APPENDIX E – Construction Noise and Vibration Impact Assessments

Construction Noise and Vibration Impact Assessment

More Trains More Services - Kembla Grange Electrical Works

Prepared for: Transport for Tomorrow

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For and on behalf of

ADE Consulting Group Pty Ltd

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	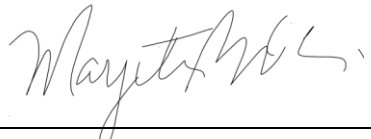	
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Definitions

Some common terms and definitions are provided in the table below.

An **Acoustic Glossary** is provided in **Appendix I**.

Term / Abbreviation	Summary
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed
Attenuation	The reduction in the level of sound or vibration
CEMP	Construction Environmental Management Plan
CNVIA	Construction Noise and Vibration Impact Assessment
CNVMP	Construction Noise and Vibration Management Plan
Construction	Includes all work required to construct the More Trains More Services infrastructure, includes commissioning trials of equipment and temporary use of any part of the Project
dBA	Decibels using the A-weighted scale measured according to the frequency of the human ear
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DPIE	Department of Planning, Industry and Environment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
Environmental aspect	Defined by AS/NZS ISO 14001:2015 as an element of an organisation's activities, products or services that can interact with the environment
Environmental impact	Defined by AS/NZS ISO 14001:2015 as any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects
Environmental objective	Defined by AS/NZS ISO 14001:2015 as an overall environmental goal, consistent with the environmental policy, that an organisation sets itself to achieve
Environmental target	Defined by AS/NZS ISO 14001:2015 as a detailed performance requirement, applicable to the organisation or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives
EPA	NSW Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
ER	Environmental Representative
EPL	Environment Protection Licences under the POEO Act
Feasible and reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.

Term / Abbreviation	Summary
Heritage Item	A place, building, work, relic, archaeological site, tree, movable object or precinct of heritage significance that is listed under one or more of the following registers: the State Heritage Register under the Heritage Act 1977 (NSW), a state agency heritage and conservation register under section 170 of the Heritage Act 1977 (NSW), a Local Environmental Plan under the EP&A Act, the World, National or Commonwealth Heritage lists under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth), and an "Aboriginal object" or "Aboriginal place" as defined in section 5 of the National Parks and Wildlife Act 1974 (NSW)
Highly Noise Affected	As defined in the ICNG
Highly noise intensive works	Works which are defined as annoying under the ICNG, including: a) use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work; b) grinding metal, concrete or masonry; c) rock drilling; d) line drilling; e) vibratory rolling; f) bitumen milling or profiling; g) jackhammering, rock hammering or rock breaking; h) rail tamping and regulating; and i) impact piling.
ICNG	Interim Construction Noise Guideline (DECC, 2009)
$L_{Aeq,15\ min}$	The A-weighted equivalent continuous (energy average) sound pressure level of the construction works under consideration over a 15-minute period and excludes other noise sources such as from industry, road, rail and the community. Sometimes tabulated as Leq or dBA Leq.
MTMS	More Trains More Services
NPfI	Noise Policy for Industry (EPA, 2017)
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
Planning Secretary	Planning Secretary of the Department (or nominee, whether nominated before or after the date on which this approval was granted)
RBL	The Rating Background Level for each period is the medium value of the ABL (Assessment Background Level) values for the period over all of the days measured. There is therefore an RBL value for each period (day, evening and night)
Sensitive Land Uses	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres and passive recreation areas (including outdoor grounds used for teaching). Receivers that may be considered to be sensitive include commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, and retail spaces), and industrial premises as identified by the Planning Secretary Note: For the purpose of determining appropriate mitigation, a multi-storey residential flat building must not be counted as a single sensitive receiver.
SHR	State Heritage Register
Sleep Disturbance	Where the subject development / premises night-time L_{Amax} noise levels at a residential location exceed $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater
SPL SWL	Sound Pressure Level Sound Power Level
TAHE	Transport Asset Holding Entity
TfNSW	Transport for NSW
TfNSW CNVS	Transport for New South Wales Construction Noise and Vibration Strategy, Version 4.2 dated 23 April 2019, Program Management Office, Planning, Environment and Sustainability
TfT	Transport for Tomorrow

1 Introduction

1.1 Background

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for electrical upgrade works proposed to be undertaken along approximately 2,000 m within the rail corridor between approximately 350 m northeast of Kembla Grange Racecourse Station to approximately 100 m northeast of the Mullet Creek rail bridge under the More Trains More Services South Works Program.

1.2 Project description

The More Trains More Services (MTMS) Program is a series of staged investments designed to progressively deliver service improvements across the network, as part of a broader transformation from a complex, constrained network, to a modern, simplified operation utilising world-class technology.

As part of the MTMS Program integrated infrastructure, fleet and operational changes will deliver service improvements on the T4 Eastern Suburbs & Illawarra (T4), T8 Airport & South (T8) and South Coast line.

The NSW Government is delivering the New Intercity Fleet (NIF) to replace the trains carrying customers from Sydney to the Central Coast, Newcastle, the Blue Mountains and the South Coast. Currently the majority of intercity trains operate as eight car trains however the NIF program would introduce 10-car trains.

The proposed electrical upgrades are required at the Kembla Grange site to support the operation of the NIF trains on the south coast.

1.3 Objectives

This Construction Noise and Vibration Impact Assessment (CNVIA) aims to achieve the following:

- Describe the proposed electrical works at Kembla Grange
- Identify noise and vibration sensitive receivers adjacent to the proposals site location
  - Assign construction noise and vibration criteria
- Assess the potential noise and vibration impacts to the surrounding receivers within the community
- Establish and identify feasible and reasonable mitigation
- Establish project-specific mitigation measures per-receiver based on the predicted impact during each period of the proposed works schedule.

1.4 Proposed Works

Kembla Grange comprises of various activities proposed to be undertaken in order to complete the Electrical Works package of the MTMS program.

The anticipated works are as follows:

- 3 x 400 mm^2 Direct Current (DC) Feeder cables from new Isolating Ration Connecting Switch (IRCS) to K171 at CK91+488 km
- 3 x 400mm^2 DC Feeder cables from new IRCS to K181 at CL91+490 km
- External IRCS with access platform
- A combination of Combined Services Route (CSR) and Galvanized Street Trough (GST) routes for the DC Feeder route from Kembla Grange Substation to K171 and K181
- Walkway / access bridge over existing culvert to access GST
- Six new Overhead Wiring (OHW) structures to be installed to support new overlap
- Replace 1800 m of Twin Contact Wire
- New feeding overlap to be constructed approximately 100 m towards Sydney
- Fixed midpoint to be relocated if necessary, worst case requires a new jumpered overlap.

1.5 Site location

The site is located along the rail corridor between 350 m northeast of the Kembla Grange Racecourse train station and stretches approximately 2000 m southwest through Kembla Grange, concluding approximately 100 m northeast of the Mullet Creek rail bridge, north of Brownsville.

The Kembla Grange Racecourse train station is located approximately 91.586 km south of Sydney CBD.

Figure 1 below provides an aerial overview of the site's location and anticipated alignment.

Figure 1 Site location and alignment, Kembla Grange NSW

1.6 Guidelines and standards

In order to undertake the noise and vibration assessment required for TfT, local and international guidelines and standards were considered.

Relevant documents pertaining to the measurement, assessment, and management of noise and vibration in Australia are provided below in **Table 1**.

Table 1 Summary of relevant documents

Guideline / Standard	Published by	Relevance
AS 1055:2018 Acoustics – Description and measurement of environmental noise	Australian Standards	Measurement of noise
AS 2659.1-1998 Guide to the use of sound measuring equipment – Portable sound level meters	Australian Standards	Measurement of noise
AS 2436:2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites	Australian Standards	Management of Noise and Vibration on Construction Sites
AS/NZS 2107-2016: Acoustics - Recommended design sound levels and reverberation times for building interiors	Australian Standards	Internal sound level design for Management of Noise
Interim Construction Noise Guideline	Department of Climate Change, 2009	Management of Noise on Construction Sites
Noise Policy for Industry	Environment Protection Authority, 2017	Management of Industry Noise, measurement of noise
Transport for New South Wales Construction Noise and Vibration Strategy	Transport for New South Wales (TfNSW), 2019	Management of Noise and Vibration on Construction Sites
Road Noise Policy	Department of Energy, Climate Change and Water, 2011	Management of Road Traffic Noise, Construction Traffic, and Sleep Disturbance
Accessing Vibration: A Technical Guideline	Department of Conservation, 2006	Management of Vibration
BS 7385: Part 2-1993 Evaluation and measurement of vibration in buildings	British Standards	Management of Vibration
DIN4150-2016: Structural vibration Part 3: Effects of Vibration on Structures	German Standards	Management of Vibration

2 Existing Environment

The projects locality is considered Suburban/Urban.

The dominant ambient noise environment is considered to be natural fauna, road traffic noise from the nearby Princes Highway, rail traffic along the South Coast (SCO) rail line, and some ambient noise from nearby commercial and industrial land use may be present within the area.

The Kembla Grange Racecourse is located near the project site.

Background noise levels have been derived from AS1055.3:1997 *Acoustics – Description and measurement of environmental noise Part 3: Acquisition of data pertinent to land use*, reproduced from the TfNSW CNVS (2019) and presented below in **Table 2**.

Table 2 Typical background noise levels for different areas

Area type	Description	Rating Background Level (RBL)		
		Day	Evening	Night
Rural	Areas with negligible transportation	40	35	30
Suburban/Urban	Areas with low density transportation	45	40	35
Urban	Areas with medium density transportation OR some commerce or industry	50	45	40
Urban/Industrial	Areas with dense transportation OR with some commerce or industry	55	50	45

Note: AS1055:1997 is superseded and this table does not appear in the revised 2018 version of this Australian standard. Its use here is based on the TfNSW CNVS reproduction of this information for assessment purposes in lieu of noise monitoring or establishing of ambient noise levels for the purpose of establishing relevant construction noise management levels

Note: Day, Evening and Night-time as defined in the Noise Policy for Industry (NPfI)

2.1 Sensitive land uses

The project is surrounded by a diverse community of various sensitive receiver types and land uses. These include:

- Residential: villas, free standing houses, and townhouses
- Commercial
- Stables and out-door passive/active recreational areas
- Educational Facilities
- Places of Worship
- Scattered light industry

The project is divided into three Noise Catchment Areas (NCAs), surrounding the project boundaries.

The NCA boundaries represent logical boundaries based on topography and the type of receivers applicable for that location.

An overview of the NCAs is provided below in **Table 3**, and an illustration is provided in **Figure 2**.

Table 3 Noise Catchment Area overview

NCA	Area type	Locality
NCA01	Suburban/Urban	Northern most section of the alignment, comprised of predominately scattered commercial and industrial land use. The Macedonian Orthodox Monastery is located within this locality
NCA02	Suburban/Urban	Comprised of Stables, some commercial and residential land use. The Kembla Grange racecourse is situated within this locality
NCA03	Suburban/Urban	South of project site, Brownsville and Dapto locality, dominated by residential low-density housing with some scattered other sensitive land uses such as educational facilities and hotels

The category of the sensitive receivers is considered Suburban/Urban as their mixture is scattered throughout the landscape and not built-up in a medium or high-density setting.

Figure 2 and **Figure 3** below provide an overview of the surrounding sensitive receivers within the locality of Kembla Grange, Brownsville and Dapto.

A more detailed illustration of the proposed works and alignment location is provided in **Figure 1**.

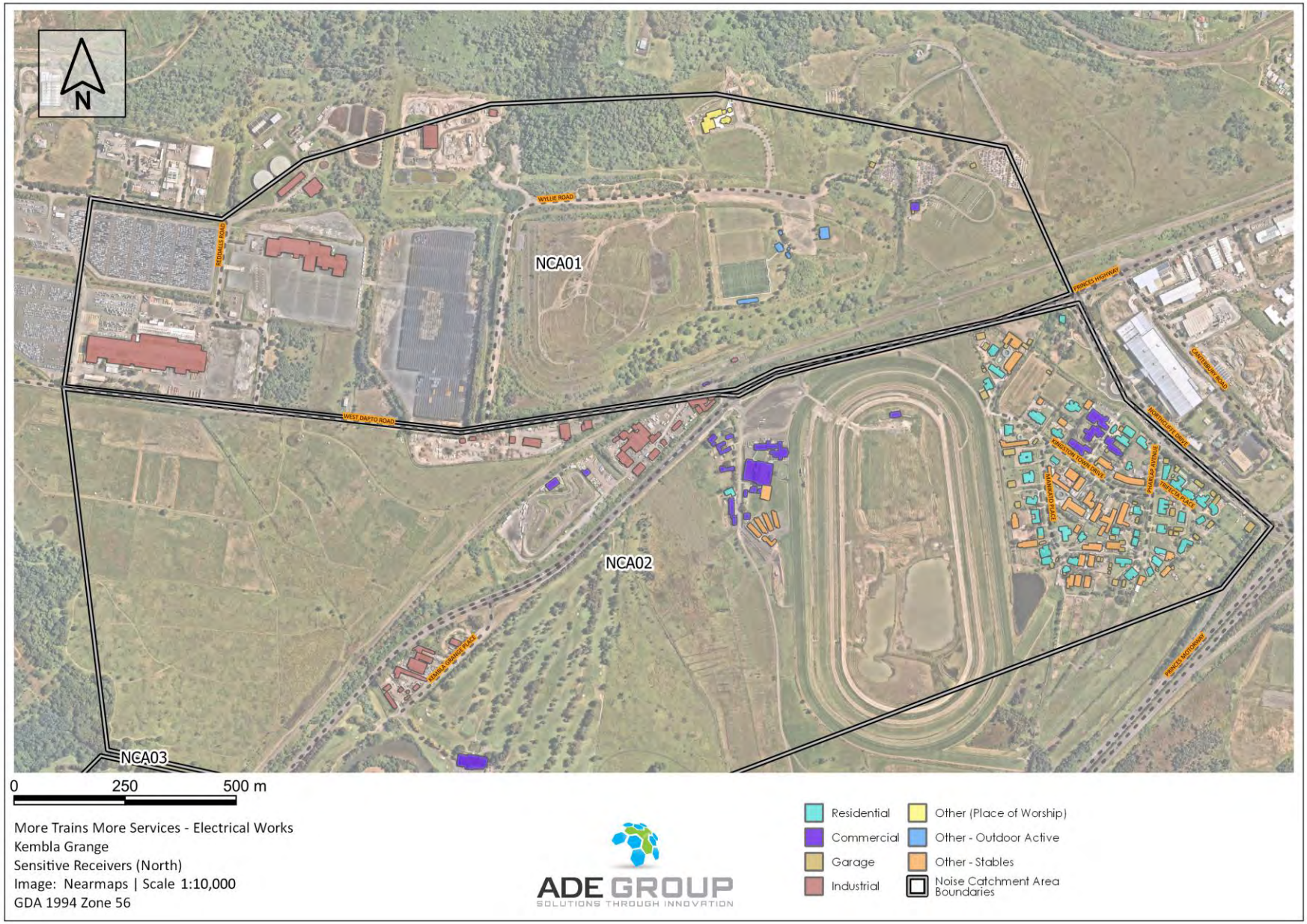

Figure 2 Overview of Kembla Grange sensitive receivers. Source: Nearmaps

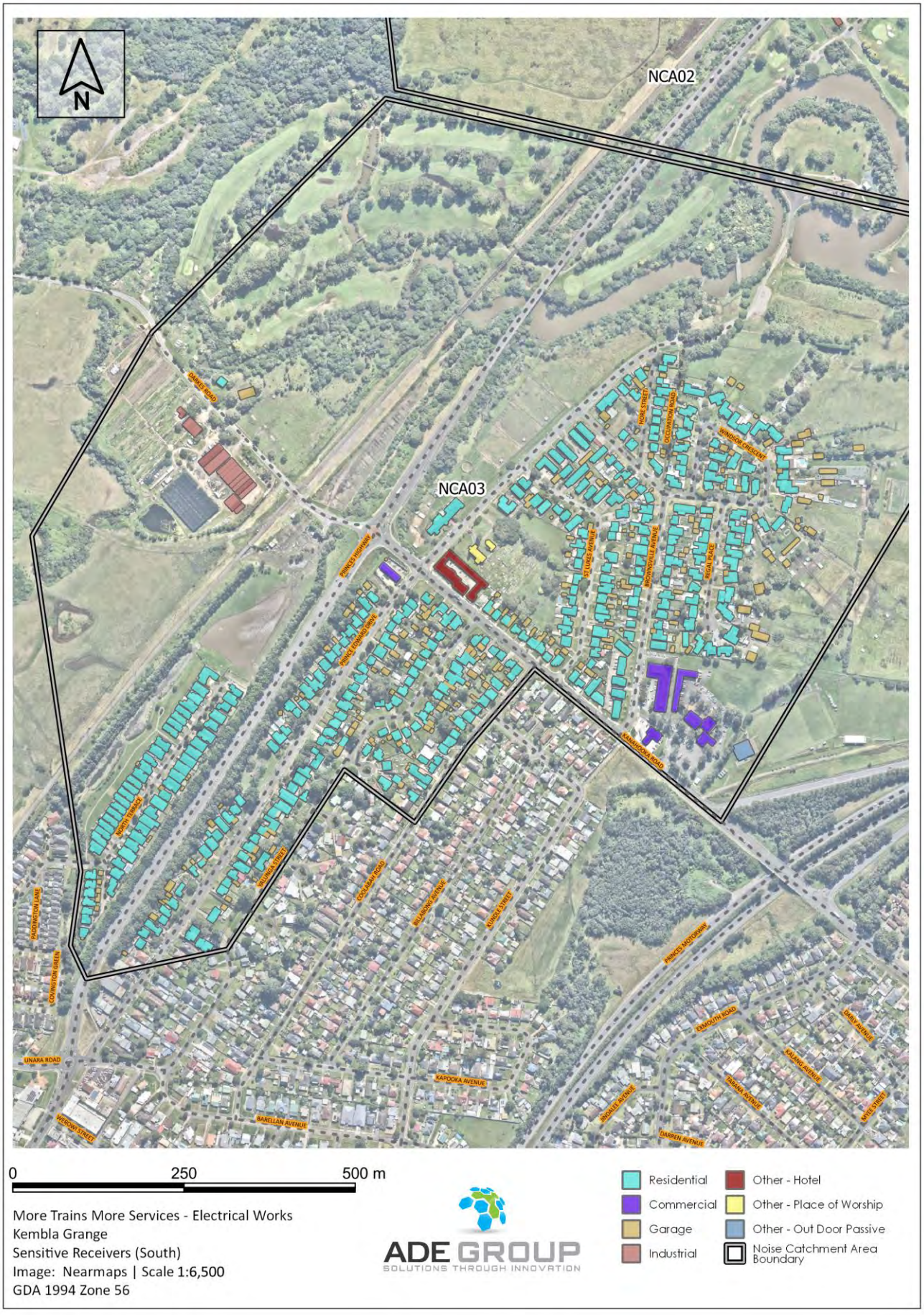

Figure 3 Overview of Brownsville and Dapto sensitive receivers. Source: Nearmaps

2.1.1 Heritage

The projects alignment passes through the Kembla Grange Racecourse Railway Station.

The railway stations platforms are a TAHE Section 170 and locally listed heritage item, and its current condition is unknown.

Figure 4 Heritage listed, or other sensitive structures

The site would be currently subjected to rail vibrations as passenger rolling stock would be passing through on the south-coast line.

3 Noise and Vibration Criteria

The EPA recommends management levels and goals when assessing the potential impacts of construction related noise and vibration.

Works under Transport for New South Wales reference relevant guidelines, policies, and standards tabulated in **Table 1** which provide the framework for management of noise and vibration from construction sites in New South Wales.

This section summarises the noise and vibration goals relevant to the construction works. The noise and vibration criteria vary over the different time periods defined throughout any one 24 hour period (generally more stringent criteria applies in more sensitive evening and night-time periods.

3.1 Airborne construction noise management levels

3.1.1 Residential receivers

Airborne construction noise which impacts residences and other sensitive land uses is assessed and managed through the Department of Environment and Climate Change Interim Construction Noise Guideline (2009).

Project Specific Noise Management Levels (NMLs) are established based on estimated noise level derived from the AS1055.3:1997 Standard, and the TfNSW CNVS Appendix B. The estimated background noise levels are considered conservative and are used for assessment purposes only.

Where noise levels are predicted (or measured) to exceed the NMLs, construction noise minimisation practices are recommended to be investigated.

Table 4 below describes the noise management levels pertaining to residential receivers and how to apply them.

Table 4 Noise at residences using quantitative assessment (ICNG, 2009)

Time of Day	NML dB $L_{Aeq,15min}$	How to apply
Standard 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 $L_{Aeq(15\ minute)}$ is greater than the noise affect 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 level represents the point above which there may be a strong community reaction to noise. • Where noise is above the level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: o 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 o If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

The resulting Noise Management Levels (NMLs) for all residential noise-sensitive receivers is tabulated below in **Table 5**. These levels represent the noise levels in which projects potential impact, and subsequent noise monitoring (during works) is to be assessed against.

Table 5 Noise Management Level (dBA $L_{Aeq,15\ minute}$) for Residential Receivers

NCA	Area Usage	Standard	Out of Hours (RBL +5)			Sleep Disturbance
		Day	Day	Evening	Night-time	
NCA01	Suburban/Urban	55	50	45	40	55
NCA02	Suburban/Urban	55	50	45	40	55
NCA03	Suburban/Urban	55	50	45	40	55

Note: Sleep Disturbance screening is based on L_{Amax} noise levels (refer to **Definitions**)
Note: NMLs based on TfNSW CNVS and AS1055 estimated noise levels

3.1.1.1 Sleep disturbance and awakening

The TfNSW CNVS assessment process requires an assessment of Sleep Disturbance and Sleep Awakening events as part of the impact assessment process.

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 EPA's Noise Policy for Industry (NPfI) with further guidance sourced from the EPA Road Noise Policy (RNP, 2011).

Although the NPfI sleep disturbance criteria relates to industrial noise, it is also considered relevant for reviewing potential impacts from construction noise as a screening criterion to identify the need for further assessment.

The CNVS recommends that a detailed maximum noise level assessment should be undertaken where a project results in night-time $L_{A1,1\ minute}$ (L_{Amax}) noise levels which exceed a noise level of the prevailing background level (RBL) plus 15 dB.

The RNP indicates that internal noise levels between 50 and 55 dB L_{Amax} are unlikely to cause sleep awakenings, however above this threshold a sleep awakening event is considered likely to occur. To assess external noise levels, a conservative +10 dB outside-to-inside correction is applied as outlined in the ICNG, hence an external noise level screening of 65 dB L_{Amax} is adopted to assess the likelihood of a sleep awakening event occurring.

The resultant sleep disturbance criterion for each NCA is tabulated in **Table 5** above.

3.1.2 Other sensitive land uses and commercial receivers

The project is surrounded by a number of non-residential land uses. **Table 6** below outlines the NMLs for other sensitive receivers.

Table 6 Noise at sensitive land uses (other than residential) using quantitative assessment

Land use	Management level $L_{Aeq,15\ minute}$ (applicable when properties are in use)
Industrial Premises	External noise level 75 dBA
Offices, retail outlets and other commercial properties	External noise level 70 dBA
Classrooms at school and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community centres	Refer to the recommended 'maximum' internal levels outlined in AS2107 for specific uses

Other noise-sensitive receivers not defined in the ICNG require noise level criteria derived from AS 2107:2016.

