	In locations where 'moderate' or 'high' impacts are predicted (see **Table 36**), engagement with the affected communities will be outlined in the community and stakeholder engagement plan and undertaken during detailed design to determine their preference for mitigation and management measures.
Cumulative and consecutive construction impacts	The likelihood of cumulative construction noise impacts will be reviewed during detailed design when detailed construction schedules are available. Co-ordination will occur between the various projects to minimise concurrent works in the same areas, where possible.
	Consecutive construction impacts, or 'construction fatigue', may occur in NCA01, NCA02 and NCA03, near the Joyce Drive and O'Riordan Street intersection, due to the construction of several projects. The potential consecutive impacts from the Botany Rail Duplication and other major projects will be investigated further as the project progresses. Specific additional management and mitigation measures designed to address potential consecutive impacts will be developed and used to minimise the impacts as far as practicable, in consultation with the affected community.
	Where works on multiple projects are occurring outside of Standard Construction Hours in similar areas there is potential for increased impacts at nearby affected receivers. Sufficient coordination will occur between the projects regarding evening or night-time works to ensure that appropriate respite is provided to affected receivers.

Item	Discussion and Recommendations
General Measures	
Implement community consultation measures	Community consultation measures will be included in the project community and stakeholder engagement plan, including: • Periodic notification (monthly letterbox drop or equivalent) detailing all upcoming construction activities delivered to impacted sensitive receivers at least 14 days prior to commencement of relevant works.
Site inductions will be included in the site EMPs for Enabling Works and the CNVMP for main construction works	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Relevant licence and approval conditions • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios/phone calls on speaker on site. No dropping of materials from height, throwing of metal items and slamming of doors. No unnecessary idling of vehicles near to receivers.
Construction hours and scheduling	Where feasible and reasonable, construction will be carried out during Standard Construction Hours (see **Table 25**). Work generating high noise and/or vibration levels will be scheduled during less sensitive time periods, where possible.
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored pile rather than impact-driven piles will minimise noise and vibration impacts.
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver will be avoided. The offset distance between noisy plant and adjacent sensitive receivers will be maximised. Plant used intermittently will be throttled down or shut down. Noise-emitting plant will be directed away from sensitive receivers, where possible.
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries will occur *as far as possible* from sensitive receivers. Site access points and roads will be selected to as possible away from sensitive receivers. Dedicated loading/unloading areas will be shielded if close to sensitive receivers. Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible.

Item	Discussion and Recommendations
Silencers on Mobile Plant	Where possible noise from mobile plant will be reduced through additional: • Residential grade mufflers • Damped hammers such as 'City' Model Rammer Hammers • Air Parking brake engagement is silenced.
Shield stationary noise sources such as pumps, compressors, fans, etc	Stationary noise sources will be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Structures, such as site sheds, will be used to shield residential receivers from noise (where practicable), noting that upper floors of multi-storey buildings would be unlikely to benefit.

8.3 Approach to Operational Impacts

An Operational Noise and Vibration Review (ONVR) will be prepared to confirm the noise and vibration impacts from the project and to define the mitigation measures used to control the impacts. The ONVR will be prepared in consultation with affected stakeholders and the community and will:

- Be based on the operational noise and vibration objectives identified in this report
- Confirm the predicted operational noise and vibration impacts at the surrounding receivers based on the final design
- Review the suitability of the operational noise mitigation measures identified below and any other measures which may be considered appropriate to manage additional impacts identified as a result of design changes and include the timing of implementation
- Include a consultation strategy to seek feedback from directly affected landowners on the noise and vibration mitigation measures
- Define procedures for the management of operational noise and vibration complaints.

The ONVR will be prepared with reference to the ARTC *Noise Prediction and Mitigation Guideline* (ARTC, 2018) and would be made publicly available once complete.

8.3.1 Airborne Noise Mitigation Options

The noise modelling results show that the trigger levels are likely to be exceeded in certain locations. Noise mitigation measures are therefore required to be investigated for the project.

Operational noise impacts can be controlled in a variety of ways and a summary of the potential options is provided in **Table 48**. The RING requires that preference is given to source control measures, as they offer the greatest benefit to the largest number of receivers when compared to more localised mitigation options. Path control measures are considered next, with receiver controls being the final approach.

Table 48 Summary of Operational Noise and Vibration Mitigation Options

Description	Estimated Noise Reduction	Comments on Feasibility and Reasonableness
Source Control Measures		
Reduce speeds	A 20% reduction in maximum speed would reduce L_{Amax} noise levels by 2.5 dB and L_{Aeq} noise levels by 1.5 dB.	Reduction in train speeds would not be considered feasible as the proposed speeds are required to meet service demands. Additionally, a 20% reduction in speed would not eliminate all occurrences of curve noise and is unlikely to substantially influence maximum noise levels associated with curve noise.
Reduce overall number of train passbys	No change in L_{Amax}. 1 dB in L_{Aeq} for 20% reduction. 2 dB in L_{Aeq} for 35% reduction.	Not feasible as train numbers are required to meet service demands. Would have no effect on maximum noise levels.
Reduce train lengths	Negligible change in L_{Amax} 1.3 dB reduction in L_{Aeq} for 25% reduction in train length. 3 dB reduction in L_{Aeq} for 50% reduction in train length.	Not feasible as train lengths are required to meet capacity demand. Would have no effect on maximum noise levels.
Minimise wheel and rail roughness	Limited by whether rail roughness or wheel roughness dominates the combined system.	The existing and future predicted noise levels are not dominated by wheel or rail roughness influences. Minimising wheel and rail roughness alone is not predicted to result in a noise benefit.
Minimise train source noise levels via specifications	N/A	The project does not have the ability to control train source noise levels directly.
Minimise curving noise via improved bogey steering performance	N/A	The project does not have the ability to control wagon steering performance directly.
Track design measures – rail dampers	No significant benefit on typical ballast track.	Rail dampers are most suited to resiliently mounted track such as slab-track. No significant noise benefit is achievable for ballast track on concrete sleepers.
Exclude “noisy” individual trains from operating in the project area	N/A	The project does not have the ability to control which locomotives and wagons operate in the project area.
Relocate track crossovers	Up to approximately 3 dB in maximum airborne and ground-borne noise levels (dependant on the contribution of turnout noise to overall noise levels)	Relocating the track crossovers between Bay Street and Banksia Street would reduce the maximum noise levels at the adjacent receivers and would remove the impulsive noise characteristic associated with this track feature which was not previously a feature of rail noise in this area. This measure will be investigated further during detailed design.
New track lubrication systems	Approximately 8 dB in L_{Amax} noise levels and 1 dB in L_{Aeq} noise levels	Installation of new and properly maintained current-generation top of rail friction modifier and gauge-face lubrication systems would significantly reduce maximum noise levels associate with curve noise (wheel squeal and flanging noise). The system would not be as effective in reducing L_{Aeq} noise levels however.

Description	Estimated Noise Reduction	Comments on Feasibility and Reasonableness
Path Control Measures		
Conventional noise barriers – near rail corridor boundary	Significant noise reduction possible (ie >5 dB) where source to receiver line-of-sight is broken by barrier.	Noise barriers should be considered, where feasible and reasonable. Their use is however potentially limited by constructability and a number of other constraints, including access requirements, aesthetic impacts, daylight access, overshadowing, drainage, restriction of line of sight, maintenance access and safety concerns.
Noise barriers – low profile "platform barriers"	Up to 8 dB reduction in L_{Aeq} and L_{Amax} over unmitigated case where noise levels are dominated by rolling noise. Benefit depends on the gap remaining between the low barrier and the train.	Low profile noise barriers do not address noise from locomotive engines. Low height noise barriers are not considered feasible due to constraints imposed by rollingstock loading gauge, track maintenance requirements, and safety requirements when installed on several tracks.
Receiver Control Options		
Ventilation in accordance with Building Code requirements to allow windows to be closed (if desired) Upgraded glazing and facade elements.	Around 10 dB to 15 dB reduction in internal noise levels compared with windows open for standard glazing. Higher noise reductions possible for laminated and double glazing with acoustic seals. No benefit for outdoor areas or if windows are opened.	This option could be applicable as a final measure for where residual exceedances of the trigger levels are apparent. Several receivers triggered for mitigation of relatively modern construction which likely include facades with high acoustic performance in line with the requirements of the State Environmental Planning Policy (SEPP) Infrastructure (2007). The triggered receivers are located in close proximity to Sydney Airport and busy roads and may already have high acoustic performance facades to reduce existing aircraft, road and rail noise, as required by the Infrastructure SEPP

8.3.1.1 Recommended Noise Mitigation

The noise mitigation measures that are considered potentially feasible and reasonable for the project are discussed below. Mitigation measures will be included in the ONVR, with the identified measures being managed through ARTC's environmental management system for operation of the project.