The AS 2107 noise level criteria are generally provided as internal levels, and an internal-to-external correction of +10 dB has been applied to assume a conservative noise level with an open window for ventilation.

Table 7 NMLs for 'Other Sensitive Receivers' based on AS2107

Land use	Noise Management Level $L_{Aeq,15\ minute}$	
	Internal	External
Childcare Centre	60 dBA play area 40 dBA sleeping area	70 dBA play area 50 dBA sleeping area
Public Buildings	50 dBA	60 dBA
Café/Bar or Restaurant	50 dBA	60 dBA
Hotel	40 dBA	50 dBA
Stables	50 dBA	60 dBA

3.1.3 Maximum allowable Sound Power Levels

The Transport for New South Wales (TfNSW) Construction Noise and Vibration Strategy (CNVS) provides guidance's for the maximum allowable sound power levels from plant equipment. These noise levels are not used for assessment purposes, only when undertaking sound power level testing for plant equipment on site if necessary or as required.

All plant and equipment used on site during construction activities must be below or equal to the allowable noise levels to achieve compliance.

These guidelines are replicated below in **Table 8**.

Table 8 Maximum Allowable noise levels from plant equipment, TfNSW CNVS

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Asphalt – Truck & Sprayer		106	81
Backhoe		111	86
Chainsaw – petrol[4]	4-5hp	114	89
Compactor		106	81
Compressor		109	84
Crane – Fixed		113	88
Crane – Franna	20 tonne	98	73
Crane – Mobile		113	88
Crane – Truck mounted	20 to 60 tonne	108	83
Crusher – Rock[4]		118	93
Dozer	CAT D9	116	91
Dozer	CAT D10	121	96
Elevated work platform – scissor lift		98	73
Elevated work platform		97	77
Excavator – tracked	3 tonne	90	65

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Excavator – tracked	6 tonne	95	70
As above + hydraulic hammer[4]		115	90
Excavator – tracked	10 tonne	100	75
As above + hydraulic hammer[4]		118	93
Excavator – tracked	20 tonne	105	80
Excavator – tracked	30 tonne	110	85
As above + hydraulic hammer[4]		122	97
Excavator – tracked	40 tonne	115	90
Grader		113	88
Generator – diesel/ petrol	6kW	103	78
Generator – attenuated	30kW	92	67
Grinder[4]		105	80
Jackhammer		113	88
Lighting Tower		80	55
Lighting – Daymakers		98	73
Light Vehicle – 4WD		103	78
Line Marking Truck		108	83
Loader – Front-end (wheeled)	23 tonne	112	87
Loader – Skidsteer	1/2 tonne	107	82
Loaders – Skidsteer	1 tonne	110	85
Loader – Tracked	0 to 50 kW	115	90
Loaders – Tracked	200 to 300 kW	121	96
Pavement Laying Machine		114	89
Pavement Profiler		117	92
Pile Driver – Vibratory[4]		121	96
Piling Rig – Bored		112	87
Piling Rig – Impact[4]		134	109
Pump – Concrete		109	84
Rattle gun (hand held)		104	79
Roller – smooth drum		107	82
Roller – large pad foot		109	84
Roller – Vibratory[4]	10 tonne	109	84
Saw – Concrete[4]		118	93
Scraper		113	88
Truck – Concrete		109	84
Truck – Dump	15 tonne	110	85
Truck – Medium rigid	20 tonne	103	78
Truck – road truck/ truck & dog	30 tonne	108	83

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Truck – Vacuum (NDD or non-destructive digger)		109	84
Tub Grinder/Mulcher	40-50hp	116	91
Vibrator – Concrete[4]		113	88
Water Cart		107	82
Welding equipment		110	85
Wrench – Impact		111	86

Note 1 The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7 m) from the plant or equipment

Note 2: The SWLs presented in the above table have been compiled from a selection of field measurements conducted by Heggies Pty Ltd between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW, as well as various TfNSW Noise & Vibration impact assessments and the RMS Construction Noise & Vibration Guideline (August, 2016)

Note 3: Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites

Note 4: Equipment with special audible characteristics.

3.1.4 Construction related traffic

Some heavy truck usage may be used to haul equipment to and from the site to facilitate the activities associated with the Program. Guidance for construction related traffic on TfNSW project is taken from the CNVS which outlines that:

"additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario".

Noise monitoring has not been undertaken, therefore the existing ambient traffic noise has not been established. To assess the potential impact of truck haulage, a screening assessment has been undertaken to determine if any potential impact to the sensitive receivers is likely.

Referring to **Table 9** below, screening noise levels for construction traffic have been established for the proposal where construction traffic is anticipated to be present on Freeway/arterial roads as no local roads are anticipated to be utilized by construction traffic.

Table 9 Target construction road traffic noise

Existing road category	Target noise level, dB	
	Day 07:00 hrs to 22:00 hrs	**Night** 22:00 hrs to 07:00 hrs
Freeway/Arterial/Sub-arterial roads	$L_{Aeq,\ 15\ hour}$, 60 (external)	$L_{Aeq,\ 9\ hour}$, 55 (external)

Should the road traffic noise levels increase by more than 2 dB due to construction traffic, additional mitigation options should be considered and investigated.

3.2 Construction vibration guidelines

Generally, construction which produces vibration may be group into three categories:

- Human Comfort – in which the occupants of a building are disturbed
- Building Contents – in which highly sensitive equipment or other machinery may be affected
- Structural or cosmetic damage – in which the integrity of the buildings structure may be compromised, or weak non-structural components may be damaged.

3.2.1 Effects of vibration on structures

The levels of vibration required to cause cosmetic damage to buildings is significantly higher than the vibration levels in which humans would find tolerable.

Damage caused as a result of vibration can occur due to short-term vibration (vibration which does not occur often enough to cause structural fatigue nor produce resonance) or long-term vibration (all other types of vibration).

Where the potential for structural damage may occur, dilapidation assessments may be necessary to be undertaken prior to and during, or following, construction.

Structural damage vibration guidelines are provided below, derived from British Standard BS 7385 for transient vibration.

3.2.1.1 Transient vibration

BS 7385 provides recommendations in vibration limitations regarding transient vibration. The limits outlined below in **Table 10** are conservative and are judged to give a minimum risk to which vibration may cause damage to buildings.

Table 10 Transient vibration, British Standard BS 7385-3: 1993

Type of Building	Peak component particle velocity (PPV) in frequency range of predominant pulse	
	4 Hz – 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
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: Values referred to are at the base of the building

3.2.1.2 Safe working distances

As a guide, minimum working distances for typical items of vibration intensive plant are listed below in **Table 11**. This data is provided by TfNSW's Construction Noise and Vibration Strategy (CNVS, v4.2 2019).

The minimum working distances are quoted for both cosmetic damage (BS 7385 and DIN4150) and human comfort (Assessing Vibration – A Technical Guideline).

The minimum working distances for cosmetic damage are recommended to be complied with at all times, unless otherwise approved by the relevant authority.

The distances provided in **Table 11** are indicative and would vary depending on the plant or item used for the works, as well as the geotechnical conditions within the surrounding earth.

Table 11 Recommended minimum working distances from vibration intensive plant (TfNSW CNS)

Plant Item	Approximate Size / Weight / Model	Minimum Distance for Cosmetic Damage (BS7385)	Minimum Distance for Human Response (DEC Assessing Vibration)	Heritage (DIN4150)
Vibratory Roller	1-2 tonne	5 m	15 – 20 m	11 m
	2-4 tonne	6 m	20 m	14 m
	4-6 tonne	12 m	40 m	27 m
	7-13 tonne	15 m	100 m	33 m
	13-18 tonne	20 m	100 m	44 m
	>18 tonne	25 m	100 m	55 m
Small Hydraulic Hammer	300 kg (5 to 12 t excavator)	2 m	7 m	5 m
Medium Hydraulic Hammer	900 kg (12 to 18 t excavator)	7 m	23 m	16 m
Large Hydraulic Hammer	1600 kg (18 to 34 t excavator)	22 m	73 m	49 m
Pile Driver – Vibratory	Sheet piles	2 to 20 m	20 m	15 m
Piling Rig - Bored	≤ 800 mm	2 m (nominal)	N/A	6 m
Piling Rig – Hammer	12 t down force	15 m	50 m	45 m
Jackhammer	Hand held	1 m	Avoid contact with structure	3 m

Note: Distances are indicative only, where heavy machinery falls within safe working distances, attended vibration monitoring should be undertaken to confirm vibration levels

Note: Heritage safe working distances are conservative

Generally, vibration monitoring is recommended where construction works within these distances to particular sensitive structures are to occur. The monitoring would verify the minimum working distances at specific locations, which then may be applied to establish a buffer zone surrounding the proposed alignment.

Where the vibration monitoring demonstrates exceedances of the structural/cosmetic damage criteria (refer to **Section 3.2**), alternative construction methodology may be required, such as selection of equipment designed to produce less vibration (where feasible and reasonable).

In such case, construction works are not recommended to continue until attended vibration measurements confirm any risk of cosmetic damage, particularly to heritage structures and or other structures found to be structurally unsound by a qualified structural engineer.

3.2.1.3 Vibration screening

With the guideline values from BS7385 outlined in **Table 10**, conservative vibration damage screening levels per receiver type have been established based on the potentially worst-case scenario of any vibration intensive plant equipment being in use at any point along the works alignment within the rail corridor.

- Reinforced or framed structures: 25 mm/s
- Unreinforced or light framed structures: 7.5 mm/s.

At locations where the predicted and/or measured vibration levels are greater than those listed above, a more detailed condition assessment of the structure and the construction activities near the structure would be required to determine the applicable safe vibration level for that structure.

3.2.2 Human comfort

Construction activities which have the potential to create ground-borne vibrations may impact sensitive receivers near the project works. Humans are responsive to vibration and some discomfort may arise due to various activities, their intensity and duration.

Structural or cosmetic damage to buildings due to vibration only occur at extreme levels, relative to what humans find tolerable.

For human comfort and exposure to vibration, the NSW document *Assessing Vibration: A Technical Guideline* (DEC, 2006) provides the relevant guidance's derived from British Standards.

Table 12 below tabulates the Vibration Dose Values for human comfort. These values represent a guideline for the total accumulation of vibration energy during a 16 hour day-time period.

Table 12 Vibration Dose Values (VDV) for Intermittent Vibration ($m/s^{1.75}$)

Location	Period	Preferred value, VDV $m/s^{1.75}$	Maximum value VDV $m/s^{1.75}$
Critical areas	Day or Night	0.1	0.2
Residences	Day	0.2	0.4
	Night	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night	0.4	0.8
Workshops	Day or Night	0.8	1.6

Note: Daytime is 07:00 hrs to 22:00 hrs

Table 13 below reproduces the preferred and maximum weighted rms **α** acceleration vibration for continuous and impulsive vibration.

Table 13 Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2)

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y- axis	z-axis	x- and y-axis
Continuous Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night	0.020	0.014	0.040	0.028
Workshops	Day or night	0.04	0.029	0.080	0.058
Impulsive Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.30	0.21	0.60	0.42
	Night	0.10	0.071	0.20	0.14
Offices, schools, educational institutions, and places of worship	Day or night	0.64	0.46	1.28	0.92
Workshops	Day or night	0.64	0.46	1.28	0.92

3.3 Ground-borne noise

Ground-borne noise impacts are generally caused by high-vibration intensive plant equipment such as tunneling machines. The ICNG provides guidance for the management of ground-borne noise (GNML), these recommendations are tabulated below in **Table 14** applicable only to residential receivers.

Table 14 Ground-borne noise management levels

Evening 18:00 hrs to 22:00 hrs	Night-time 22:00 hrs to 07:00 hrs
40 dB $L_{Aeq,15min}$	35 dB $L_{Aeq,15min}$

Note: During the Daytime period (07:00 hrs to 18:00 hrs), the human comfort vibration objectives only apply

The internal noise levels are to be assessed at the centre of the most-affected habitable room. For a limited number of discrete, ongoing ground-borne noise events, such as drilling or rock-hammering, the L_{Amax} noise descriptor using a slow response on the sound level meter may be better than the L_{Aeq} noise descriptor (15 min) in describing the noise impacts.

The level of mitigation of ground-borne noise would depend on the extent of impacts and also on the scale and duration of works. Any restriction on the days when construction work is allowed would take into account whether the community:

- Has identified times of day when they are more sensitive to noise (for example Sundays or public holidays)
- Is prepared to accept a longer construction duration in exchange for days of respite.

The proposed methodology along the alignment by Kembla Grange, or any other part of the Electrical Works MTMS program do not have any tunnelling machines or subjectively high-vibration intensive equipment.

However, as bored piling works are undertaken at some locations along the alignment assessed in this report, ground-borne noise impacts are investigated on a conservative worst-case basis.

4 Construction Noise and Vibration Impact Assessment

A range of small and large plant equipment is proposed to be utilised in order to undertake the appropriate constructions activities associated with the Project.

This section summarises the anticipated construction scenarios and associated predicted noise and vibration impacts. These are as follows:

- Noise impacts within the community and to the stables
- Vibration impacts
  - Human comfort
  - Regenerated noise (ground-borne noise)
  - Heritage or other sensitive structures.

4.1 Noise

4.1.1 Proposed activities

The proposed construction activities have been divided into 10 construction scenarios in which the works are anticipated to be completed in over multiple railway possessions throughout 2022 and into 2023.

The potential impacts associated with these key activities are assessed based on the type of work that is being carried out, and the time of day/week the works are scheduled to occur over.

Construction works are anticipated to be completed in various stages with the construction activities expected to be completed by December 2023.

It is expected that the activities proposed may be required to work outside the standard daytime hours. The anticipated hours of works are as follows.

Monday to Friday Saturday	Daytime Standard Hours	07:00 hrs to 18:00 hrs 08:00 hrs to 13:00 hrs
Saturday	Daytime Out of Hours	07:00 hrs to 08:00 hrs 13:00 hrs to 18:00 hrs
Sunday Public Holidays	Daytime Out of Hours	08:00 hrs to 18:00 hrs
Monday to Sunday	Evening	18:00 hrs to 22:00 hrs
Monday to Sunday	Night-time	22:00 hrs to 07:00 hrs

Out of hours works and weekend rail Possessions are proposed for works which cannot reasonably be undertaken throughout the normal working-week.

An illustrative overview is provided below in **Table 15**.

Table 15 Periods of works, including out of hours

Hour Commencing	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Monday																			OOWH Period 1 (Evening)					
Tuesday																			OOWH Period 1 (Evening)					
Wednesday																			OOWH Period 1 (Evening)					
Thursday	OOWH Period 2																		OOWH Period 1 (Evening)					
Friday																			OOWH Period 1 (Evening)					
Saturday																			OOWH Period 1 (Evening)					
Sunday									OOWH Period 1 (Day)										OOWH Period 2					
Public Holidays																								

Table 16 below provides a general outline of the construction scenarios and their corresponding activity.

Table 16 Work Scenarios for assessment purposes

Scenario ID	Scenario	Activity	Tentative Duration	Proposed Hours of Work				
				Day	Out of Hours Period 1		Out of Hours Period 2	
					Day	Evening	Evening	Night
SN.001	Site Establishment / Demobilisation	Typical Impact	Mid weeks and weekends June 2022 to December 2023.	✓	✓	✓	✓	✓
SN.002	Concrete Works Typical CSR and Piling, Civil Works	Typical Impact	Mid weeks and weekends June 2022 to December 2023.	✓	✓	✓	✓	✓
SN.003	Concrete Works Typical CSR and Piling	High Impact	Mid weeks and weekends June 2022 to December 2023.	✓	✓	✓	✓	✓
SN.004	Steeling Works and Installation	Typical Impact	Three weekend possessions December 2022 to June 2023 and midweek works March to December 2023.	✓	✓	✓	✓	✓
SN.005	Cable Pull	Typical Impact	Three weekend possessions December 2022 to December 2023 and midweek works March to December 2023.	✓	✓	✓	✓	✓
SN.006	Overhead Wiring Works	Typical Impact	Two weekend possessions and midweek works March 2023 to December 2023.	✓	✓	✓	✓	✓
SN.007	Compound Operations and Utilisation	Typical Impact	18 months June 2022 to December 2023	✓	✓	✓	✓	✓

Scenario ID	Scenario	Activity	Tentative Duration	Proposed Hours of Work				
				Day	Out of Hours Period 1		Out of Hours Period 2	
					Day	Evening	Evening	Night
SN.008	Vegetation Management	Typical Impact	Mid weeks and weekends June 2022 to December 2023.	✓	✓	✓	✓	✓

Note: Subject to change or alterations

4.2 Noise model

4.2.1 Calculation methodology

Noise levels have been predicted using 3D predictive software SoundPLAN ver8.2. The prediction model was undertaken using the Industrial Noise ISO 9613 algorithms.

Buildings and the local terrain have been digitised within the model to represent the land surrounding the Project's alignment boundaries.

Data was sourced from Geoscape building footprint database, NSW Spatial Services, and aerial imaging sourced via Nearmaps.

4.2.2 Source noise levels

The Sound Power Levels (SWL) for general and typical construction equipment is provided in **Table 17**. The levels tabulated below are derived from global standard databases.

Construction scenarios, locations, and proposed equipment were provided to us, and confirmed with the Construction manager and TfT prior to running the assessment. The percentage of on-time is based on standard practices and experience.

Table 17 Sound Power Levels (SWL) for the construction equipment

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.001	Site Establishment / Demobilisation	Typical Impact	Hand Tools	1	67%	92	106
			Vehicle (light commercial)	1	67%	104	
			Flatbed Truck	1	67%	98	
			Lighting - Diesel Generator	1	100%	98	

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.002	Concrete Works Typical CSR and Piling, Civil Works	Typical Impact	Suction Truck	1	67%	98	107
			Excavator (14 tonne)	1	67%	95	
			Concrete Mixer Truck	1	67%	101	
			Concrete Pump	1	67%	104	
			Tipper Truck	1	67%	95	
SN.003	Concrete Works Typical CSR and Piling	High Impact	Piling - Bored	1	67%	109	111
			Concrete Mixer Truck	1	67%	101	
			Concrete Pump	1	67%	104	
			Suction Truck	1	67%	98	
			Excavator (14 tonne)	1	67%	95	
SN.004	Steeling Works and Installation	Typical Impact	Excavator (14 tonne)	1	53%	94	102
			Tipper Truck	1	33%	92	
			Welding Equipment	1	67%	95	
			Vehicle (light commercial)	1	20%	99	
			Hand Tools	1	67%	92	
SN.005	Cable Pull	Typical Impact	Vehicle (light commercial)	1	53%	103	104
			Hand Tools	1	33%	89	
			winch (electric)	1	100%	95	
SN.006	Overhead Wiring Works	Typical Impact	Elevated Working Platform	1	67%	95	103
			Hi-Rail Manitou	1	67%	89	
			Vehicle (light commercial)	1	33%	101	
			Hand Tools	1	67%	92	
			Mobile Crane - Franna	1	33%	93	

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.007	Compound Operations and Utilisation	Typical Impact	Generator	1	100%	102	107
			Ute	1	53%	95	
			Flatbed Truck	1	33%	95	
			Delivery Truck	1	53%	105	
SN.008	Vegetation Management	Typical Impact	Chainsaw	1	47%	108	109
			Mulching machine	1	67%	103	
			Ute	1	53%	95	

4.2.3 Results overview

The predicted noise levels are analysed in accordance with the policies, guidelines and standards outlined in **Table 1**, and are presented below.

The following tables and figures provide the maximum worst-case $L_{Aeq,15min}$ noise level predicted from the most impacted sensitive receiver for each NCA during all approved construction hour periods.

During most of the construction works, it is reasonable to expect that the noise levels would be lower than the predicted noise levels, as the noise model does not take into account any implemented mitigation measures.

4.2.3.1 Noise management level exceedances (project wide)

Table 18 summarises the number of residential receivers and other sensitive land use which are predicted to experience noise levels which exceed their relevant Noise Management Level, including receivers which would experience noise levels exceeding 75 dBA ($L_{Aeq,15min}$).

Table 18 Project wide overview of NML exceedances

Works Scenario	Number of Receivers exceeding relevant Noise Management Level								
	Number of Receivers	Standard Daytime		Out of Hours Works					
				Out of Hours Period 1		Out of Hours Period 2			
		Day	HNA	Daytime	Evening	Sunday Evening	Night	Sleep Disturbance	Sleep Awakening
SN.001	854	-	-	-	-	-	1	-	-
SN.002		7	-	7	19	19	124	8	-
SN.003		11	-	22	91	91	294	91	-
SN.004		3	-	3	-	-	23	-	-
SN.005		3	-	3	4	4	48	-	-
SN.006		3	-	3	1	1	30	-	-
SN.007		-	-	-	-	-	1	-	-
SN.008		1	-	2	1	1	15	15	-

Note: The predicted NML exceedances include all noise sensitive receivers except OOHW which applies to residential.
Note: HNA (Highly Noise Affected) only applies to residential receivers during standard hours
Note: NML Exceedances for residential land use is based on assumed background noise levels discussed in **Section 3.1**
Note: Evening and Night-time NML exceedances are residential only. Day and Day-time OOH include all receivers

4.2.3.2 Extent of NML exceedances

The results are broken down into four (4) subsets as follows:

NML	-	Noise levels 1 to 10 dB above NML (1 – 5 dB for out of hours)
	-	Noise levels 11 to 20 dB above NML (5 – 15 dB for out of hours)
	-	Noise levels 21 to 30 dB above NML (15 – 25 dB for out of hours)
	-	Noise levels greater than 30 dB above NML (>25 dB for out of hours)
>75 dBA	-	Highly Noise Affected, noise levels exceed 75 dBA ($L_{Aeq,15min}$) (Residential land use only)

Note: The above color code is an arbitrary scheme and not designed to flag exceedances based on their range, rather a category highlight.

The extent and distribution of the NML exceedances are tabulated and illustrated below in **Table 19**.

Table 19 Distribution of NML exceedances

Scenario	Number of Receivers															
	Total	HNA >75 dBA	Distribution of NML exceedances													
			Day				Daytime Out of Hours				Evening (including Sundays)				Night-time			
			0 - 10	10 - 20	20 -30	>30	1 - 5	5 - 15	15 - 25	>25	1 - 5	5 - 15	15 - 25	>25	1 - 5	5 - 15	15 - 25	>25
SN.001	854	0	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
SN.002			2	-	1	-	1		3	-	11		3	-	56	12	3	-
SN.003			7	-	3	-	9	1	2	-	48	11	2	-	130	81	2	-
SN.004			2	1	-	-	1	2	-	-	1	2	-	-	10	2	-	-
SN.005			2	1	-	-	-	3	-	-	-	3	-	-	21	5	-	-
SN.006			2	1	-	-	-	2	-	-	-	2	-	-	14	2	-	-
SN.007			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SN.008			1	-	-	-	1	-	-	-	1	-	-	-	7	1	-	-

Note: HNA refers to Highly Noise Affected, based on the ICNG definition
Note: All exceedances are considered conservative worst-case

A bar graph illustration of the above table is provided below in **Figure 5** and tabulates the spread of the exceedances across all work periods, and all receivers. Note, Sunday evening is included in the evening count.