Source Control – Track Lubrication Systems

As outlined in **Section 6.3**, the predicted noise impacts are primarily associated with curve noise including wheel squeal and flanging noise from trains traversing curved track at increased speed. Noise mitigation will therefore prioritise addressing curving noise.

Modern track lubrication systems are recognised as a cost-effective means of minimising curve noise. Studies undertaken in NSW have shown that curve noise from freight operation can be reduced by 1 dB and 8 dB for L_{Aeq} and L_{Amax} respectively.

An additional modelling scenario which uses these track lubrication corrections on curves has been investigated and a summary is provided in **Table 49** and **Figure 29**. The table shows the number of triggers with and without track lubrication, and the figure shows the location of the residual triggers after use of lubrication.

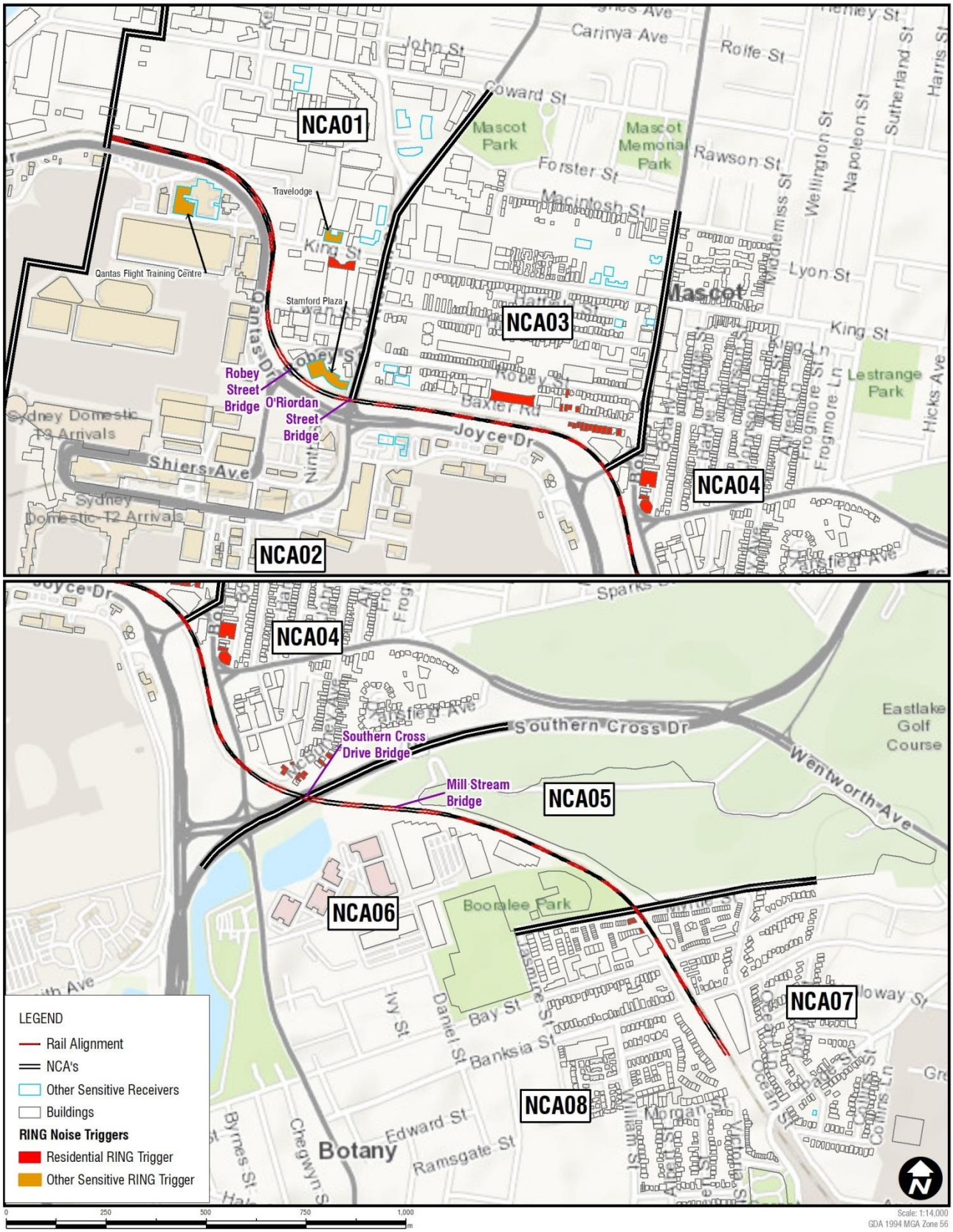
Table 49 Summary of Residual Impacts - With Track Lubrication