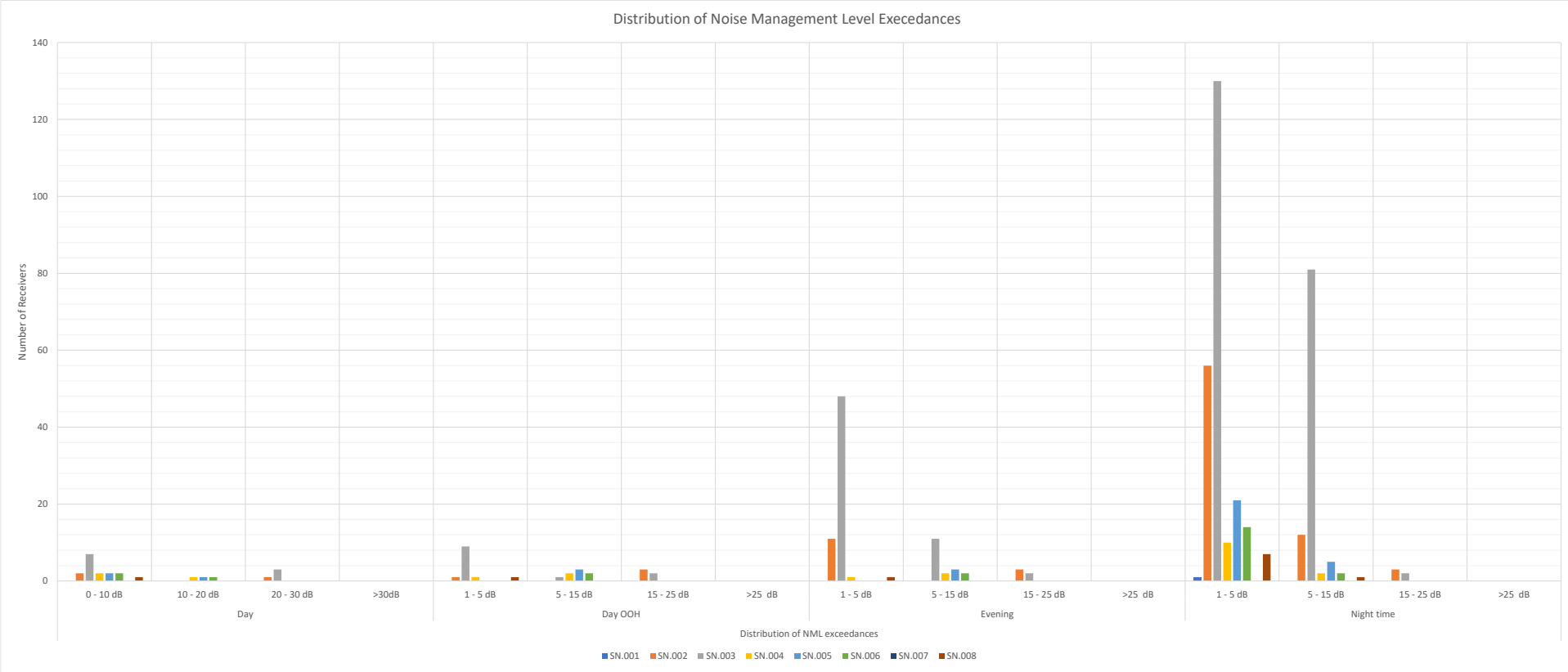

Figure 5 Extent of NML exceedances (all periods, all receivers Day, Residential only Day OOH, Evening and Night-time)

Figure 6 below tabulates the number of receivers predicted to exceed their relevant NML during standard working hours.

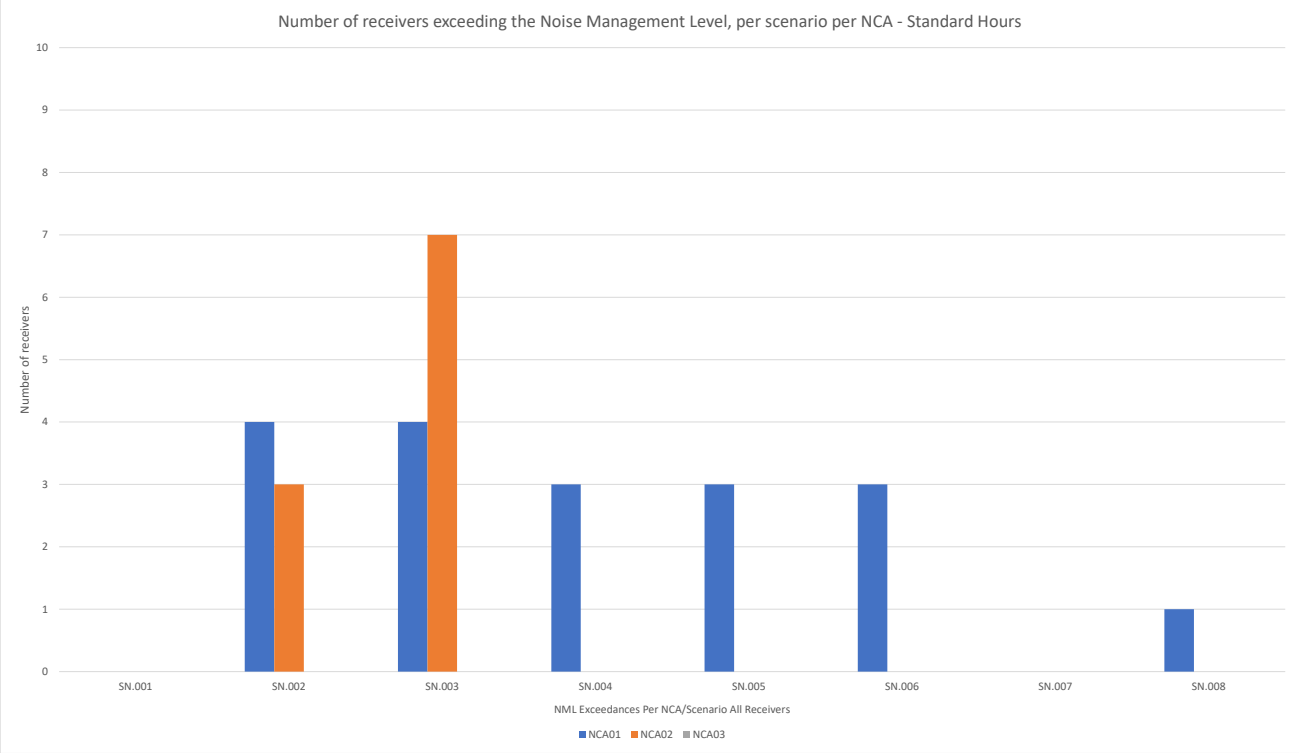

Figure 6 All sensitive receivers exceeding their relevant NML – standard hours

Figure 7 below tabulates day-time out of hours NML exceedances (all receivers).

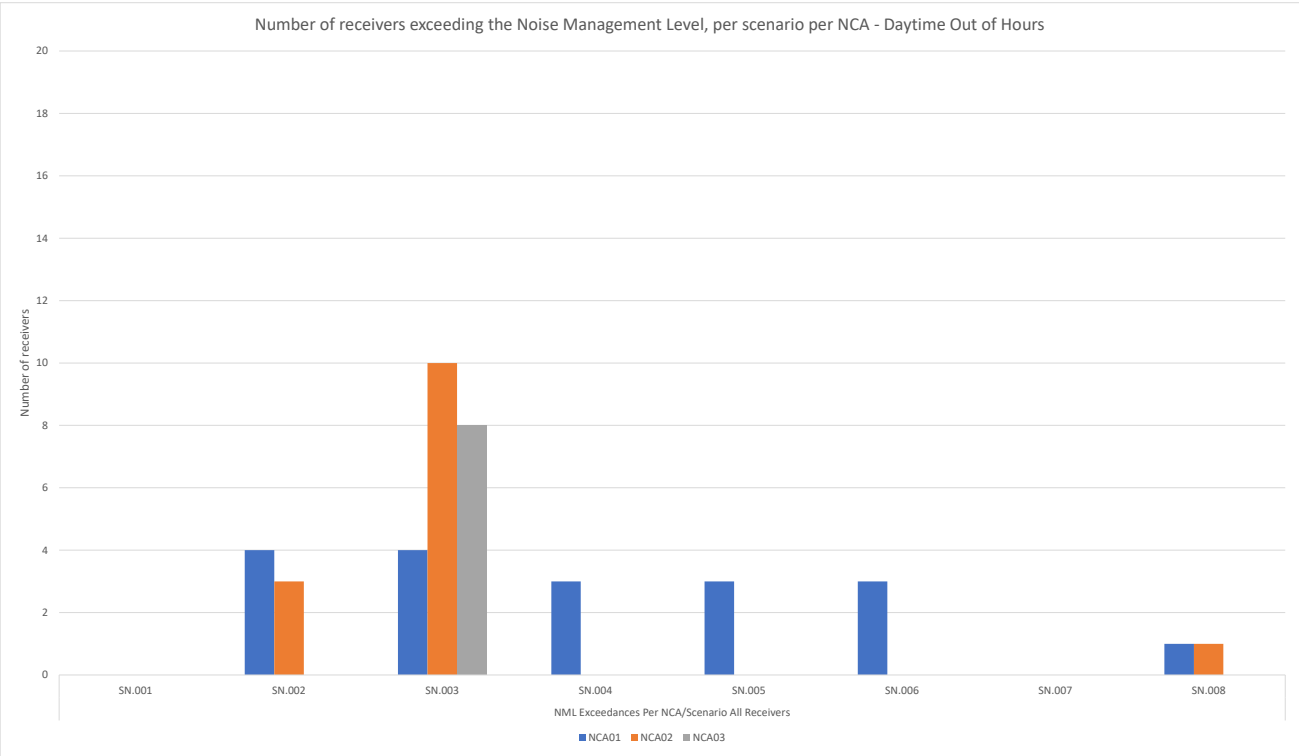

Figure 7 Receivers predicted to exceed their relevant NML during daytime OOH works

Figure 8 below tabulates evening-time out of hours residential NML exceedances.

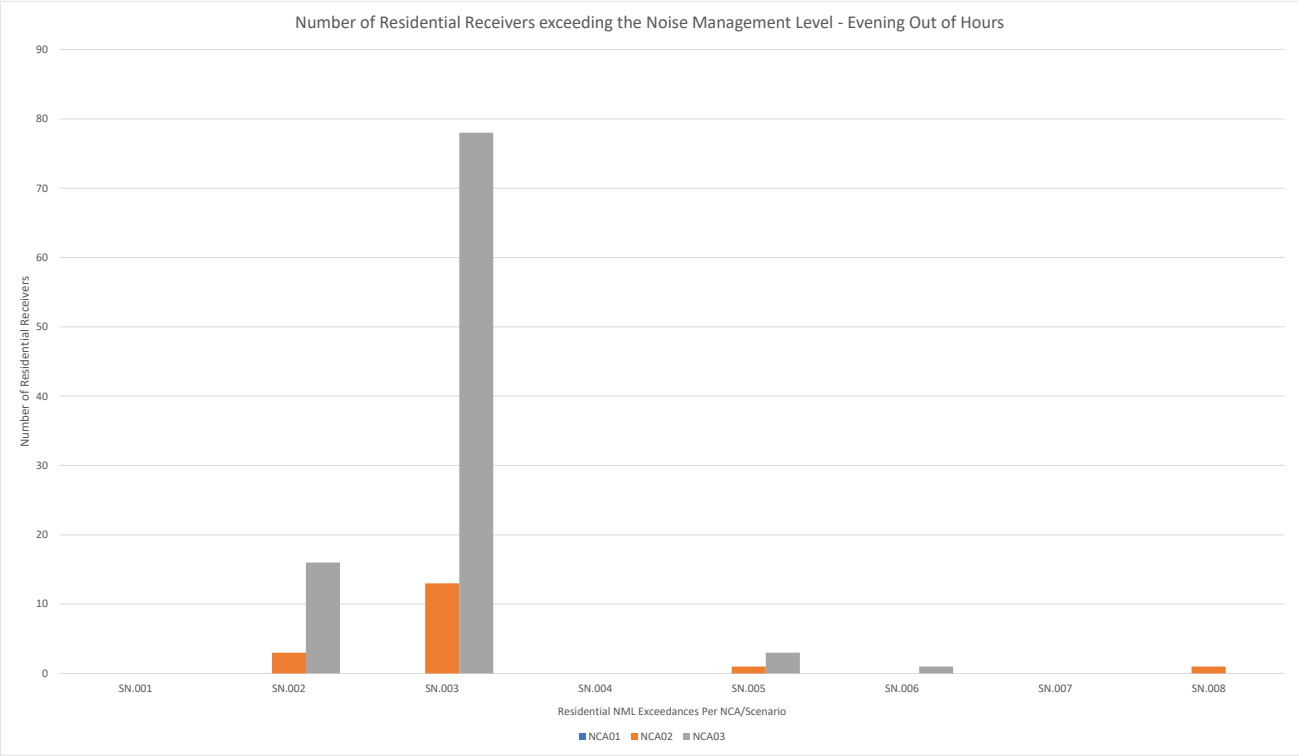

Figure 8 Residential receivers predicted to exceed their relevant NML during evening out of hours works

Figure 9 below tabulates residential NML exceedances during Sunday evening works (18:00 – 22:00 hrs).

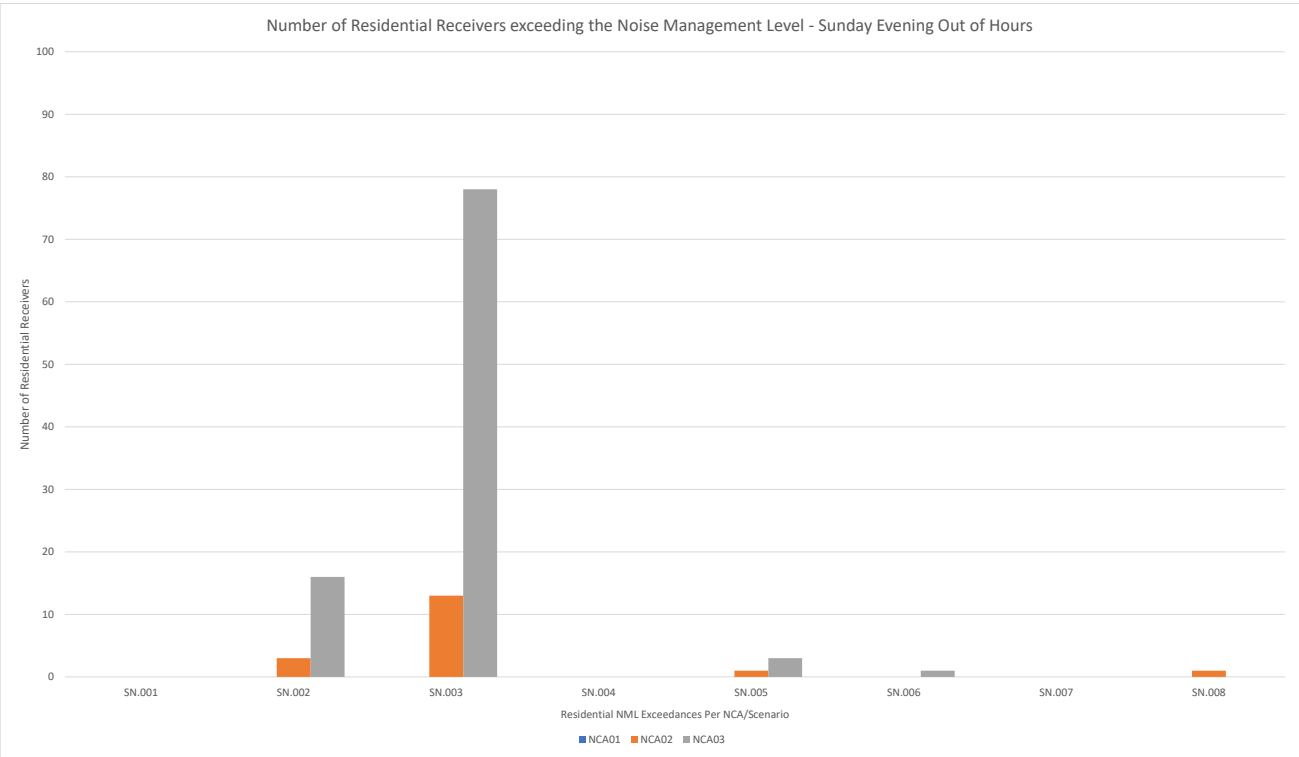

Figure 9 Residential receivers predicted to exceed their relevant NML during Sunday Evening out of hours works

Figure 10 below tabulates night-time out of hours residential NML exceedances.

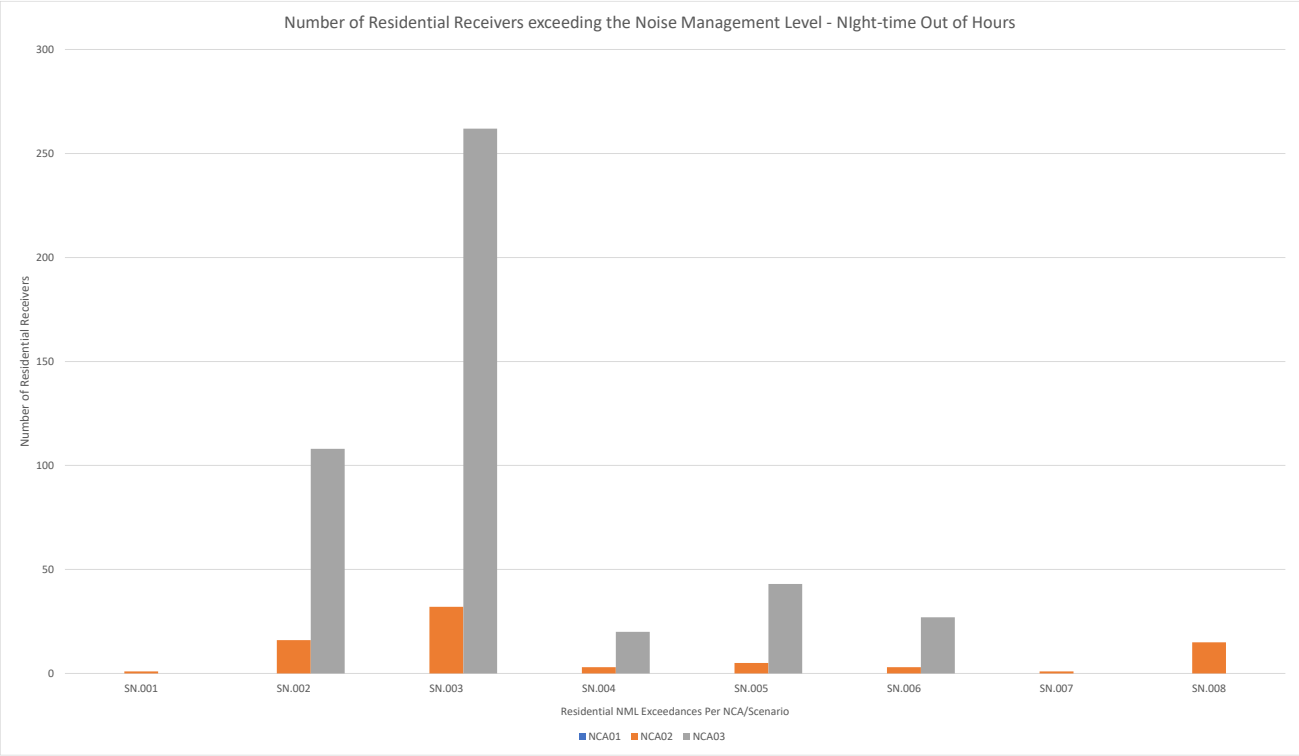

Figure 10 Residential receivers predicted to exceed their relevant NML during night-time out of hours works

4.2.3.3 Highly Noise Affected

No residential land use properties are predicted to exceed the Highly Noise Affected criteria of noise levels exceeding 75 dBA $L_{eq,15min}$.

4.2.4 Worst-case average noise levels

This section provide a tabulated and illustrative overview of the noise models predicted worst-case scenario noise levels, project-wide.

Table 20 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for residential receivers during all periods of work.

Table 20 Residential worst-case noise level overview, per NCA per scenario

NCA / Scenario	Residential - Worst Case Predicted Noise Levels, dBA Leq,15min							
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008
Daytime, Evening, and Night-time periods								
NCA01	-	-	-	-	-	-	-	-
NCA02	43	48	52	43	45	44	45	50
NCA03	31	49	53	44	46	45	33	35

Table 21 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for other sensitive land use receivers when in use.

Table 21 Other sensitive worst-case noise level overview, per NCA per scenario

NCA / Scenario	Other Sensitive - Worst Case Predicted Noise Levels, dBA $L_{eq,15min}$							
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008
Commercial								
NCA01	48	91	95	82	84	83	50	70
NCA02	52	73	77	68	70	69	54	56
NCA03	26	39	43	35	37	36	28	30
Industrial								
NCA01	47	76	80	71	73	72	49	78
NCA02	65	76	80	70	72	71	67	69
NCA03	26	41	45	36	38	37	28	30
Hotel								
NCA01	-	-	-	-	-	-	-	-
NCA02	-	-	-	-	-	-	-	-
NCA03	25	40	44	36	38	37	27	29
Outdoor Passive								
NCA01	-	-	-	-	-	-	-	-
NCA02	-	-	-	-	-	-	-	-
NCA03	24	34	38	30	32	31	26	28
Place of Worship								
NCA01	38	44	48	39	41	40	40	44
NCA02	-	-	-	-	-	-	-	-
NCA03	27	43	47	39	41	40	29	31
Stables								
NCA01	-	-	-	-	-	-	-	-
NCA02	45	47	51	42	44	43	47	49
NCA03	-	-	-	-	-	-	-	-

Note: Shaded red indicated NML exceedances

All works proposed to be undertaken to complete Electrical Works activities are proposed to be operated during all periods.

Figure 11 on the following page provides an overview of the per-receiver worst-case scenario maximum noise levels, dBA L_{eq},15min project wide.

Figure 11 Project-wide worst-case scenario noise levels dBA $L_{eq,15min}$

4.2.5 Discussion

Generally large distances (>250 m) separate the works locations to the surrounding noise sensitive receivers. The terrain is relatively flat, however large structures such as high-ceiling commercial premises, barns, stables and garages, in addition to some natural topography influence the attenuation of the noise anticipated from the work activities alignment.

4.2.5.1 NCA01 – Kembla Grange

Predominately commercial, industrial and other-sensitive land use, noise impacts are considered minimal as noise management levels are relatively higher (70 and 75 dBA) compared to NCA02 and NCA03 where more residential occupied land use is more concentrated.

Some commercial premises are anticipated to experience high noise levels due to the high noise intensive nature of the works, and their proximity to the works.

4.2.5.2 NCA02 – Kembla Grange

Kembla Grange Racecourse and associated stables with residential land use dominates this noise catchment area. Some of the commercial buildings and high ceiling barns and stables act as shields to most of the residential homes within this area. Some evening and night-time exceedances of NMLs are noticed here where high impact works would be anticipated to occur in line-of-sight to the works at distances within 250 – 350 m.

However, the sensitivity of the stables and the livestock contained within should not be dismissed, although no impacts are anticipated (predicted maximum noise level 51 dBA L_{eq}) at the closest most impacted Stable.

4.2.5.3 NCA03 – Brownsville

Some residual impacts are anticipated within this NCA, as works occurring within 250 – 300 m from the project alignment and proposed works, which, are high noise intensive in nature. Some evening and night-time NML exceedances are anticipated in this area where works may occur during time-sensitive periods and with line-of-sight to the works.