NCA	Side	Number of Exceedances of RING Noise Trigger Levels					
		2034 No Mitigation		2034 With Lubrication		Difference	
		Residential	Other Sensitive	Residential	Other Sensitive	Residential	Other Sensitive
NCA01	Up	1	3	1	2	-	1
NCA02	Down	-	2	-	-	-	2
NCA03	Up	43	2	17	-	26	2
NCA04	Up	52	-	11	-	41	-
NCA05	Up	-	-	-	-	-	-
NCA06	Down	-	-	-	-	-	-
NCA07	Up	39	-	-	-	39	-
NCA08	Down	47	-	5	-	42	-
Sub Total		**182**	**7**	**34**	**2**	**148**	**5**
TOTAL		**189**		**36**		**153**	

The use of a modern track lubrication system on all curves is likely to remove all maximum noise levels triggers within the project area. Track lubrication is also expected to reduce L_{Aeq} noise levels by up to 1dB. The above shows that this mitigation option is likely to reduce the number of RING triggers from 189 receivers to 36, which is a reduction of around 80 per cent.

It is therefore recommended that a properly maintained modern track lubrication system is installed by the project. The specification of the noise control system for each curve would be determined as part of the ONVR following an investigation of each curve.

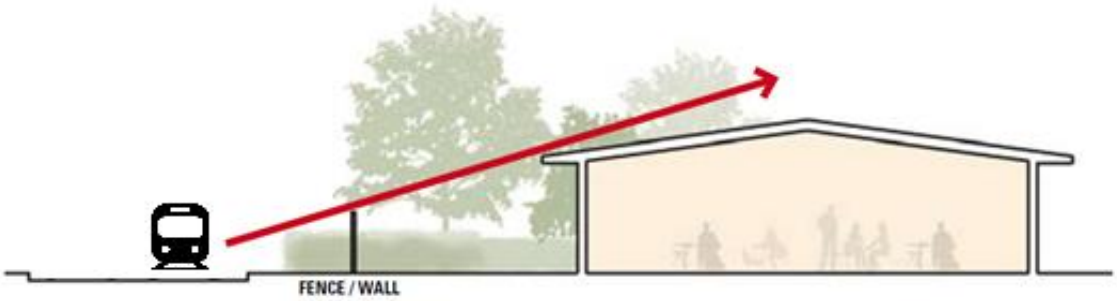
Figure 29 Residual Triggered Receivers after Lubrication Used



Path Control – Noise Barriers

Noise barriers (in the form of walls or earth mounds) can provide significant noise reductions and also reduce both external and internal noise levels. Where space allows, raised earth mounds can be used as noise barriers and can be enhanced by placing a low wall on top. Noise walls are often more feasible than a mound as the footprint is much smaller. An indicative noise barrier cross section is shown in **Figure 30**.

Figure 30 Noise Wall/Barrier Cross Section



Noise barriers can however introduce a number of negative aspects, including access to property, aesthetic impacts, daylight access, overshadowing, drainage, graffiti, restriction of line-of-sight, maintenance access and safety concerns.

Noise barriers are typically most efficient when receivers are located at ground floor level. As the height of a receiver increases, the noise reduction reduces due to line-of-sight over the top of the barrier.

Assessment of Noise Barriers

Noise barriers have been considered in locations of the project where triggers remain after the use of track lubrication (see **Figure 29**). This includes:

- NCA03 – to the north of the rail corridor, due to residential triggers on Baxter Road
- NCA04 – to the east of the rail corridor, south of the level crossing, due to triggers on Botany Road
- NCA04 – to the north of the rail corridor near to Southern Cross drive, due triggers on McBurney Avenue
- NCA08 – to the west of the rail corridor, near Myrtle Street.

A summary of the considered factors for these noise barriers is provided below in **Table 50**.

Table 50 Noise Barrier Analysis

Noise Barrier	Considerations	Considered Feasible?
NCA03 – Baxter Road	- A barrier of around 3 m in height and 75 m in length is likely to remove all residual triggers on Baxter Road (apart from the newly built apartments in the same building as the Branksome Hotel). - However, the existing car park to the east of the noise barrier has been modelled as a solid building whereas it is partially open and may reduce the effectiveness of the noise barrier by allowing noise through.	Potentially
NCA04 – Botany Road	- Barrier is within the Sydney Airport OLS. - Potential visual impact issues given the height from the road and viewpoints across Wentworth Avenue.	No
NCA04 – McBurney Avenue	- Barrier is within the Sydney Airport OLS.	No
NCA08 – Myrtle Street	- Small number of triggered receivers in this area. - Barrier would be less effective at floors above ground and first, and many residential buildings in this area have more than two floors. - Potential for reflected noise to result in additional triggers on opposite side of the rail corridor due to the open nature of freight wagons. - Construction of absorptive barriers has historically been an issue on the network. Repeated vandalism requires overpainting that can reduce the effectiveness of certain absorptive linings.	Potentially

Other general items to consider when evaluating noise barriers are provided below:

- They provide a facade which attracts vandalism in the form of graffiti. This encourages vandals into the rail corridor which introduces a significant safety risk
- Noise barriers often have a significant visual amenity impact by blocking open views and can often cause secondary issues by the lack of passive surveillance
- Depending on solar orientation, noise barriers can often lead to overshadowing of adjacent properties.

The feasibility and reasonableness of noise barriers would be considered further as the project progresses.

Receiver Control – At-property Treatment

Where residual impacts remain after the use of at-source and in-corridor mitigation, the final approach is to use at-property mitigation.

Treatments to building facades usually involve higher performance windows, doors and seals to keep noise out. Facade treatments require occupants to keep their windows and doors closed meaning some form of mechanical ventilation is usually required to maintain adequate air flow. At-property treatments can also involve upgrades to property boundary fences.

The scope and feasibility of at-property treatments would depend on the existing condition of each property.

This assessment identifies where consideration of noise mitigation is required in accordance with the requirements of the RING. The recommended potentially feasible and reasonable property treatments would be considered in more detail during the detailed design stage of the project.

The final mitigation strategy should however consider that the receivers which are affected by the project are already subject by high existing noise levels from existing sources of road, rail and aircraft noise, and may already have been mitigated with at-property treatment. Recently built receivers would also have been designed and constructed with increased facade specifications to control high existing noise levels near Sydney Airport, as required by the Infrastructure SEPP. For this reason, provision of upgraded facade elements may not be justified in some areas of the project.

At this early stage in the project hotels have been conservatively assessed against residential criteria on the assumption that they may have people who reside permanently on site. Where exceedances of the RING trigger levels are predicted, only areas of permanent residence require consideration for at-property treatment. Other areas of hotels not used as a permanent residence are considered commercial, which the RING does not provide operational noise criteria for.

In the area around NCA01 and NCA03, the Sydney Gateway road project is may also result in operational road traffic noise impacts on similar receivers to Botany Rail Duplication. Where elements of both projects occur in the same location, there is potential for operational mitigation measures to be required for both projects at the same receivers. The final operational mitigation strategy for each project should consider the impacts from both the road and rail project with the aim of maximising the benefit provided by the mitigation in a pragmatic way.

8.3.2 Ground-borne Noise and Vibration Mitigation

As outlined in **Section 6.6**, exceedances of the ground-borne noise trigger levels are exceeded for several residential receivers positioned in close proximity to the rail track and/or new rail crossovers.

At this stage it is unclear if these receiver buildings would contain habitable rooms where the ground-borne noise would be higher than the airborne noise level. As such, further consideration of potential ground-borne noise impacts would be investigated during the detailed design stage of the project when the extent of airborne rail noise mitigation, train speeds, and the position of track turnouts is confirmed.

8.3.3 Operational Mitigation Summary

A number of approaches to mitigating operational noise impacts have been investigated and will be further reviewed as the project progresses. This review would include:

- Review of the use of track lubrication as the primary source of noise control for operational noise impacts
- Review of the feasibility and reasonableness of using noise barriers to provide path control mitigation to nearby receivers, noting the specific constraints that are applicable to the project
- Review of the locations where at-property treatment should be considered (after the use of source and path control measures) to mitigate residual impacts at individual receivers.