4.2.6 Sleep Disturbance and Awakening

An L_{max} noise assessment was undertaken for all plant equipment proposed for use during the night-time period to assess the likely hood of noise events causing sleep disturbance.

Approximately 94 residential properties are predicted to exceed the sleep disturbance criterion of the prevailing background noise level +15 dB. These properties are concentrated to Brownsville area where night-works of highly-noise intensive impact

This is likely due to the relatively flat topography surrounding the project site, the alignment exceeding 2,000 m in length, and, the relatively low assumed and adopted background noise levels.

Residential properties predicted to experience noise levels resulting in sleep disturbance is provided in **Figure 12** below.

No residential receivers are predicted to experience night-time external $L_{A1,1minute}$ noise levels exceeding 65 dBA L_{max} resulting in the probability of at least one (1) sleep awakening event per night. No sleep awakening events are anticipated.

Figure 12 Residential receivers exceeding sleep disturbance screening criterion

4.2.7 Construction Traffic

Construction related traffic is not anticipated to have any impact to the receivers as the project location passes near the Princes Highway. Construction traffic would utilize the Highway as the main thoroughfare to the site.

The addition of a single truck in any one (1) hour period would not increase the existing traffic noise levels in any meaningful or measurable way, and, the distance from the project site to the residential receivers exceeds 250 m, the construction traffic would not pass in relative close proximity to these receivers, or be masked by the existing traffic along the highway.

No impacts are anticipated.

4.3 Vibration

The safe working distances outlined in **Section 3.2.1.2** and presented in **Table 11** are considered to be stringently conservative for continuous vibration. Works within the safe working distances does not guarantee that any impact would occur, rather that consideration regarding methodology and potential impacts may be required.

The distances provided in **Table 11** are generally estimations for vibration intensive equipment such as rollers and piling equipment.

The works outlined within this assessment are not anticipated to include any vibration intensive plant, however bored piling works are anticipated to be undertaken at some locations within the rail corridor.

A subjective risk assessment is provided below in **Table 22** which outlines the most vibration sensitive structures in close proximity to the Project.

Table 22 Potential vibration impacts

Item	Approximate Distance (m) to works	Type of structure	Risk assessment			
			Cosmetic	Structural	Human Comfort	Vibration Monitoring
Kembla Grange Racecourse Railway Station	≈1 m	Heritage	Minor	No	n/a	Yes

Note: Risk assessment is subjective and not formulated from any structural engineering advice

Any vibration intensive works occurring on or near the Kembla Grange Racecourse Railway Station has the potential to exacerbate existing damage, or cause minor cosmetic damage to the structure. The condition is currently unknown, any damage would be considered minor such as cracks in mortar or other brickwork, existing cracks becoming larger, or, lose tiles falling from their potions if their adhesive is wearing out.

The existing site would be subjected to existing rail vibration, which based on experience could be between 2 to 5 mm/s PPV during passenger rollingstock pass-bys.

The likelihood of any damage is low, however where any vibration intensive plant is anticipated to be operated within close proximity to the structure (refer to **Table 11**), vibration monitoring is required to establish the vibration levels from the works are operating within the safe values (ie <3 mm/s for continuous, or, 15 mm/s for transient vibration) for the works prescribed.

5 Environmental Mitigation Measures

5.1 Standard mitigation

The Transport for New South Wales CNVS provides a base framework for all feasible and reasonable noise management and mitigation practices.

The strategies outlined below in **Table 23** describe various work practices to minimise noise on work sites. These items summarise the most effective measures, designed to manage and lower noise impacts from construction works.

Table 23 Standard Mitigation Measures

Action Required	Applies to	Details
Management Measures		
Implementation of any project specific mitigation measurement required	Airborne Noise Ground-borne noise and vibration	In addition to the measures set out in this table, any project specific mitigation measures identified in the environmental assessment documentation (e.g. EA, REF, submissions or representations report) or approval or licence conditions must be implemented
Operation of plant equipment	Airborne Noise	All plant and equipment on site to be operated in a proper and efficient manner by an appropriately qualified and competent operator
Implement community consultation measures	Airborne Noise Ground-borne noise and vibration	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website • Project Infoline • Construction Response Line • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings and • Community Based Forums (if required by approval conditions)
Register of noise sensitive receivers	Airborne Noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan

Action Required	Applies to	Details
Construction Respite Periods	Airborne Noise Ground-borne noise and vibration	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site Inductions	Airborne Noise Ground-borne noise and vibration	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 high noise generating activities • 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	Airborne Noise	• No swearing or unnecessary shouting or loud stereos/radios; on site. • No dropping of materials from height; throwing of metal items; and slamming of doors. • No excessive revving of plant and vehicle engines • Controlled release of compressed air.
Monitoring	Airborne Noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.

Action Required	Applies to	Details
Attended vibration measurements	Ground-borne noise and vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances
Update Construction Environmental Management Plans	Airborne Noise Ground-borne noise and vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies
Building Condition Surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage
Source Controls		
Construction hours and scheduling	Airborne Noise Ground-borne noise and vibration	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods
Construction respite periods	Airborne Noise Ground-borne noise and vibration	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block
Equipment selection	Airborne Noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	Airborne Noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in **Table 8**
Rental plant and equipment	Airborne Noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in **Table 8**
Plan worksites and activities to minimise noise and vibration	Airborne Noise Ground-borne noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site
Non-tonal reversing alarms	Airborne Noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work

Action Required	Applies to	Details
Minimise disturbance arising from delivery of goods to construction sites	Airborne Noise	• Loading and unloading of materials/deliveries is to occur as far as possible from NSRs • Select site access points and roads as far as possible away from NSRs • Dedicated loading/unloading areas to be shielded if close to NSRs • Delivery vehicles to be fitted with straps rather than chains for unloading, wherever feasible and reasonable
Use and siting of plant	Airborne Noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Construction related traffic	Airborne Noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on mobile plant	Airborne Noise	Where possible reduce noise from mobile plant through additional fittings including: • Residential grade mufflers • Damped hammers such as “City” Model • Rammer Hammers • Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Airborne Noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Airborne Noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘In-service test procedure’ and standard.

Action Required	Applies to	Details
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne Noise	Stationary noise sources would 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	Airborne Noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant

5.1.1 Additional noise mitigation measures

In accordance with the TfNSW CNVS, the implementation of standard mitigation measures, and compliance with maximum sound power levels for plant and equipment, construction hour management, and standard community consultation measures outlined within the CNVS should reduce the noise and any potential vibration impacts on nearby sensitive receivers.

The TfNSW CNVS provides guidance for Transport Projects where exceedances of the construction noise and vibration management levels are likely to, or are predicted to, occur. These measures are summarised from the CNVS and presented below in **Table 24**.

Table 24 Description of Additional Mitigation Measures

Measure	Description	Abbreviation
Periodic Notification	For each I&S project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the I&S Community Engagement Team in cases where AMM are not triggered as shown in **Table 25**, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the I&S Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended.	V

Measure	Description	Abbreviation
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	SN
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre- purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all I&S projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative Construction Methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days.	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all I&S projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with I&S Community Engagement Representatives.	DR

5.1.2 Applying additional mitigation measures

Additional Mitigation Measures (AMM) are recommended to be considered to offset impacts where the application of standard and project-specific mitigation measures (outlined in **Table 23**) are taken into consideration when assessing the potential noise and vibration impacts, however the relevant NMLs are still predicted to be exceeded.

Table 25 below tabulates the thresholds for each time period and range of noise above the predicted L_{eq} impact to the surrounding sensitive receivers.

Table 25 Additional Mitigation Measures

Construction Hours	Receiver perception	Predicted dBA (L_{eq}) above RBL		Predicted dBA (L_{eq}) above ANML		Additional management measures
		Range (dB)		Range (dB)		
Standard Hours Monday to Friday – 7 am to 6 pm Saturday – 8 am to 1 pm	Noticeable	5	10	0		-
	Clearly audible	>10	20	<10		-
	Moderately intrusive	>20	30	>10	20	PN, V
	Highly Intrusive	>30		>20		PN, V
	>75 dBA Leq	n/a		n/a		PN, V, SN
OOHW Period 1 Monday to Friday - 6 pm to 10 pm Saturday – 7 am to 8 am, 1 pm to 10 pm Sunday/PH – 8 am – 6 pm	Noticeable	5	10	<5		-
	Clearly audible	>10	20	>5	15	PN, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR
OOHW Period 2 Monday to Saturday – 12 am to 7 am, 10 pm to 12 am Sunday/PH – 12 am to 8am, 6 pm to 12 am	Noticeable	5	10	<5		PN
	Clearly audible	>10	20	>5	15	PN, V, SN, RO, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR, AA

Notes PN = Project Notification SN = Specific Notification, Individual Briefings, or phone call
V = Verification Monitoring AA = Alternative Accommodation RP = Respite Period
DR = Duration Reduction RO = Project Specific Respite Offer

Additional notes to **Table 25** include the following:

- SWLs used for the purpose of estimating noise impact shall be increased by 5 dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics.
- Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 7 am-8 am and 1 pm-6 pm, Sundays / Public Holidays 8 am-6 pm)
- Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays / Public Holidays 6 pm-10 pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

5.1.2.1 Overview of additional mitigation measures

Under the TfNSW CNVS, noise levels predicted to exceed the Airborne Noise Management Levels (ANML) require specific additional mitigation measures, summarised above in Section

The extent of the additional noise mitigations (AMM) is broken down per each scenario in the following figures during each assessed time period.

Figure 13 below illustrates an overview of the AMM per scenario during standard construction hours for all receivers impacted by the works.

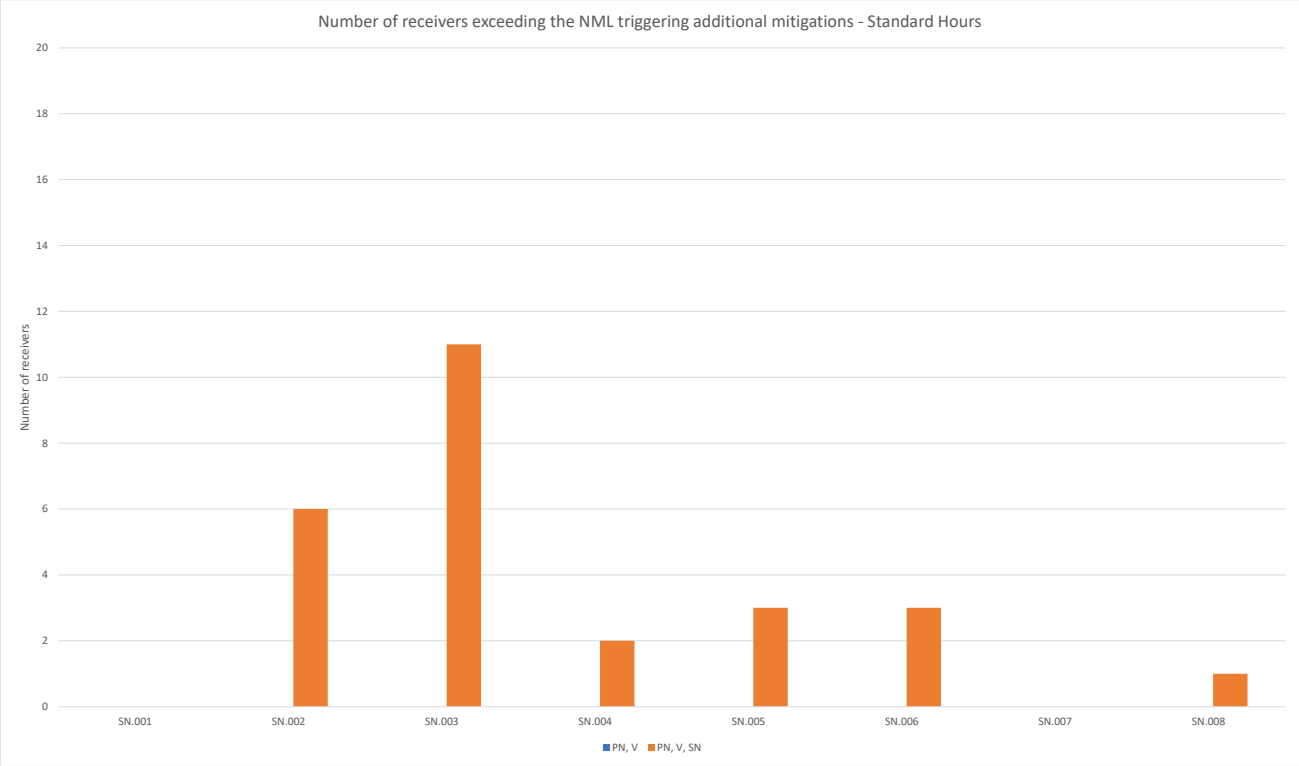

Figure 13 Additional mitigation – Standard Hours

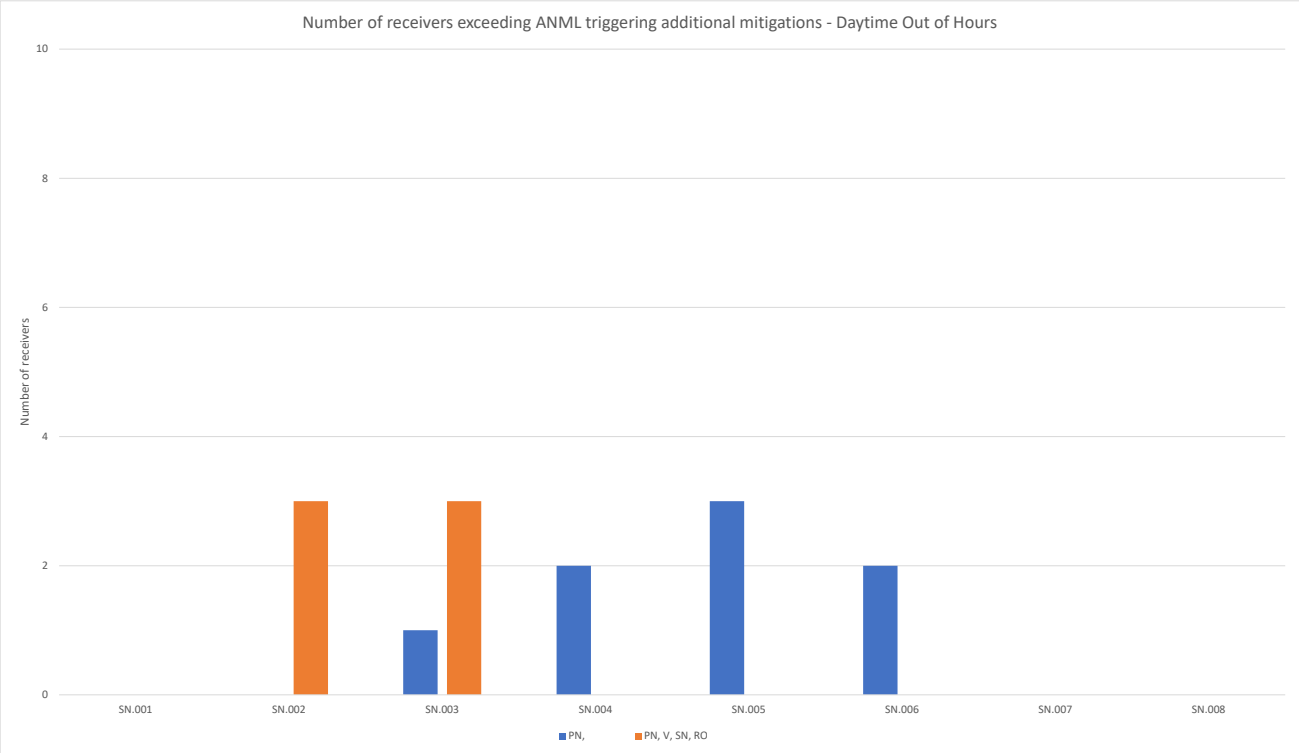

Figure 14 Additional mitigation (all receivers) – Daytime – Out of hours

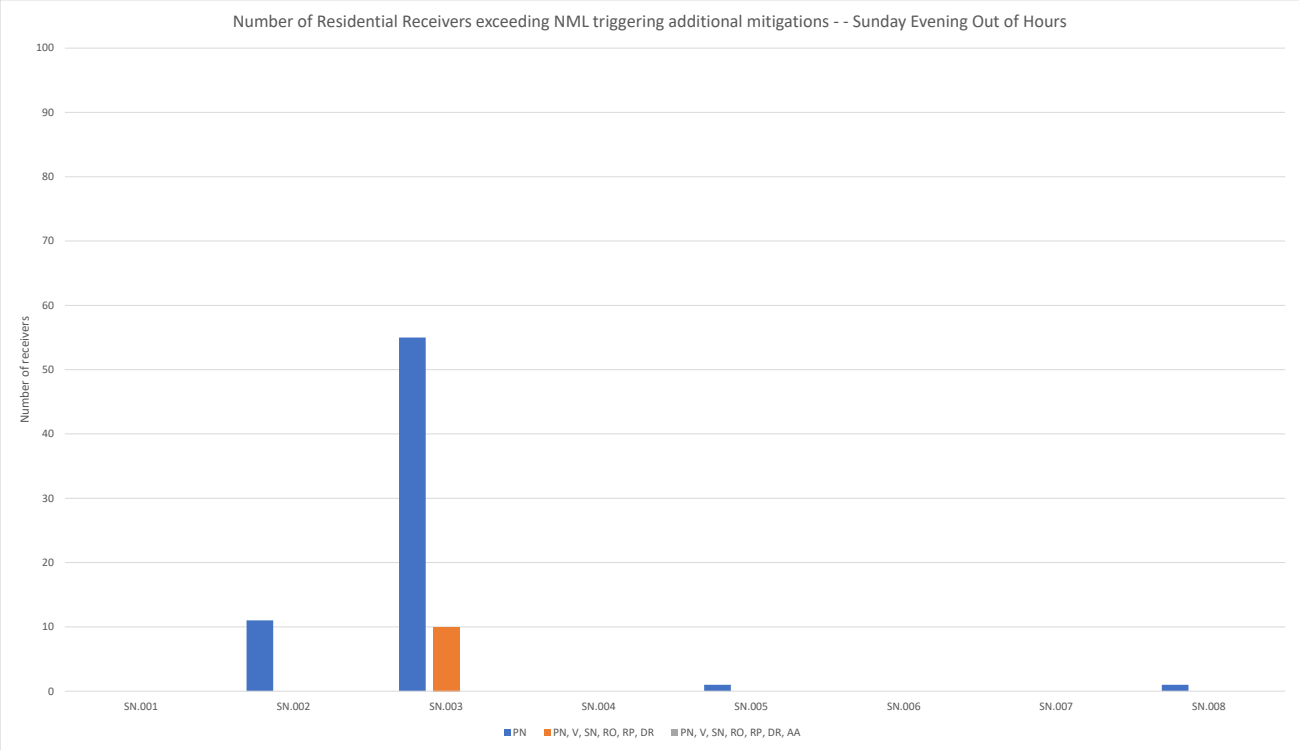

Figure 15 Additional mitigation (Residential) – Sunday Evening – Out of hours

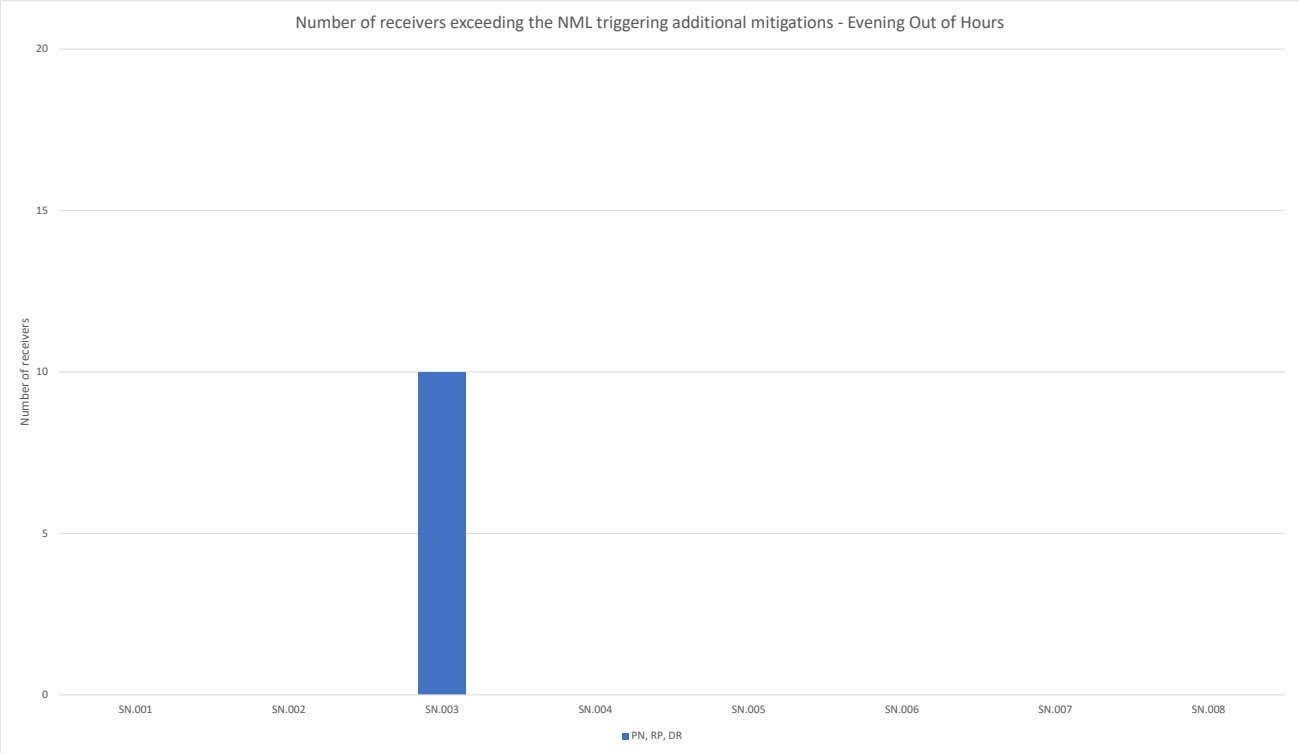

Figure 16 Additional mitigation (Residential) – Evening – Out of hours

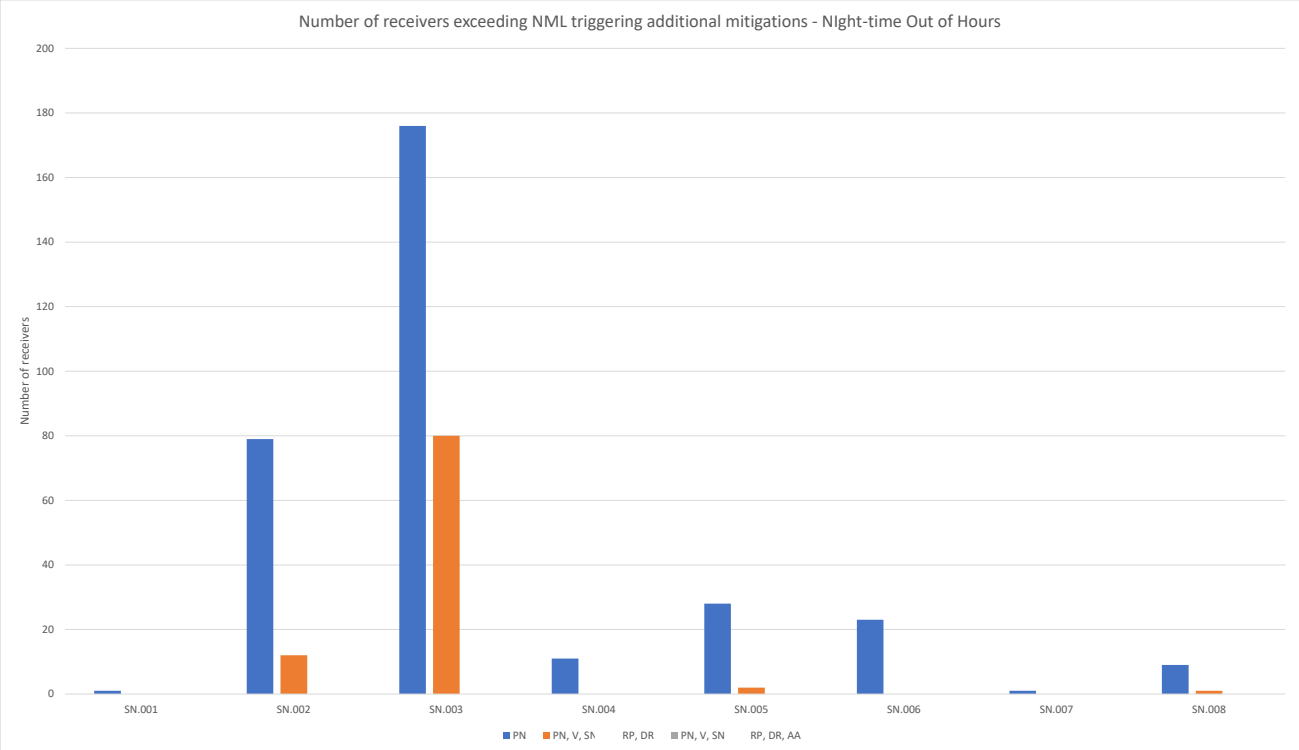

Figure 17 Additional mitigation (Residential) – Night-time – Out of hours

5.1.2.2 Extent of additional mitigation measures

The following maps provide an illustrative overview of the extent of the necessary and required AMM.

Figure 18 Additional Noise Mitigation Measures, Daytime extent (all receivers)

Figure 19 Additional Noise Mitigation Measures, Daytime out of hours

Figure 20 Additional Noise Mitigation Measures, Sunday Evening out of hours

Figure 21 Additional Noise Mitigation Measures, Evening extent (residential receivers only)

Figure 22 Additional Noise Mitigation Measures, Night-time extent (residential receivers only)

5.2 Discussion

Most of the noise sensitive receivers are at least 250 m from the alignment where works would be undertaken. Residential receivers triggered for noise mitigation measures would be due to flat topography with the lack of natural barriers, line of sight, and the highly noise intensive nature of some of the work activities.

There are no residential premises triggered for any alternative accommodation as there are no immediately adjacent receivers impacted by the works.

Some close proximity commercial and/or industrial receivers are anticipated to experience high noise during some high impact works such as concreting works.

Regarding the Stables within Kembla Grange, the recommendation is to provide Project Notification during the works.

5.2.1 Daytime OOH

Only two sensitive land uses are triggered for any additional mitigations. These premises are the Kembla Grange Racecourse Railway Station (when in use), and, the go-kart commercial premises. No residential land uses are triggered for any additional mitigations during this period.

When in use, Project Notifications is required to be provided to both premises. Additional mitigation should be explored for the railway station when it is in use.

5.2.2 Respite offer

Up to 10 properties are triggered for respite offer during works occurring in the Sunday Evening time period (18:00 onwards). These are located within the locality of Kembla Grange and Brownsville.

These properties are illustrated below in **Figure 23**.

Figure 23 Sunday Evening Respite Offers

5.2.3 Recommendations

In accordance with the TfNSW CNVS, appropriate mitigation outlined in **Table 23** should be applied where feasible and reasonable. Additional recommendations are formulated as follows:

- Undertake attended noise monitoring during the works where works are anticipated to be in close proximity to noise sensitive receivers along the rail corridor between Kembla Grange and Brownsville
  - In the event that noise levels exceed those tabulated in this report:
    - Noise management level or sleep disturbance exceedances would be responded to thorough review of equipment on site
    - Review of implemented mitigation (standard and project specific if relevant)
    - Review of sensitive-land use specific mitigation measures (if relevant)
    - Review of feasible and reasonable mitigation
  - Where noise levels do not exceed those tabulated in this report:
    - Apply the AMM mitigations tabulated in **Table 25**
    - Provide the Stables in Kembla Grange with Project Notification during works
- Vibration monitoring is not anticipated to be necessary unless the following circumstances arise:
  - In the event of any one (1) adverse community comment, complaint, or concern
  - Where any dilapidation report outlines conditional concerns for any structure not outlined in this report, and, where any vibration intensive plant equipment no longer operates within the prescribed safe working distances (refer to **Table 11**) of those structures
  - Where formulated as part of any one inclusive construction noise and vibration management plan (CNVMP) outlining the necessary requirements for monitoring.

It would be anticipated that the application of feasible and reasonable noise and vibration management practices would lower the noise levels presented in this report; noise model analysis does not factor in barriers, hording, or other generic or standard mitigations, the assessment only assesses the worst-case noise levels at the most reasonably close distance to a sensitive receiver's most habitable room.

6 Conclusion

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for electrical upgrade works proposed to be undertaken along approximately 2,000 m within the rail corridor between approximately 350 m northeast of Kembla Grange Racecourse Station to approximately 100 m northeast of the Mullet Creek rail bridge under the More Trains More Services South Works Program.

A 3D noise model was built in SoundPlan to assess the potential impacts of the construction on the nearby noise sensitive receivers. This assessment found the following:

- There are no residential receivers predicted to exceed ICNG defined Highly Noise Affected criteria of >75 dB $L_{Aeq,15min}$
- Mitigation measures in accordance with the TfNSW Construction Noise and Vibration Strategy are required for surrounding sensitive land uses
  - The Stables in Kembla Grange to be notified through letterbox drops or specific notification during works
- Approximately 94 residential receivers are predicted to exceed sleep disturbance screening criterion during night-time OOH works across the project, there are no anticipated sleep awakening events
  - There are no residential properties triggered for Alternative Accommodation
  - Up to 10 properties are triggered for respite offers during Sunday evening works
- Construction related traffic noise impacts are not anticipated to impact the amenity of the local communities
- Kembla Grange Railway Station is situated within the alignment which may include the use of bored piling. This is not a vibration intensive activity, however the structure may be located within the safe working distances outlined in **Table 11**
  - Vibration monitoring is recommended on this structure during bored piling activities to establish the vibration levels from the activity, and, ensure the vibration from the activity is within the safe limitation and no impact to the structure would occur
- There are no regenerated noise impacts anticipated

Additional recommendations are formulated:

- Noise monitoring is recommended where identified within this report, and, during high impact noise activities occurring during the night-time period, to confirm noise levels predicted within the model
- In the event of noise or vibration complaints or adverse community comments or concerns:
  - Attended noise/vibration monitoring in accordance with the relevant standards, policies and guidelines
  - Noise management level or sleep disturbance exceedances would be responded to through review of equipment on site
  - Review of implemented mitigation (standard and project specific)
  - Discussions with local Stakeholders if necessary
  - Review of sensitive-land use specific mitigation measures
  - Review of feasible and reasonable mitigation

- Further mitigation measures may be necessary should any attended noise monitoring noise levels measure greater $L_{Aeq,15min}$ noise levels than those predicted and presented in **Section 4.2.4**.

- Vibration monitoring may be necessary under the following conditions:
  - In the event of any one (1) adverse community comment, complaint, or concern
  - Where any dilapidation report outlines conditional concerns for any structure not outlined in this report, and, where any vibration intensive plant equipment no longer operates within the prescribed safe working distances (refer to **Table 11**) of those structures
  - Where formulated as part of any one inclusive construction noise and vibration management plan (CNVMP) outlining the necessary requirements for monitoring.

Appendix I – Glossary

1 Sound Pressure Level

Defined as:

$$L_p = 10log_{10}\left(\frac{p^2}{p_{ref}^2}\right)dB$$

In the above equation, p is the sound pressure fluctuation relative to atmospheric pressure, and *pref* is 20 microPascals (2 x 10-5 Pa), the approximate threshold of hearing.

Sound or noise is the sensation produced at the ear by small fluctuations in atmospheric pressure. Human ears are sensitive to changes to sound pressure over a wide range, from 20 microPascals to 60 Pascals, in lieu of using a linear scale to represent this range, a logarithmic scale is adopted to better handle

2 Sound Power Level

Sound power level cannot be directly measured using a microphone, it does not change with distance and is not influenced by atmospheric conditions. The sound power level refers to the total energy of the sound, and is reference to 1 Pico Watt.

3 Weighting and Loudness

The overall level of a sound is usually expressed as dB(A) and not dB. Weighting refers to the human ear's frequency response to sound. Typically, sound is measured with an A-weighted filter which reduces the significance of lower frequencies and very high frequencies, increasing the importance of mid-frequencies (500 Hz to 4 kHz), and being a good measure of the "loudness" of a sound.

A change of 1 to 2 dB(A) is difficult to detect, whilst a change of 3 to 5 dB(A) corresponds to a small but noticeable change. A 10 dB(A) change corresponds to a doubling or halving in apparent loudness.

4 Noise Metrics and Statistical Noise Levels

i) L_{Aeq} - The time averaged A-weighted sound pressure level for the interval, as defined in AS1005.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

ii) L_{Amin}/L_{Amax} - Minimum or Maximum A-weighted noise level detected during the measuring period. It refers to the minimum background noise detected or the maximum L*p* measured.

iii) L_{A90} - A-weighted noise level which is exceeded for 90% of the measuring period. It is usually used as the descriptor for background noise level during the measurement period.

iv) L_{A1} - Noise level which is exceeded for 1% of the measurement period.

v) L_{A10} - Noise level which is exceeded for 10% of the measurement period. The L_{A10} is often referred to as the average *maximum* noise level.

5 Background Noise

The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed.

6 Ambient Noise

Ambient noise of an environment: the all-encompassing sound associated with that environment, being a composite of sounds from many sources.

7 Vibration

The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related

8 Displacement

The change in position of an object, is a vector quantity. (Stress indicator).

9 Velocity

The rate of change of displacement, is a vector quantity. (Fatigue indicator).

10 Acceleration

The rate of change of velocity, is a vector quantity. (Indicator of force).

11 Frequency

The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.

12 Hertz

The unit of frequency or pitch of a sound. One hertz equals one cycle per second.

13 Peak Particle Velocity (PPV)

The greatest instantaneous particle velocity during a given time interval if measurements are made in 3-axis. The resultant Peak Particle Velocity (PPV) is the vector sum i.e. the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur.

14 Root Mean Square rms

The rms value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.

15 Vibration Dose Value VDV

The Vibration Dose Value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when the structure is occupied.

16 Peak

The peak is the maximum amplitude during a measurement period.

17 Peak to Peak P-P

The peak-to-peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.

18 Logarithmic Scale

Comparing frequency with large amplitude differences be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale, however a logarithmic scale shows prominent vibration components equally well at any amplitude.

19 Zero Crossing Frequency

Determining the apparent dominate frequency of a given sample can be achieved by using the Zero Crossing Frequency.

20 Primary Waves P Waves

Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

21 Secondary Waves S Waves

Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.

22 Rayleigh Waves R Waves

Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.

23 Accelerometer

A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs'.

24 Geophone

Geophones measure velocity by means of a magnetic core surrounded by an electrical coil. When the surface vibrates, the geophone housing moves however the coil stays stationary, thus the movement of the magnet in the coil causes an electrical current which is calibrated to velocity of vibration.

25 Filter

A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.

26 Short-term vibration

Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.

27 Long-term vibration

All types of vibration not covered by the definition of 'short-term vibration'

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Construction Noise and Vibration Impact Assessment

More Trains More Services - Albion Park Electrical Works

Prepared for: Transport for Tomorrow

Job Number: A301022.0167.04 v1.8f **| Date:** 31/08/2022

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For and on behalf of

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		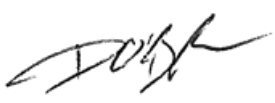
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Definitions

Some common terms and definitions are provided in the table below.

An **Acoustic Glossary** is provided in **Appendix I**.

Term / Abbreviation	Summary
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed
Attenuation	The reduction in the level of sound or vibration
CEMP	Construction Environmental Management Plan
CNVIA	Construction Noise and Vibration Impact Assessment
CNVMP	Construction Noise and Vibration Management Plan
Construction	Includes all work required to construct the More Trains More Services infrastructure, includes commissioning trials of equipment and temporary use of any part of the Project
dBA	Decibels using the A-weighted scale measured according to the frequency of the human ear
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DPIE	Department of Planning, Industry and Environment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
Environmental aspect	Defined by AS/NZS ISO 14001:2015 as an element of an organisation's activities, products or services that can interact with the environment
Environmental impact	Defined by AS/NZS ISO 14001:2015 as any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects
Environmental objective	Defined by AS/NZS ISO 14001:2015 as an overall environmental goal, consistent with the environmental policy, that an organisation sets itself to achieve
Environmental target	Defined by AS/NZS ISO 14001:2015 as a detailed performance requirement, applicable to the organisation or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives
EPA	NSW Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
ER	Environmental Representative
EPL	Environment Protection Licences under the POEO Act
Feasible and reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.

Term / Abbreviation	Summary
Heritage Item	A place, building, work, relic, archaeological site, tree, movable object or precinct of heritage significance that is listed under one or more of the following registers: the State Heritage Register under the Heritage Act 1977 (NSW), a state agency heritage and conservation register under section 170 of the Heritage Act 1977 (NSW), a Local Environmental Plan under the EP&A Act, the World, National or Commonwealth Heritage lists under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth), and an "Aboriginal object" or "Aboriginal place" as defined in section 5 of the National Parks and Wildlife Act 1974 (NSW)
Highly Noise Affected	As defined in the ICNG
Highly noise intensive works	Works which are defined as annoying under the ICNG, including: a) use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work; b) grinding metal, concrete or masonry; c) rock drilling; d) line drilling; e) vibratory rolling; f) bitumen milling or profiling; g) jackhammering, rock hammering or rock breaking; h) rail tamping and regulating; and i) impact piling.
ICNG	Interim Construction Noise Guideline (DECC, 2009)
$L_{Aeq,15\ min}$	The A-weighted equivalent continuous (energy average) sound pressure level of the construction works under consideration over a 15-minute period and excludes other noise sources such as from industry, road, rail and the community. Sometimes tabulated as L_{eq} or dBA L_{eq}.
MTMS	More Trains More Services
NPfI	Noise Policy for Industry (EPA, 2017)
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
Planning Secretary	Planning Secretary of the Department (or nominee, whether nominated before or after the date on which this approval was granted)
RBL	The Rating Background Level for each period is the medium value of the ABL (Assessment Background Level) values for the period over all of the days measured. There is therefore an RBL value for each period (day, evening and night)
Sensitive Land Uses	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres and passive recreation areas (including outdoor grounds used for teaching). Receivers that may be considered to be sensitive include commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, and retail spaces), and industrial premises as identified by the Planning Secretary Note: For the purpose of determining appropriate mitigation, a multi-storey residential flat building must not be counted as a single sensitive receiver.
SHR	State Heritage Register
Sleep Disturbance	Where the subject development / premises night-time L_{Amax} noise levels at a residential location exceed $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater
SPL SWL	Sound Pressure Level Sound Power Level
TAHE	Transport Asset Holding Entity
TfNSW	Transport for NSW
TfNSW CNVS	Transport for New South Wales Construction Noise and Vibration Strategy, Version 4.2 dated 23 April 2019, Program Management Office, Planning, Environment and Sustainability

Term / Abbreviation	Summary
TfT	Transport for Tomorrow

1 Introduction

1.1 Background

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for electrical upgrade works proposed to be undertaken within the rail corridor over a 2,300 m length, between Albion Park Station and approximately 200 m north of the Haywards Bay Drive road over-bridge under the More Trains More Services South Works Program.

1.2 Project description

The More Trains More Services (MTMS) Program is a series of staged investments designed to progressively deliver service improvements across the network, as part of a broader transformation from a complex, constrained network, to a modern, simplified operation utilising world-class technology.

As part of the MTMS Program integrated infrastructure, fleet and operational changes will deliver service improvements on the T4 Eastern Suburbs & Illawarra (T4), T8 Airport & South (T8) and South Coast line.

The NSW Government is delivering the New Intercity Fleet (NIF) to replace the trains carrying customers from Sydney to the Central Coast, Newcastle, the Blue Mountains and the South Coast.

Currently the majority of intercity trains operate as eight car trains however the NIF program would introduce 10-car trains.

The proposed electrical upgrades are required at the Albion Park Rail site to support the operation of the NIF trains on the south coast.

1.3 Objectives

This Construction Noise and Vibration Impact Assessment (CNVIA) aims to achieve the following:

- Describe the proposed electrical works at Albion Park
- Identify noise and vibration sensitive receivers adjacent to the proposals site location
  - Assign construction noise and vibration criteria
- Assess the potential noise and vibration impacts to the surrounding receivers within the community
- Establish and identify feasible and reasonable mitigation
- Establish project-specific mitigation measures per-receiver based on the predicted impact during each period of the proposed works schedule.

1.4 Proposed Works

Albion Park Rail upgrade comprises of various proposed construction activities in order to complete the Electrical Works package of the MTMS program.

The anticipated works are as follows:

- 3 x 400 mm^2 DC Feeder cables from new Isolating and Rail Connecting Switch (IRCS) to K201 at CK101+541km
- 2 x 400 mm^2 DC Feeder cables from existing Direct Current Circuit Breaker (DCCB) to new IRCS
- 2 x 240 mm^2 cables from new IRCS to main negative bus
- 2 x 95 mm^2 cables from new IRCS to test rail
- External IRCS with access platform and two access doors
- Backfill approximately 0.5 m wide in front of the existing compound to allow for the new fence alignment, earthing grid installation and maintain pedestrian access around the compound
- New perimeter fence to substation
  - Earthing grid upgrades at the substation
- New vehicular gate and pedestrian access gate to left hand side, foundation of 300 mm deep x 150 mm wide around perimeter
- New earthing grid and earth stakes, internally and externally to substation compound, 6^{no} stakes at 10 m depth
- Down conductors and earthing stakes to power poles 800 m either side of the substation. A combination of CSR and GST route will be required for the DC Feeder route from Albion Park substation to K201.

1.5 Site location

The site stretches approximately 2,300 m and is located along the rail corridor between Albion Park train station and 200 m north of the Haywards Bay Drive over-bridge in Haywards Bay. Albion Park train station is located approximately 103.341 km South of Sydney CBD.

Figure 1 below provides an aerial overview of the site's location and anticipated alignment.

Figure 1 Site location and works alignment

1.6 Guidelines and standards

In order to undertake the noise and vibration assessment required for TfT, local and international guidelines and standards were considered.

Relevant documents pertaining to the measurement, assessment, and management of noise and vibration in Australia are provided below in **Table 1**.

Table 1 Summary of relevant documents

Guideline / Standard	Published by	Relevance
AS 1055:2018 Acoustics – Description and measurement of environmental noise	Australian Standards	Measurement of noise
AS 2659.1-1998 Guide to the use of sound measuring equipment – Portable sound level meters	Australian Standards	Measurement of noise
AS 2436:2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites	Australian Standards	Management of Noise and Vibration on Construction Sites
AS/NZS 2107-2016: Acoustics - Recommended design sound levels and reverberation times for building interiors	Australian Standards	Internal sound level design for Management of Noise
Interim Construction Noise Guideline	Department of Climate Change, 2009	Management of Noise on Construction Sites
Noise Policy for Industry	Environment Protection Authority, 2017	Management of Industry Noise, measurement of noise
Transport for New South Wales Construction Noise and Vibration Strategy	Transport for New South Wales (TfNSW), 2019	Management of Noise and Vibration on Construction Sites
Road Noise Policy	Department of Energy, Climate Change and Water, 2011	Management of Road Traffic Noise, Construction Traffic, and Sleep Disturbance
Accessing Vibration: A Technical Guideline	Department of Conservation, 2006	Management of Vibration
BS 7385: Part 2-1993 Evaluation and measurement of vibration in buildings	British Standards	Management of Vibration
DIN4150-2016: Structural vibration Part 3: Effects of Vibration on Structures	German Standards	Management of Vibration

2 Existing Environment

The project's locality is considered a mixture of suburban/urban and urban. The dominant ambient noise environment is considered to comprise natural fauna, road traffic noise from the nearby Princes Motorway (Albion Park by-pass), Princes Highway, rail traffic along the South Coast (SCO) rail line.

Additionally, ambient noise from nearby commercial land use may be present within the area, as well as easterly winds from the nearby Haywards Bay and Koona Bay.

Background noise levels have been derived based on the methods provided in AS1055.3:1997 *Acoustics – Description and measurement of environmental noise Part 3: Acquisition of data pertinent to land use*, reproduced from the TfNSW CNVS (2019) and presented below in **Table 2**.

Table 2 Typical background noise levels for different areas

Area type	Description	Rating Background Level (RBL)		
		Day	Evening	Night
Rural	Areas with negligible transportation	40	35	30
Suburban/urban	Areas with low density transportation	45	40	35
Urban	Areas with medium density transportation OR some commerce or industry	50	45	40
Urban/Industrial	Areas with dense transportation OR with some commerce or industry	55	50	45

Note: AS1055:1997 has been superseded and this table does not appear in the revised 2018 version of this Australian standard. Its use here is based on the TfNSW CNVS (2019) reproduction of this information for assessment purposes in lieu of noise monitoring or establishing of ambient noise levels for the purpose of establishing relevant construction noise management levels

Note: Day, Evening and Night-time as defined in the Noise Policy for Industry (NPfI, EPA 2017)

2.1 Sensitive land uses

The project is surrounded by a diverse community of various sensitive receiver types and land uses. These include:

- Residential: villas, free standing houses, and townhouses
- Commercial
- Isolated areas of light industry

The project is divided into five (5) Noise Catchment Areas (NCAs), surrounding the project boundaries.

The NCA boundaries represent logical boundaries based on topography and the type of receivers applicable for that location.

An overview of the NCAs is provided below in **Table 3**, and corresponding illustrations follow in **Figure 2** and **Figure 3**.

Table 3 Noise Catchment Area overview

NCA	Area type	Locality
NCA01	Urban	Yallah – West of rail corridor - some commercial, predominately residential
NCA02	Suburban/Urban	Haywards Bay – East of rail corridor – predominately residential
NCA03	Urban	Albion Park Rail – West of rail corridor, predominately industry and commercial only
NCA04	Suburban/Urban	Albion Park Rail – East of rail corridor – predominately residential
NCA05	Suburban/Urban	Albion Park Rail – East and west of rail corridor south of works – predominately residential

While an overall illustration of the proposed works and alignment location is provided in **Figure 1**, the following, **Figure 2 and Figure 3** below provide illustration of the surrounding sensitive receivers within the locality of Yallah, Haywards Bay, and Albion Park Rail.