9 Conclusion

9.1 Construction Noise and Vibration

- As the nearest receivers to the project are relatively close in some areas, the worst-case construction noise impacts for the project would be consistent with most major infrastructure projects in urban areas, and are likely to be 'high' at certain times. The highest impacts would be when works requiring noise intensive equipment, such as rockbreakers or concrete saws, are in use near to receivers.
- The worst-case construction noise impacts on **residential receivers** are generally limited to receivers near Baxter Road (in NCA03), on McBurney Avenue (in NCA04) and in the southern extent of the study area (in NCA07/NCA08). The other catchments either have no residential receivers or receivers are sufficiently far from the works to minimise the impacts.

  'High' impacts are likely at the nearest receivers when noise intensive equipment is in use. Noise intensive equipment would however only be required for relatively short periods and noise levels and impacts during typical works would be significantly lower and generally result in 'minor' or 'moderate' impacts.
- The closest **hotels** to the project are near to the Joyce Drive and O'Riordan Street intersection and are likely to be subject to 'high' worst-case impacts. Notwithstanding, the most affected hotels would generally have high performance facades and glazing, which could potentially reduce construction noise impacts to acceptable internal levels.
- The **Qantas flight training centre** is located next to Qantas Drive and has several flight simulators and other areas highly sensitive to impacts. When works are immediately outside, the use of noise intensive equipment is likely to result in 'high' worst-case impacts.
- 'Moderate' worst-case impacts are seen at the nearest **commercial receivers** when noise intensive equipment is in use. Noise levels and exceedances during works not using noise intensive equipment are expected to be significantly lower and frequently compliant with the management levels.
- The main potential sources of construction **vibration** are from vibratory rollers and rockbreakers. The distance between the construction works and the nearest sensitive receivers is generally sufficient for most structures to be unlikely to suffer cosmetic damage. A small number of structures which are close to the project are however within the minimum working distances, including a number of heritage items.
- The project would apply all feasible and reasonable work practices to reduce the potential impacts. Specific strategies have been developed and would be detailed in the Construction Environmental Management Plan for the project. Site specific Construction Noise and Vibration Management Plans and Construction Noise and Vibration Impact Statements would also be developed before any works begin.
- Consecutive construction impacts, or 'construction fatigue', from extended impacts from Botany Rail Duplication and other major projects may occur near the Joyce Drive and O'Riordan Street intersection. Whilst each project would apply mitigation measures that are suitable for controlling impacts from their project in isolation, the measures may not be sufficient to address impacts from extended works. The potential for 'construction fatigue' should be investigated further as the project progresses.

9.2 Operational Rail Noise

- The urban nature of the study area means that many receivers are close to major existing sources of transportation noise and already subject to relatively high existing noise levels.
- The project is predicted to result in increased rail noise levels in study area, which is a result of:
  - Increased train speeds, which increases rail noise levels adjacent to the project and also the occurrence and noise level of curving noise (ie wheel squeal and flanging noise)
  - A higher volume of trains
  - The new track being closer to certain receivers.
- Worst-case increases of around 8 dB are predicted for maximum noise levels, with daytime and night-time L_{Aeq} noise levels predicted to increase by around 3 dB.
- The increased noise levels result in a number of areas where receivers are predicted to exceed the trigger levels. These areas are generally near to curved track and include:
  - Around King Street (in NCA01)
  - Near Baxter Road (in NCA03)
  - Near Botany Road and McBurney Avenue (in NCA04)
  - Along Myrtle Street (in NCA07/NCA08).
- A total of 189 receivers (182 residential and seven 'other sensitive') are predicted to have exceedances of the operational trigger levels. Additional noise mitigation should be considered for these receivers. It is however noted that six of the 'other sensitive' receivers are hotels and only areas of permanent residence require assessment and consideration for mitigation.
- Noise mitigation to minimise the impacts has been investigated. Use of a modern, well maintained track lubrication system on curves is likely to substantially reduce curve noise, with the number of receivers predicted to be reduced from 189 to 36.
- Residual impacts after the use of lubrication could be managed with noise barriers and / or at-property treatments. The mitigation strategy would be further developed during detailed design.
- The final mitigation approach should consider that the receivers which would be affected by the project are already subject by high existing noise levels from existing sources of road, rail and aircraft noise, and may already have been mitigated with at-property treatments. Recently built receivers would also have been designed and constructed with increased facade specifications to control high existing noise levels in the study area, as required by the Infrastructure SEPP.