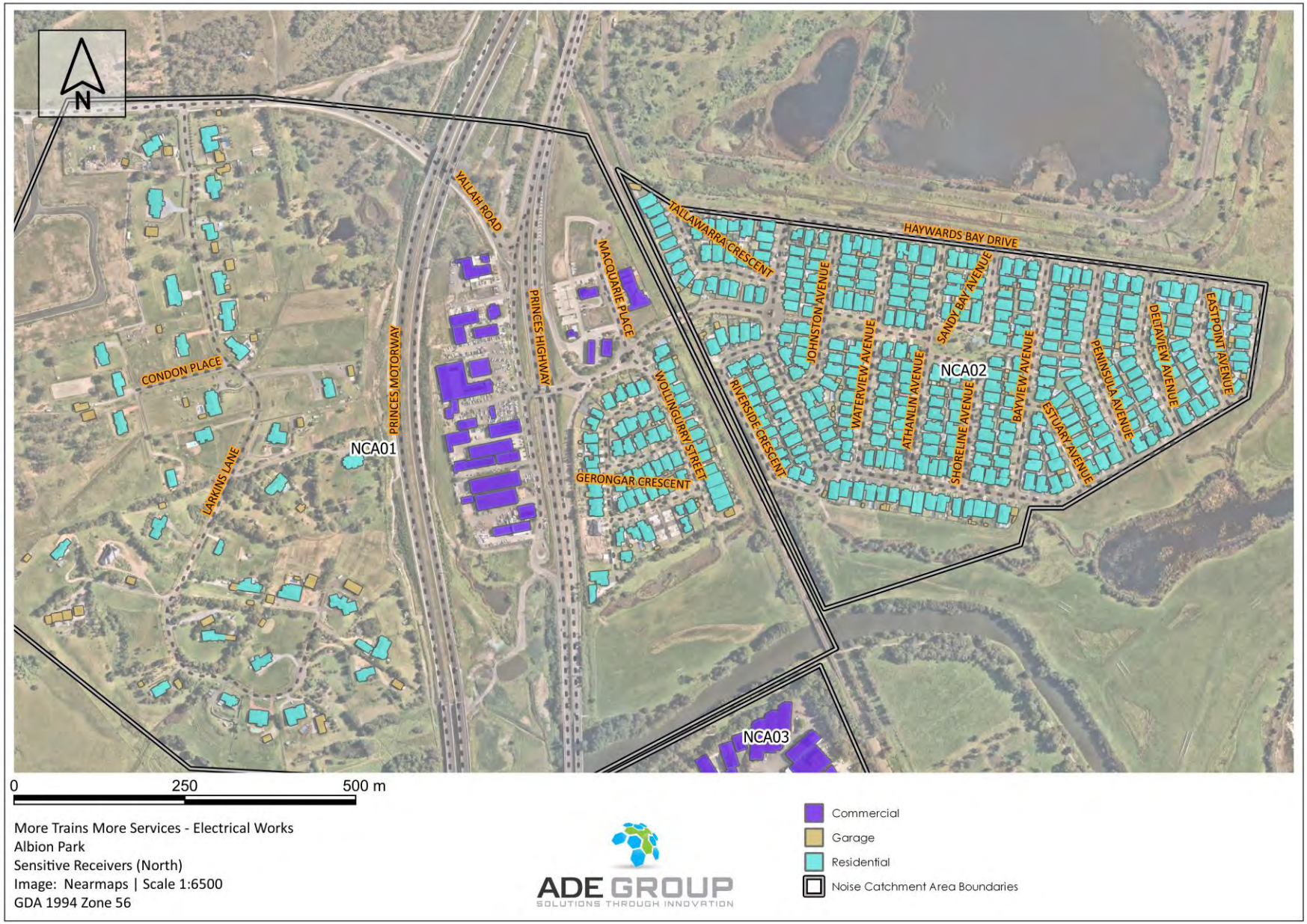

Figure 2 Overview of Haywards Bay and Yallah sensitive receivers. Source: Nearmaps

Figure 3 Overview of Albion Park Rail sensitive receivers. Source: Nearmaps

2.1.1 Heritage

The project's alignment is understood to not pass by identified listed heritage structures or other structures considered structurally unsound.

However, locally, the Heritage Act section 170 has 'heritage listed' the Dairy Factory (identified through Mecone Mosaic) which sits on the rail level crossing on Creamery Road. Built around 1899, the condition is unknown, however operations at the factory ceased in 1985 and it appears the site has remained vacant since.

The condition is unknown, although likely to be rundown however structurally sound. For conservative purposes, this report assumes the building may be structurally unsound.

Figure 4 Heritage listed, or other sensitive structures

The Dairy Factory would be currently subjected to rail vibrations as passenger rolling stock would be passing through on the south-coast line.

3 Noise and Vibration Criteria

This section summarises the noise and vibration goals relevant to the proposed construction works for the project. The noise and vibration criteria varies over the different time periods defined throughout any one 24 hour period, noting that generally more stringent criteria applies in more sensitive evening and night-time periods.

The NSW EPA recommends management levels and goals when assessing the potential impacts of construction related noise and vibration. Similarly, construction works undertaken by Transport for New South Wales reference relevant guidelines, policies, and standards, which are tabulated in **Table 1,** and provide the framework for management of noise and vibration from construction sites in New South Wales.

3.1 Airborne construction noise management levels

3.1.1 Residential receivers

Airborne construction noise which impacts residences and other sensitive land uses is assessed and managed through the Department of Environment and Climate Change Interim Construction Noise Guideline (2009). Project Specific Noise Management Levels (NMLs) are established based on estimated noise levels derived from the AS1055.3:1997 Standard, and the TfNSW CNVS Appendix B.

The estimated background noise levels are considered conservative and are used for assessment purposes only.

Where noise levels are predicted (or measured) to exceed the NMLs, construction noise minimisation practices are recommended to be investigated.

Table 4 which follows, describes the noise management levels pertaining to residential receivers and how to apply them.

Table 4 Noise at residences using quantitative assessment (ICNG, 2009)

Time of Day	NML dB $L_{Aeq,15min}$	How to apply
Standard 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 $L_{Aeq(15\ minute)}$) is greater than the noise affect 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 level represents the point above which there may be a strong community reaction to noise. • Where noise is above the level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: o 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 o If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

The resultant Noise Management Levels (NMLs) for all residential noise-sensitive receivers is tabulated below in **Table 5**. These levels represent the noise levels in which the project's potential impact, and subsequent noise monitoring (during works) is to be assessed against.

Table 5 Noise Management Level (dBA $L_{Aeq,15\ minute}$) for Residential Receivers

NCA	Area Usage	Standard	Out of Hours (RBL +5)			Sleep Disturbance
		Day	Day	Evening	Night-time	
NCA01	Urban	60	55	50	45	55
NCA02	Suburban/Urban	55	50	45	40	50
NCA03	Urban	60	55	50	45	n/a
NCA04	Suburban/Urban	55	50	45	40	50
NCA05	Suburban/Urban	55	50	45	40	50

Note: Sleep Disturbance is based on RBL+15 dB
Note: NMLs based on TfNSW CNVS and AS1055 estimated noise levels

3.1.1.1 Sleep disturbance and awakening

The TfNSW CNVS (2019) assessment process requires an assessment of Sleep Disturbance and Sleep Awakening events as part of the impact assessment process. 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 EPA's Noise Policy for Industry (NPfI) with further guidance sourced from the EPA Road Noise Policy (RNP, 2011).

Although the NPfI sleep disturbance criteria relates to industrial noise, it is also considered relevant for reviewing potential impacts from construction noise as a screening criterion to identify the need for further assessment.

The CNVS recommends that a detailed maximum noise level assessment should be undertaken where a project results in night-time $L_{A1,1\ minute}$ (L_{Amax}) noise levels which exceed a noise level of the prevailing background level (RBL) plus 15 dB.

The RNP indicates that internal noise levels between 50 and 55 dB L_{Amax} are unlikely to cause sleep awakenings, however above this threshold a sleep awakening event is considered likely to occur. To assess external noise levels, a conservative +10 dB outside-to-inside correction is applied as outlined in the ICNG, hence an external noise level screening of 65 dB L_{Amax} is adopted to assess the likelihood of a sleep awakening event occurring.

Resultant sleep disturbance criterion for each NCA is tabulated in **Table 5** above.

3.1.2 Other sensitive land uses and commercial receivers

The project is surrounded by a number of non-residential land uses. **Table 6** below outlines the NMLs for other sensitive receivers.

Table 6 Noise at sensitive land uses (other than residential) using quantitative assessment

Land use	Management level $L_{Aeq,15\ minute}$ (applicable when properties are in use)
Industrial Premises	External noise level 75 dBA
Offices, retail outlets and other commercial properties	External noise level 70 dBA
Classrooms at school and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community centres	Refer to the recommended 'maximum' internal levels outlined in AS2107 for specific uses

Other noise-sensitive receivers not defined in the ICNG require noise level criteria derived from AS 2107:2016.

The AS 2107 noise level criteria are generally provided as internal levels, and an internal-to-external correction of +10 dB has been applied to assume a conservative noise level with an open window for ventilation.

Table 7 NMLs for 'Other Sensitive Receivers' based on AS2107

Land use	Noise Management Level $L_{Aeq,15\ minute}$	
	Internal	External
Childcare Centre	60 dBA play area 40 dBA sleeping area	70 dBA play area 50 dBA sleeping area
Public Buildings	50 dBA	60 dBA
Café/Bar or Restaurant	50 dBA	60 dBA
Hotel	40 dBA	50 dBA

3.1.3 Maximum allowable Sound Power Levels

The Transport for New South Wales (TfNSW) Construction Noise and Vibration Strategy (CNVS) provides guidance for the maximum allowable sound power levels from plant equipment. These noise levels are not used for assessment purposes, only when undertaking sound power level testing for plant equipment on site if necessary or as required.

Levels of all plant and equipment used on site during construction activities must be below, or equal to, the allowable noise levels to achieve compliance.

These guidelines are replicated below in **Table 8**.

Table 8 Maximum Allowable noise levels from plant equipment, TfNSW CNVS

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Asphalt – Truck & Sprayer		106	81
Backhoe		111	86
Chainsaw – petrol[4]	4-5 hp	114	89
Compactor		106	81
Compressor		109	84
Crane – Fixed		113	88
Crane – Franna	20 tonne	98	73
Crane – Mobile		113	88
Crane – Truck mounted	20 to 60 tonne	108	83
Crusher – Rock[4]		118	93
Dozer	CAT D9	116	91
Dozer	CAT D10	121	96
Elevated work platform – scissor lift		98	73
Elevated work platform		97	77
Excavator – tracked	3 tonne	90	65
Excavator – tracked	6 tonne	95	70
As above + hydraulic hammer[4]		115	90

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Excavator – tracked	10 tonne	100	75
As above + hydraulic hammer[4]		118	93
Excavator – tracked	20 tonne	105	80
Excavator – tracked	30 tonne	110	85
As above + hydraulic hammer[4]		122	97
Excavator – tracked	40 tonne	115	90
Grader		113	88
Generator – diesel/ petrol	6 kW	103	78
Generator – attenuated	30 kW	92	67
Grinder[4]		105	80
Jackhammer		113	88
Lighting Tower		80	55
Lighting – Daymakers		98	73
Light Vehicle – 4WD		103	78
Line Marking Truck		108	83
Loader – Front-end (wheeled)	23 tonne	112	87
Loader – Skidsteer	1/2 tonne	107	82
Loaders – Skidsteer	1 tonne	110	85
Loader – Tracked	0 to 50 kW	115	90
Loaders – Tracked	200 to 300 kW	121	96
Pavement Laying Machine		114	89
Pavement Profiler		117	92
Pile Driver – Vibratory[4]		121	96
Piling Rig – Bored		112	87
Piling Rig – Impact[4]		134	109
Pump – Concrete		109	84
Rattle gun (hand held)		104	79
Roller – smooth drum		107	82
Roller – large pad foot		109	84
Roller – Vibratory[4]	10 tonne	109	84
Saw – Concrete[4]		118	93
Scraper		113	88
Truck – Concrete		109	84
Truck – Dump	15 tonne	110	85
Truck – Medium rigid	20 tonne	103	78
Truck – road truck/ truck & dog	30 tonne	108	83
Truck – Vacuum (NDD or non-destructive digger)		109	84

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Tub Grinder/Mulcher	40-50 hp	116	91
Vibrator – Concrete[4]		113	88
Water Cart		107	82
Welding equipment		110	85
Wrench – Impact		111	86

Note 1 The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7 m) from the plant or equipment

Note 2: The SWLs presented in the above table have been compiled from a selection of field measurements conducted by Heggies Pty Ltd between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW, as well as various TfNSW Noise & Vibration impact assessments and the RMS Construction Noise & Vibration Guideline (August, 2016)

Note 3: Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites

Note 4: Equipment with special audible characteristics.

3.1.4 Construction related traffic

Some heavy truck usage may be used to haul equipment to and from the site to facilitate the activities associated with the Program.

Guidance for construction related traffic on TfNSW project is taken from the CNVS which outlines that:

"additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario"

Noise monitoring has not been undertaken, therefore the existing ambient traffic noise has not been established. To assess the potential impact of truck haulage, a screening assessment has been undertaken to determine if any potential impact to the sensitive receivers is likely.

Referring to **Table 9** below, screening noise levels for construction traffic have been established for the proposals where construction traffic is anticipated to be present on local roads.

Table 9 Target construction road traffic noise

Existing road category	Target noise level, dB	
	Day 07:00 hrs to 22:00 hrs	**Night** 22:00 hrs to 07:00 hrs
Local Road	$L_{Aeq,\ 1\ hour}$, 55 (external)	$L_{Aeq,\ 1\ hour}$, 50 (external)

Should the road traffic noise levels increase by more than 2 dB due to construction traffic, additional mitigation options should be considered and investigated.

3.2 Construction vibration guidelines

Generally, construction which produces vibration may be group into three categories:

- Human Comfort – in which the occupants of a building are disturbed
- Building Contents – in which highly sensitive equipment or other machinery may be affected

- Structural or cosmetic damage – in which the integrity of the buildings structure may be compromised, or weak non-structural components may be damaged.

3.2.1 Effects of vibration on structures

The levels of vibration required to cause cosmetic damage to buildings is significantly higher than the vibration levels in which humans would find tolerable.

Damage caused as a result of vibration can occur due to short-term vibration (vibration which does not occur often enough to cause structural fatigue nor produce resonance) or long-term vibration (all other types of vibration).

Where the potential for structural damage may occur, dilapidation assessments may be necessary to be undertaken prior to and during, or following, construction. Structural damage vibration guidelines are provided below, derived from British Standard BS 7385 for transient vibration.

3.2.1.1 Transient vibration

BS 7385 provides recommendations in vibration limitations regarding transient vibration. The limits outlined below in **Table 10** are conservative and are judged to give a minimum risk to which vibration may cause damage to buildings.

Table 10 Transient vibration, British Standard BS 7385-3: 1993

Type of Building	Peak component particle velocity (PPV) in frequency range of predominant pulse	
	4 Hz – 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
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: Values referred to are at the base of the building

3.2.1.2 Safe working distances

As a guide, minimum working distances for typical items of vibration intensive plant are listed below in **Table 11**. These data are provided by TfNSW's Construction Noise and Vibration Strategy (CNVS, v4.2 2019). The minimum working distances are quoted for both cosmetic damage (BS 7385 and DIN4150) and human comfort (Assessing Vibration – A Technical Guideline).

The minimum working distances for cosmetic damage are recommended to be complied with at all times, unless otherwise approved by the relevant authority. The distances provided in **Table 11** are indicative and would vary depending on the plant or item used for the works, as well as the geotechnical conditions within the surrounding earth.

Table 11 Recommended minimum working distances from vibration intensive plant (TfNSW CNS)

Plant Item	Approximate Size / Weight / Model	Minimum Distance for Cosmetic Damage (BS7385)	Minimum Distance for Human Response (DEC Assessing Vibration)	Heritage (DIN4150)
Vibratory Roller	1-2 tonne	5 m	15 – 20 m	11 m
	2-4 tonne	6 m	20 m	14 m
	4-6 tonne	12 m	40 m	27 m
	7-13 tonne	15 m	100 m	33 m
	13-18 tonne	20 m	100 m	44 m
	>18 tonne	25 m	100 m	55 m
Small Hydraulic Hammer	300 kg (5 to 12texcavator)	2 m	7 m	5 m
Medium Hydraulic Hammer	900 kg (12 to 18t excavator)	7 m	23 m	16 m
Large Hydraulic Hammer	1600 kg (18 to 34t excavator)	22 m	73 m	49 m
Pile Driver – Vibratory	Sheet piles	2 to 20 m	20 m	15 m
Piling Rig - Bored	≤ 800 mm	2 m (nominal)	N/A	6 m
Piling Rig – Hammer	12 t down force	15 m	50 m	45 m
Jackhammer	Hand held	1 m	Avoid contact with structure	3 m

Note: Distances are indicative only, where heavy machinery falls within safe working distances, attended vibration monitoring should be undertaken to confirm vibration levels

Note: Heritage safe working distances are conservative

Generally, vibration monitoring is recommended where construction works within these distances to particular sensitive structures are to occur. The monitoring would verify the minimum working distances at specific locations, which then may be applied to establish a buffer zone surrounding the proposed alignment.

Where the vibration monitoring demonstrates exceedances of the structural/cosmetic damage criteria (refer to **Section 3.2**), alternative construction methodology may be required, such as selection of equipment designed to produce less vibration (where feasible and reasonable).

In such case, construction works are not recommended to continue until attended vibration measurements confirm any risk of cosmetic damage, particularly to heritage structures and or other structures found to be structurally unsound by a qualified structural engineer.

3.2.1.3 Vibration screening

With the guideline values from BS7385 outlined in **Table 10**, conservative vibration damage screening levels per receiver type have been established based on the potentially worst-case scenario of any vibration intensive plant equipment being in use at any point along the works alignment within the rail corridor.

- Reinforced or framed structures: 25 mm/s
- Unreinforced or light framed structures: 7.5 mm/s.

At locations where the predicted and/or measured vibration levels are greater than those listed above, a more detailed condition assessment of the structure and the construction activities near the structure would be required to determine the applicable safe vibration level for that structure.

3.2.2 Human comfort

Construction activities which have the potential to create ground-borne vibrations may impact sensitive receivers near the project works. Humans are responsive to vibration and some discomfort may arise due to various activities, their intensity and duration.

Structural or cosmetic damage to buildings due to vibration only occur at extreme levels, relative to what humans find tolerable.

For human comfort and exposure to vibration, the NSW document *Assessing Vibration: A Technical Guideline* (DEC, 2006) provides the relevant guidance's derived from British Standards.

Table 12 below tabulates the Vibration Dose Values for human comfort. These values represent a guideline for the total accumulation of vibration energy during a 16 hour day-time period, or 9-hour night-time period where applicable.

Table 12 Vibration Dose Values (VDV) for Intermittent Vibration ($m/s^{1.75}$)

Location	Period	Preferred value, VDV $m/s^{1.75}$	Maximum value VDV $m/s^{1.75}$
Critical areas	Day or Night	0.1	0.2
Residences	Day	0.2	0.4
	Night	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night	0.4	0.8
Workshops	Day or Night	0.8	1.6

Note: Daytime is 07:00 hrs to 22:00 hrs

Table 13 below reproduces the preferred and maximum weighted rms **α** acceleration vibration for continuous and impulsive vibration.

Table 13 Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2)

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y- axis	z-axis	x- and y-axis
Continuous Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night	0.020	0.014	0.040	0.028
Workshops	Day or night	0.04	0.029	0.080	0.058
Impulsive Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.30	0.21	0.60	0.42
	Night	0.10	0.071	0.20	0.14
Offices, schools, educational institutions, and places of worship	Day or night	0.64	0.46	1.28	0.92
Workshops	Day or night	0.64	0.46	1.28	0.92

3.3 Ground-borne noise

Ground-borne noise impacts are generally caused by high-vibration intensive plant equipment such as tunneling machines. The ICNG provides guidance for the management of ground-borne noise (GNML), these recommendations are tabulated below in **Table 14** applicable only to residential receivers.

Table 14 Ground-borne noise management levels

Evening 18:00 hrs to 22:00 hrs	Night-time 22:00 hrs to 07:00 hrs
40 dB $L_{Aeq,15min}$	35 dB $L_{Aeq,15min}$

Note: During the Daytime period (07:00 hrs to 18:00 hrs), the human comfort vibration objectives only apply

The internal noise levels are to be assessed at the centre of the most-affected habitable room. For a limited number of discrete, ongoing ground-borne noise events, such as drilling or rock-hammering, the L_{Amax} noise descriptor using a slow response on the sound level meter may be better than the L_{Aeq} noise descriptor (15 min) in describing the noise impacts.

The level of mitigation of ground-borne noise would depend on the extent of impacts and also on the scale and duration of works. Any restriction on the days when construction work is allowed would take into account whether the community:

- Has identified times of day when they are more sensitive to noise (for example Sundays or public holidays)
- Is prepared to accept a longer construction duration in exchange for days of respite.

The proposed methodology along the alignment by the localities of Yallah and Haywards Bay, and, Albion Park Rail, or any other part of the Electrical Works MTMS program do not have any tunnelling machines or subjectively high-vibration intensive equipment.

However, as bored piling works are undertaken at some locations along the alignment assessed in this report, ground-borne noise impacts are investigated on a conservative, worst-case basis.

4 Construction Noise and Vibration Impact Assessment

A range of small and large plant equipment is proposed to be utilised in order to undertake the appropriate constructions activities associated with the Project.

This section summarises the anticipated construction scenarios and associated predicted noise and vibration impacts. These are as follows:

- Noise impacts within the community
- Vibration impacts
  - Human comfort
  - Regenerated noise (ground-borne noise)
  - Heritage or other sensitive structures.

4.1 Noise

4.1.1 Proposed activities

The proposed construction activities have been divided into 9 construction scenarios in which the works are anticipated to be completed, over multiple railway Possessions throughout 2022 and into 2023.

The potential impacts associated with these key activities are assessed based on the type of work that is being carried out, and the time of day/week the works are scheduled to occur over. Construction works are anticipated to be completed in various stages with the construction activities expected to be completed by mid 2023.

It is expected that the activities proposed may be required to work outside the standard daytime hours. The anticipated hours of works are as follows.

Monday to Friday Saturday	Daytime Standard Hours	07:00 hrs to 18:00 hrs 08:00 hrs to 13:00 hrs
Saturday	Daytime Out of Hours	07:00 hrs to 08:00 hrs 13:00 hrs to 18:00 hrs
Sunday Public Holidays	Daytime Out of Hours	08:00 hrs to 18:00 hrs
Monday to Sunday	Evening	18:00 hrs to 22:00 hrs
Monday to Sunday	Night-time	22:00 hrs to 07:00 hrs

Out of hours works and weekend rail Possessions are proposed for works which cannot reasonably be undertaken throughout the normal working-week.

An illustrative overview is provided as follows in **Table 15**.

Table 15 Periods of works, including out of hours

Hour Commencing	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Monday																								
Tuesday																								
Wednesday																								
Thursday	OOWH Period 2							Standard Hours											OOWH Period 1 (Evening)					
Friday																								
Saturday																								
Sunday									OOWH Period 1 (Day)										OOWH Period 2					
Public Holidays																								

Table 16 below provides a general outline of the construction scenarios and their corresponding activity.

Table 16 Work Scenarios for assessment purposes

Scenario ID	Scenario	Activity	Tentative Duration	Proposed Hours of Work				
				Day	Out of Hours Period 1		Out of Hours Period 2	
					Day	Evening	Evening	Night
SN.001	Site Establishment / Demobilisation	Typical Impact	Mid weeks and weekends June 2022 to December 2023	✓	✓	✓	✓	✓
SN.002	Concrete Works Typical CSR Civil Works	Typical Impact	Mid weeks and weekends June 2022 to December 2023	✓	✓	✓	✓	✓
SN.003	Steeling Works and Installation	Typical Impact	Three weekend possessions December 2022 to December 2023 and midweek works March to December 2023	✓	✓	✓	✓	✓
SN.004	Cable Pull	Typical Impact	Three weekend possessions December 2022 to December 2023 and midweek works March to December 2023	✓	✓	✓	✓	✓
SN.005	Overhead Wiring Works	Typical Impact	Two weekend possessions and midweek works March 2023 to December 2023	✓	✓	✓	✓	✓
SN.006	Compound Operations and Utilisation	Typical Impact	18 months June 2022 to December 2023	✓	✓	✓	✓	✓
SN.007	Earthing Works	Typical Impact	Three weekend possessions June 2022 to Dec 2022	✓	✓	✓	✓	✓
SN.008	Earthing Works Piling (Bored)	**Hight Impact**	Three weekend possessions June 2022 to Dec 2022	✓	✓	✓	✓	✓
SN.009	Vegetation Management	Typical Impact	Mid weeks and weekends June 2022 to December 2023	✓	✓	✓	✓	✓

Note: Subject to change or alterations

4.2 Noise model

4.2.1 Calculation methodology

Noise levels have been predicted using 3D predictive software SoundPLAN ver8.2. The prediction model was undertaken using the Industrial Noise ISO 9613 algorithms.

Buildings and the local terrain have been digitised within the model to represent the land surrounding the Project's alignment boundaries.

Data was sourced from Geoscape building footprint database, NSW Spatial Services, and aerial imaging sourced via Nearmaps.

4.2.2 Source noise levels

The Sound Power Levels (SWL) for general and typical construction equipment is provided in **Table 17**. The levels tabulated below are derived from global standard databases.

Construction scenarios, locations, and proposed equipment were provided to us, and confirmed with the Construction Manager and TfT prior to running the assessment. The percentage of on-time is based on standard practices and experience.

Table 17 Sound Power Levels (SWL) for the construction equipment

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.001	Site Establishment / Demobilisation	Typical Impact	Hand Tools	1	67%	92	106
			Vehicle (light commercial)	1	67%	104	
			Flatbed Truck	1	67%	98	
			Lighting - Diesel Generator	1	100%	98	
SN.002	Concrete Works Typical CSR and Piling, Civil Works	Typical Impact	Suction Truck	1	20%	93	107
			Excavator (14 tonne)	1	47%	94	
			Concrete Mixer Truck	1	47%	100	
			Concrete Pump	1	47%	103	
			Tipper Truck	1	33%	92	
SN.003	Steeling Works and Installation	Typical Impact	Excavator (14 tonne)	1	53%	94	102
			Tipper Truck	1	33%	92	
			Welding Equipment	1	67%	95	
			Vehicle (light commercial)	1	20%	99	
			Hand Tools	1	67%	92	

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.004	Cable Pull	Typical Impact	Vehicle (light commercial)	1	53%	103	104
			Hand Tools	1	33%	89	
			winch (electric)	1	100%	95	
SN.005	Overhead Wiring Works	Typical Impact	Elevated Working Platform	1	67%	95	103
			Hi-Rail Manitou	1	67%	89	
			Vehicle (light commercial)	1	33%	101	
			Hand Tools	1	67%	92	
			Mobile Crane - Franna	1	33%	93	
SN.006	Compound Operations and Utilisation	Typical Impact	Generator	1	100%	102	106
			Ute	1	53%	95	
			Flatbed Truck	1	33%	95	
			Delivery Truck	1	33%	103	
SN.007	Earthing Works	Typical Impact	Elevated Working Platform	1	67%	95	101
			Ute	1	53%	95	
			Flatbed Truck	1	53%	97	
			Tipper Truck	1	33%	92	
SN.008	Earthing Works	High Impact	Piling - Bored	1	67%	109	110
			Elevated Working Platform	1	53%	94	
			Ute	1	47%	95	
			Flatbed Truck	1	33%	95	
			Tipper Truck	1	33%	92	

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.009	Vegetation Management	Typical Impact	Chainsaw	1	47%	108	109
			Mulching machine	1	67%	103	
			Ute	1	53%	95	

4.2.3 Results overview

The predicted noise levels are analysed in accordance with the policies, guidelines and standards outlined in **Table 1**, and are presented below.

The following tables and figures provide the maximum worst-case $L_{Aeq,15min}$ noise level predicted from the most impacted sensitive receiver for each NCA during all approved construction hour periods. During most of the construction works, it is reasonable to expect that the noise levels would be lower than the predicted noise levels, as the noise model does not take into account implemented mitigation measures.

4.2.3.1 Noise management level exceedances (project wide)

Table 18 summarises the number of residential receivers and other sensitive land use which are predicted to experience noise levels which exceed their relevant Noise Management Level, including receivers which would experience noise levels exceeding 75 dBA ($L_{Aeq,15min}$).

Table 18 Project wide overview of NML exceedances

Works Scenario	Number of Receivers exceeding relevant Noise Management Level								
	Number of Receivers	Standard Daytime		Out of Hours Works					
				Out of Hours Period 1		Out of Hours Period 2			
		Day	HNA >75 dBA	Daytime	Evening	Sunday Evening	Night	Sleep Disturbance	Sleep Awakening
SN.001	1282	161	-	264	434	434	647	377	92
SN.002		147	2	251	444	444	661	444	82
SN.003		1	-	4	13	13	48	13	-
SN.004		3	-	6	21	21	76	15	1
SN.005		97	-	173	308	308	505	243	43
SN.006		16	-	36	80	80	112	52	6
SN.007		66	-	131	223	223	400	250	41
SN.008		208	8	367	574	574	752	700	174
SN.009		5	-	18	64	64	267	413	7

Note: The predicted NML exceedances include all noise sensitive receivers except OOHW which applies to residential.
Note: HNA (Highly Noise Affected) only applies to residential receivers during standard hours
Note: NML Exceedances for residential land use is based on assumed background noise levels discussed in **Section 3.1**
Note: Evening and Night-time NML exceedances are residential only. Day and Day-time OOH include all receivers

4.2.3.2 Extent of NML exceedances

The results are broken down into four (4) subsets as follows:

NML	-	Noise levels 1 to 10 dB above NML (1 – 5 dB for out of hours)	
	-	Noise levels 11 to 20 dB above NML (5 – 15 dB for out of hours)	
	-	Noise levels 21 to 30 dB above NML (15 – 25 dB for out of hours)	
	-	Noise levels greater than 30 dB above NML (>25 dB for out of hours)	
>75 dBA	-	Highly Noise Affected, noise levels exceed 75 dBA ($L_{Aeq,15min}$) (Residential land use only)	

Note: The above color code is an arbitrary scheme and not designed to flag exceedances based on their range, rather a category highlight.

The extent and distribution of the NML exceedances are tabulated and illustrated below in **Table 19**.

Table 19 Distribution of NML exceedances

Scenario	Number of Receivers															
	Total	HNA >75 dBA	Distribution of NML exceedances													
			Day				Day OOH				Evening (Residential only)				Night time (Residential only)			
			0 - 10	10 - 20	20 - 30	>30	1 - 5	5 - 15	15 - 25	>25	1 - 5	5 - 15	15 - 25	>25	1 - 5	5 - 15	15 - 25	>25
SN.001	1282	8	84	46	-	-	55	94	46	-	116	141	94	4	139	256	94	46
SN.002			91	36	2	-	60	102	36	2	118	159	49	19	139	269	102	38
SN.003			1	-	-	-	1	1	-	-	3	4	-	-	24	8	1	-
SN.004			3	-	-	-	2	3	-	-	7	5	1	-	27	17	3	-
SN.005			56	21	-	-	47	63	21	-	79	110	45	2	113	192	63	21
SN.006			7	6	-	-	7	9	6	-	22	23	7	-	22	53	9	6
SN.007			36	12	-	-	45	43	12	-	55	86	33	1	108	147	43	12
SN.008			120	40	7	-	87	136	40	7	128	225	80	32	118	346	136	52
SN.009			4	-	-	-	5	4	-	-	28	16	1	-	104	54	4	-

Note: HNA refers to Highly Noise Affected, based on the ICNG definition
Note: All exceedances are considered conservative worst-case

A bar graph illustration of the above table is provided below in **Figure 5** and tabulates the spread of the exceedances across all work periods, and all receivers. Note, Sunday evening is included in the evening count.

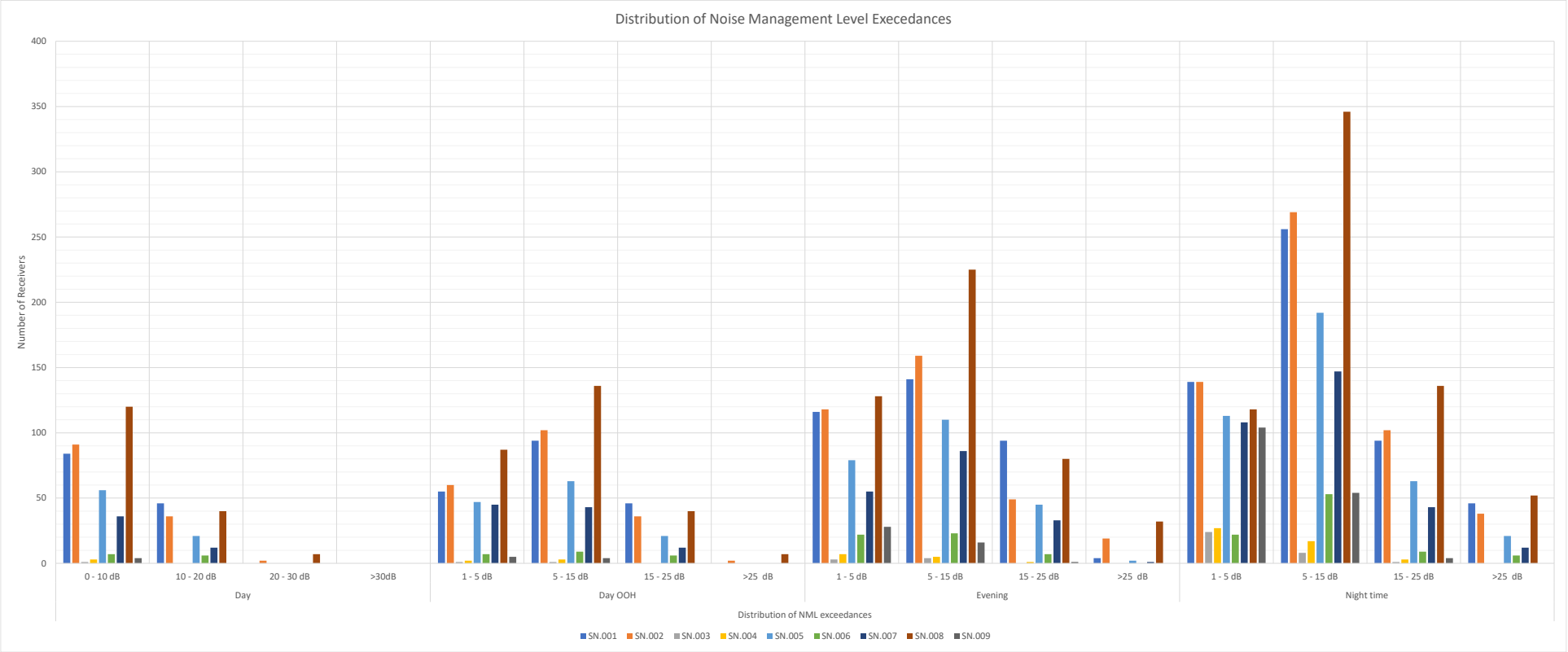

Figure 5 Extent of NML exceedances (all periods, all receivers Day, Residential only Day OOH, Evening and Night-time)

Figure 6 below tabulates the number of receivers predicted to exceed their relevant NML during standard working hours.

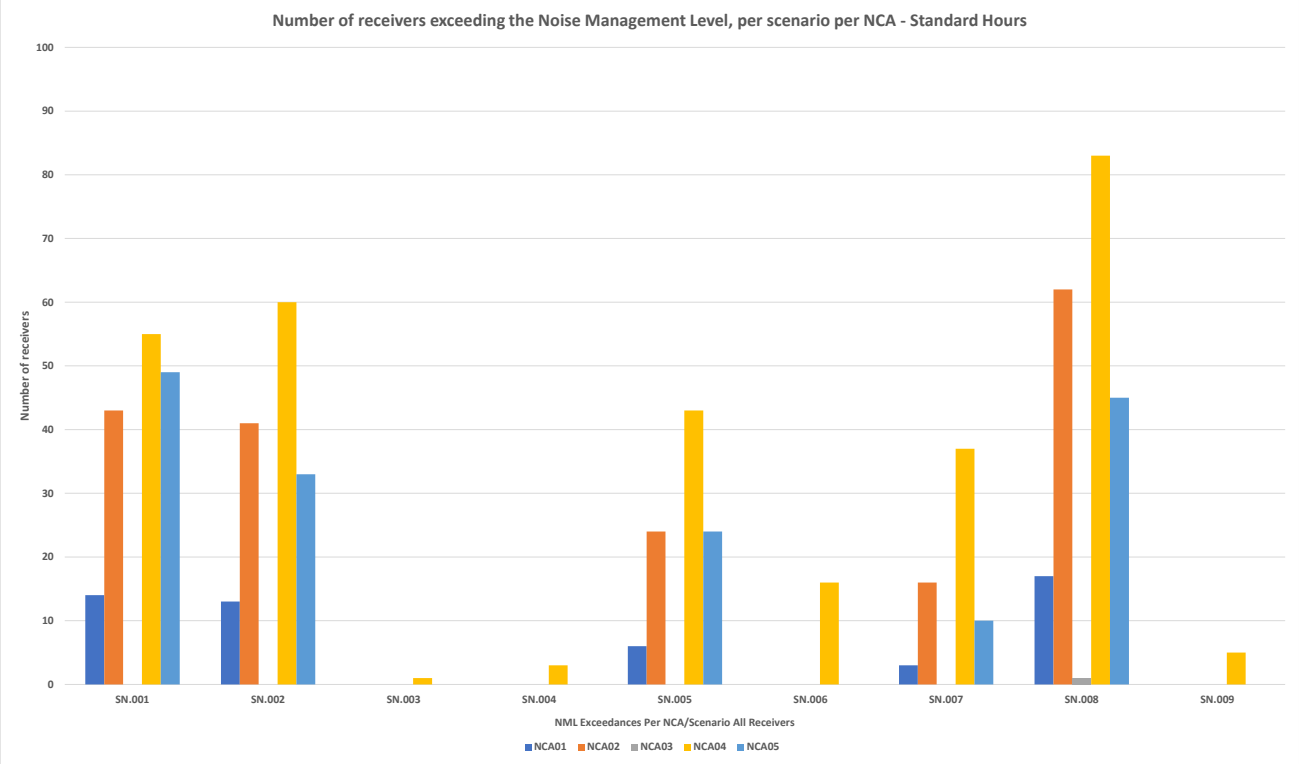

Figure 6 All sensitive receivers exceeding their relevant NML – standard hours

Figure 7 below tabulates day-time out of hours NML exceedances for all receivers.

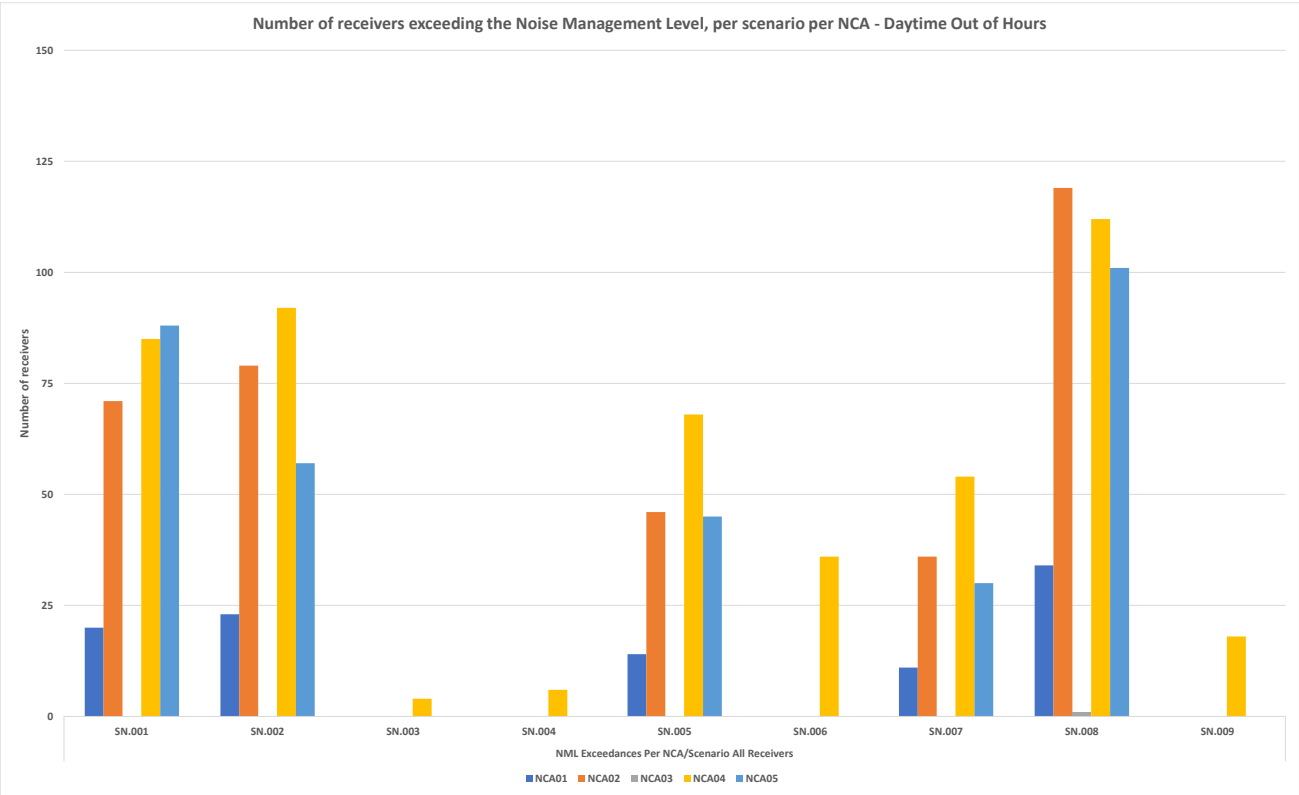

Figure 7 Receivers predicted to exceed their relevant NML during daytime OOH works

Figure 8 below tabulates evening-time out of hours residential NML exceedances.

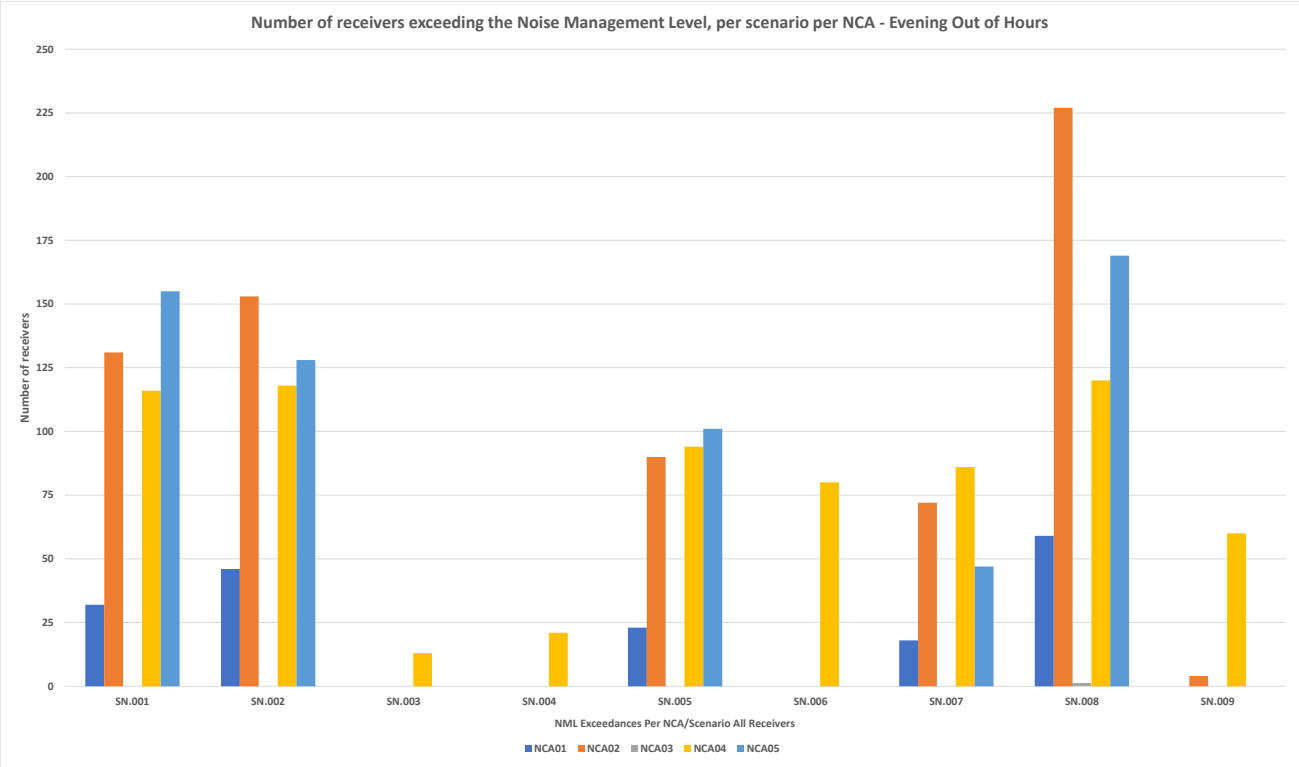

Figure 8 Residential receivers predicted to exceed their relevant NML during evening out of hours works

Figure 9 below tabulates residential NML exceedances during Sunday evening works (18:00 – 22:00 hrs).

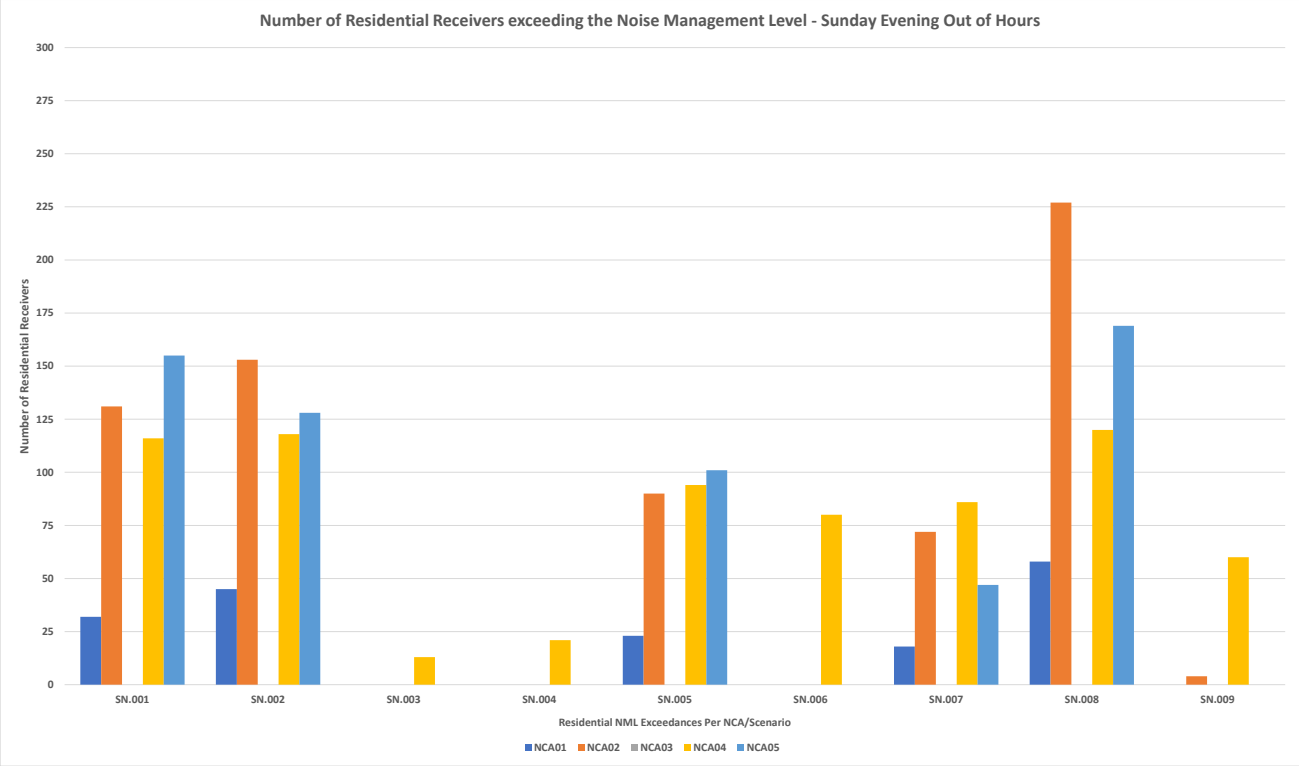

Figure 9 Residential receivers predicted to exceed their relevant NML during Sunday Evening out of hours works

Figure 10 below tabulates night-time out of hours residential NML exceedances.

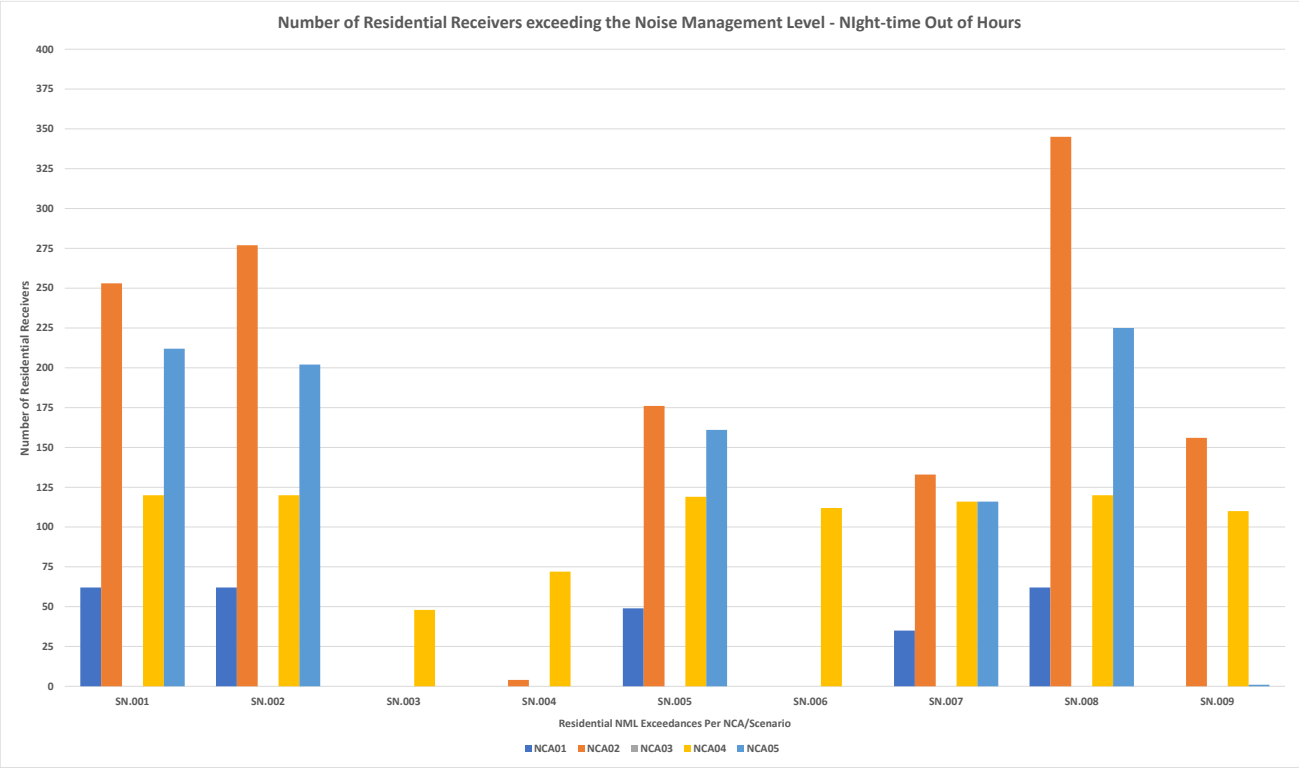

Figure 10 Residential receivers predicted to exceed their relevant NML during night-time out of hours works

4.2.3.3 Highly Noise Affected

Eight (8) residential land use are predicted to exceed the Highly Noise Affected criteria of noise levels exceeding 75 dBA $L_{eq,15min}$. These properties are located by the Haywards Bay Drive road over bridge, Shearwater Boulevard, and one property located on Bateman Avenue.

All eight of these properties are triggered during SN.008 Earthing Works where bored piling is proposed to be in use. These eleven properties are illustrated in **Figure 11**.

Figure 11 Highly Noise Affected residential land use

4.2.4 Worst-case average noise levels

This section provides a tabulated and illustrative overview of the noise models predicted worst-case scenario noise levels, project-wide.

Table 20 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for residential receivers during all periods of work.

Table 20 Residential worst-case noise level overview, per NCA per scenario

NCA / Scenario	Residential - Worst Case Predicted Noise Levels, dBA $L_{eq,15min}$								
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008	SN.009
Residential									
NCA01	71	67	37	39	63	39	61	70	44
NCA02	72	72	39	41	68	39	66	75	46
NCA03	-	-	-	-	-	-	-	-	-
NCA04	71	78	59	61	74	70	72	81	61
NCA05	70	65	34	36	65	39	59	68	40

Note: Shaded red indicates Highly Noise Affected during standard construction hours

Table 21 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for commercial and industrial premises receivers during standard hours, and daytime out of hours.

Table 21 Other sensitive worst-case noise level overview, per NCA per scenario

NCA / Scenario	Other Sensitive - Worst Case Predicted Noise Levels, dBA $L_{eq,15min}$								
	SN.001	SN.002	SN.003	SN.004	SN.005	SN.006	SN.007	SN.008	SN.009
Commercial - Daytime and Daytime OOH									
NCA01	70	72	34	36	68	35	66	75	41
NCA02	45	42	26	28	38	28	36	45	33
NCA03	66	67	63	65	58	66	61	70	69
NCA04	-	-	-	-	-	-	-	-	-
NCA05	47	44	27	29	41	33	38	47	34
Industrial – Daytime and Daytime OOH									
NCA01	-	-	-	-	-	-	-	-	-
NCA02	-	-	-	-	-	-	-	-	-
NCA03	67	65	48	50	61	67	59	68	53
NCA04	-	-	-	-	-	-	-	-	-
NCA05	-	-	-	-	-	-	-	-	-

Note: Shaded red indicated NML exceedances

All activities proposed to be undertaken to complete Electrical Works are proposed throughout all periods.

The following maps provides an overview of the 'per-receiver' typical and worst-case scenario maximum noise levels, dBA L_{eq},15min project wide as the nighttime predicted noise levels correspond to the same as those during the daytime.

Figure 12 Project-wide typical noise levels, dBA $L_{eq,15min}$

Figure 13 Project-wide worst-case scenario noise levels dBA $L_{eq,15min}$

4.2.5 Discussion

Most of the noise levels are concentrated to the first row of housing along both the East and West sides of the corridor. Noise spread is due to the lack of natural barriers as the terrain is relatively flat.

4.2.5.1 NCA01 – Yallah

This area is comprised of a mixture of low-density residential and commercial premises with some scattered rural farm areas towards the West. Most of the noise is concentrated along the rail corridor where noise levels reach up to 70-71 dBA $L_{eq,15min}$ at the most impacted receivers in close proximity to the works.

The properties of rural area are not expected to be impacted by impacts due to the distance of their properties from the project.

Noise impacts are anticipated primarily from site establishment, concrete works, and earthing works in the area.

4.2.5.2 NCA02 – Haywards Bay

General noise levels are spread throughout part of the work activities. No residential premises are predicted to exceed 75 dBA $L_{eq,15min}$, however noise levels are anticipated to reach up to (but not exceed) 75 dBA $L_{eq,15min}$ at residential properties along the rail corridor.

Noise impacts are anticipated primarily from site establishment, concrete works, and earthing works in the area.

4.2.5.3 NCA03 – Albion Park Rail Commercial

Some commercial and industrial land uses may experience noise levels during normal working hours exceeding 70 dBA $L_{eq,15min}$. Low impacts are anticipated within NCA03, with only three-four commercial land uses predicted to exceed the commercial NML of 70 dBA $L_{eq,15min}$.

4.2.5.4 NCA04 and NCA05 – Albion Park Rail Residential

Dominated by residential land use, eight properties are triggered for noise levels exceeding 75 dBA $L_{eq,15min}$ during standard working hours. These properties are located along Shearwater Boulevard within NCA04 and are anticipated to have noise levels up to 81 dBA $L_{eq,15min}$ during SN.008 high-impact earthing works in close proximity to the premises where bored piling is proposed.

Two of these properties are predicted to exceed 75 dBA L_{eq} during concreting works.

Where highly noise intensive plant equipment is proposed to be operated in any other period other than standard hours, additional noise mitigation measures would be required.

4.2.6 Sleep Disturbance and Awakening

An L_{max} noise assessment was undertaken for all plant equipment proposed for use during the night-time period to assess the likelihood of noise events causing sleep disturbance.

Approximately **716** residential properties are predicted to exceed the sleep disturbance criterion of the prevailing background noise level +15 dB. This is likely due to the relatively flat topography surrounding the project site, the alignment exceeding 2,000 m in length, line of sight to works, and, the relatively low assumed and adopted background noise levels.

Residential properties predicted to experience noise levels resulting in sleep disturbance is provided in **Figure 14** below.

Approximately **184** residential receivers with external $L_{A1,1minute}$ noise levels exceeding 65 dBA L_{max} resulting in the probability of at least one (1) sleep awakening event per night is presented in **Figure 15**.

Figure 14 Residential receivers exceeding sleep disturbance screening criterion

Figure 15 Residential receivers predicted to experience at least one (1) sleep awakening event per night

4.2.7 Construction Traffic

A screening assessment was carried out to assess the potential impact of truck usage of five (5) potential routes on local roads, including local roads within Yallah and Haywards Bay, the rail corridor between the Creamery Road level crossing and the southern laydown areas, and, the rail corridor access point on Shearwater Boulevard/Koona Street and the sub-station.

The estimation of one haulage truck per hour along one of the five routes by the rail corridor with an estimated sound power level of 108 dBA (SWL) may have impact noise levels up to 56 dBA $L_{eq,9\ hour}$, or up to 65 dBA $L_{eq,1\ hour}$.

The predicted traffic noise level from the truck indicates exceedances of the local road traffic noise targets up to 10 dB during the daytime, and up to 15 dB during the night-time. However, the existing traffic noise levels have not been ascertained, therefore it's difficult to establish whether the predicted level exceeds the existing level by 2 dB.

The presence of the existing rail line which includes passenger service rolling stock would have already existing relatively higher noise levels for receivers along the corridor.

Therefore, it is reasonable to conclude that the predicted truck noise levels would not be anticipated to have an impact to the receivers in which a 2 dB increase above existing noise levels would be noticeable.

The screening assessment is considered worst-case, however inconclusive as to the potential impact from additional construction traffic.

Table 22 below summarises the worst-case construction traffic noise levels for each of the five routes assessed.

Table 22 Predicted construction related traffic noise levels

Route	Predicted traffic noise, dBA		**Predicted** exceedances above RNP Local Road criteria, dB
	$L_{Aeq,1hr}$	$L_{Aeq,9hr}$	
Route 1	59	51	9
Route 2	62	54	12
Route 2 (Alternative through Spoonbill and Private Property)	64	55	14
Route 3	63	54	13
Route 4	63	55	13
Route 5	65	56	15

Note: Night-time noise level assumed for worst-case conservative approach to traffic assessment

The five routes assessed are illustrated below in **Figure 16**.

Figure 16 Construction Traffic routes

4.2.7.1 Recommendations

A noise monitoring program may be implemented or carried out to confirm the anticipated impact, with additional operator attended monitoring prior to site occupation to establish the existing ambient noise environment, and, determine if the predicted traffic noise levels are below the existing ambient.

Any background/ambient noise monitoring should be undertaken in the daytime, evening and night-time period to supplement the assumed background noise levels per the NPfI, AS1055, and industry best practice. Long term noise logging is not required.

4.2.7.2 Noise Monitoring

Ambient noise monitoring prior to site occupation may demonstrate existing ambient noise levels (L_{eq}) exceeding the predicted traffic noise levels. In this case, no further action would be required or necessary as the predicted truck noise levels would be equal to or less than the existing ambient noise environment, hence no impact.

Where the predicted traffic noise exceeds the measured ambient noise by 2.1 dB or greater, additional mitigation should be considered where feasible and reasonable. Such measures may include but are not limited to:

- Noise monitoring to confirm predicted noise impacts
  - Where monitoring of the construction traffic shows impact lower than predicted, no further action would be necessary
- Alternative route or access points to the corridor
- Community notifications (ie letterbox drops)
- No local road use during the night-time period (ie only daytime access)
- Deliveries and truck use scheduled during daytime period.

The purpose for undertaking ambient noise monitoring is to establish a supplementary assessment background level (ABL) and average noise levels for the daytime and night-time period to assess the predicted noise levels of construction traffic against the existing ambient environment. This measurement would facilitate the screening assessment outlined in **Section 4.2.7**.

Where measurement of traffic noise levels is undertaken, the measured dBA $L_{eq,1\ hour}$ (or estimated L_{eq} based on an L_{AE} assessment) would be used to directly compare against the supplemental background and ambient noise level.

During the measurement, construction related traffic is required to be present. The engaged acoustic consultant would liaise with the construction contractor to determine the anticipated delivery time frame of any plant equipment during the sensitive time period under assessment (likely the night-time period).

4.3 Vibration

The safe working distances outlined in **Section 3.2.1.2** and presented in **Table 11** are considered to be conservative for continuous vibration. Works within the safe working distances does not guarantee that any impact would occur, rather that consideration regarding methodology and potential impacts may be required.

The distances provided in **Table 11** are generally estimations for vibration intensive equipment such as rollers and piling equipment.

The works outlined within this assessment are not anticipated to include any vibration intensive plant, however bored piling works are anticipated to be undertaken at some locations within the rail corridor.

During night-time use of the bored piling, up to 5 dB exceedances of the ground-borne night-time criteria is anticipated, within the **clearly audible** TfNSW limitations.

A subjective risk assessment is provided below in **Table 23** which outlines the most vibration sensitive structures in close proximity to the Project.

Table 23 Potential vibration impacts

Item	Approximate Distance (m) to works	Type of structure	Risk assessment			
			Cosmetic	Structural	Human Comfort	Vibration Monitoring
Residential	≈15	House	No	No	Low	Complaints
Albion Park Dairy Factory	>300 m	Local Heritage	No	No	n/a	No

Note: Risk assessment is subjective and not formulated from structural engineering advice

Vibration impacts to human comfort where fully loaded trucks passing along Koona St and Shearwater Boulevard during the nighttime period may have an estimated (calculated) Vibration Dose Values of up to 0.2 $m/s^{1.75}$ which indicates compliance of the maximum night-time value of 0.26 $m/s^{1.75}$. Vibration monitoring would be required during the receipt of any one (1) valid complaint of vibration.

The estimated Vibration Dose is calculated from known velocities of loaded trucks, the dosage is based on one single truck in any one-hour period with a drive-by time of up to 30 seconds. The calculated level is only a general screening estimation, should vibration monitoring be undertaken (required from the receipt of any one valid community complaint), on-site measurement data may be higher due to the road conditions, truck axel weight and loaded conditions, speed of the vehicle and route taken. Vibration monitoring data would be compared to the weighted rms acceleration values tabulated in **Table 13** outlined in **Section 3.2.2**.

The predicted vibration levels at the heritage Dairy Factory from piling works within the rail corridor are estimated to be less than 2 mm/s, no impacts to the heritage Dairy Factory are anticipated, vibration monitoring at the heritage structure is not anticipated to be necessary.

5 Environmental Mitigation Measures

5.1 Standard mitigation

The Transport for New South Wales CNVS (2019) provides a base framework for all feasible and reasonable noise management and mitigation practices.

The strategies outlined below in **Table 24** describe various work practices to minimise noise on work sites. These items summarise the most effective measures, designed to manage and lower noise impacts from construction works.

Table 24 Standard Mitigation Measures

Action Required	Applies to	Details
Management Measures		
Implementation of any project specific mitigation measurement required	Airborne Noise Ground-borne noise and vibration	In addition to the measures set out in this table, any project specific mitigation measures identified in the environmental assessment documentation (e.g. EA, REF, submissions or representations report) or approval or licence conditions must be implemented
Operation of plant equipment	Airborne Noise	All plant and equipment on site to be operated in a proper and efficient manner by an appropriately qualified and competent operator
Implement community consultation measures	Airborne Noise Ground-borne noise and vibration	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website • Project Infoline • Construction Response Line • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings and • Community Based Forums (if required by approval conditions)
Register of noise sensitive receivers	Airborne Noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan

Action Required	Applies to	Details
Construction Respite Periods	Airborne Noise Ground-borne noise and vibration	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site Inductions	Airborne Noise Ground-borne noise and vibration	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 high noise generating activities • 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	Airborne Noise	• No swearing or unnecessary shouting or loud stereos/radios; on site. • No dropping of materials from height; throwing of metal items; and slamming of doors. • No excessive revving of plant and vehicle engines • Controlled release of compressed air.
Monitoring	Airborne Noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.

Action Required	Applies to	Details
Attended vibration measurements	Ground-borne noise and vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances
Update Construction Environmental Management Plans	Airborne Noise Ground-borne noise and vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies
Building Condition Surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage
Source Controls		
Construction hours and scheduling	Airborne Noise Ground-borne noise and vibration	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods
Construction respite periods	Airborne Noise Ground-borne noise and vibration	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block
Equipment selection	Airborne Noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	Airborne Noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in **Table 8**
Rental plant and equipment	Airborne Noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in **Table 8**
Plan worksites and activities to minimise noise and vibration	Airborne Noise Ground-borne noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site
Non-tonal reversing alarms	Airborne Noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work

Action Required	Applies to	Details
Minimise disturbance arising from delivery of goods to construction sites	Airborne Noise	• Loading and unloading of materials/deliveries is to occur as far as possible from NSRs • Select site access points and roads as far as possible away from NSRs • Dedicated loading/unloading areas to be shielded if close to NSRs • Delivery vehicles to be fitted with straps rather than chains for unloading, wherever feasible and reasonable
Use and siting of plant	Airborne Noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Construction related traffic	Airborne Noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on mobile plant	Airborne Noise	Where possible reduce noise from mobile plant through additional fittings including: • Residential grade mufflers • Damped hammers such as “City” Model • Rammer Hammers • Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Airborne Noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Airborne Noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘In-service test procedure’ and standard.

Action Required	Applies to	Details
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne Noise	Stationary noise sources would 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	Airborne Noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant

5.1.1 Additional noise mitigation measures

In accordance with the TfNSW CNVS, the implementation of standard mitigation measures, and compliance with maximum sound power levels for plant and equipment, construction hour management, and standard community consultation measures outlined within the CNVS should reduce the noise and potential vibration impacts on nearby sensitive receivers.

The TfNSW CNVS provides guidance for Transport Infrastructure and Place (IP) Projects where exceedances of the construction noise and vibration management levels are likely to, or are predicted to, occur. These measures are summarised from the CNVS and presented below in **Table 25**.

Table 25 Description of Additional Mitigation Measures

Measure	Description	Abbreviation
Periodic Notification	For each IP project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is established on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the IP Community Engagement Team in cases where AMM are not triggered as shown in **Table 26**, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the IP Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended.	V

Measure	Description	Abbreviation
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	SN
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre- purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is established on a case-by-case basis and may not be applicable to all IP projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative Construction Methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note: this management measure does not apply to OOHW Period 1 – Days.	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all IP projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with IP Community Engagement Representatives.	DR

5.1.2 Applying additional mitigation measures

Additional Mitigation Measures (AMM) are recommended to be considered to offset impacts where the application of standard and project-specific mitigation measures (outlined in **Table 24**) are taken into consideration when assessing the potential noise and vibration impacts, however the relevant NMLs are still predicted to be exceeded.

Table 26 below tabulates the thresholds for each time period and range of noise above the predicted L_{eq} impact to the surrounding sensitive receivers.

Table 26 Additional Mitigation Measures

Construction Hours	Receiver perception	Predicted dBA (L_{eq}) above RBL		Predicted dBA (L_{eq}) above ANML		Additional management measures
		Range (dB)		Range (dB)		
Standard Hours Monday to Friday – 7 am to 6 pm Saturday – 8 am to 1 pm	Noticeable	5	10	0		-
	Clearly audible	>10	20	<10		-
	Moderately intrusive	>20	30	>10	20	PN, V
	Highly Intrusive	>30		>20		PN, V
	>75 dBA Leq	n/a		n/a		PN, V, SN
OOHW Period 1 Monday to Friday - 6 pm to 10 pm Saturday – 7 am to 8 am, 1 pm to 10 pm Sunday/PH – 8 am – 6 pm	Noticeable	5	10	<5		-
	Clearly audible	>10	20	>5	15	PN, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR
OOHW Period 2 Monday to Saturday – 12 am to 7 am, 10 pm to 12 am Sunday/PH – 12 am to 8am, 6 pm to 12 am	Noticeable	5	10	<5		PN
	Clearly audible	>10	20	>5	15	PN, V, SN, RO, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR, AA

Notes PN = Project Notification SN = Specific Notification, Individual Briefings, or phone call
V = Verification Monitoring AA = Alternative Accommodation RP = Respite Period
DR = Duration Reduction RO = Project Specific Respite Offer

Additional notes to **Table 26** include the following:

- SWLs used for the purpose of estimating noise impact shall be increased by 5 dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics.
- Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 7 am-8 am and 1 pm-6 pm, Sundays / Public Holidays 8 am-6 pm)
- Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays / Public Holidays 6 pm-10 pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

5.1.2.1 Overview of additional mitigation measures

Under the TfNSW CNVS, noise levels predicted to exceed the Airborne Noise Management Levels (ANML) require specific additional mitigation measures, summarised above in **Section 5.1.2**.

The extent of the additional noise mitigations (AMM) is broken down per each scenario in the following figures during each assessed time period.

Figure 17 below illustrates an overview of the AMM per scenario during standard construction hours for all receivers impacted by the works.

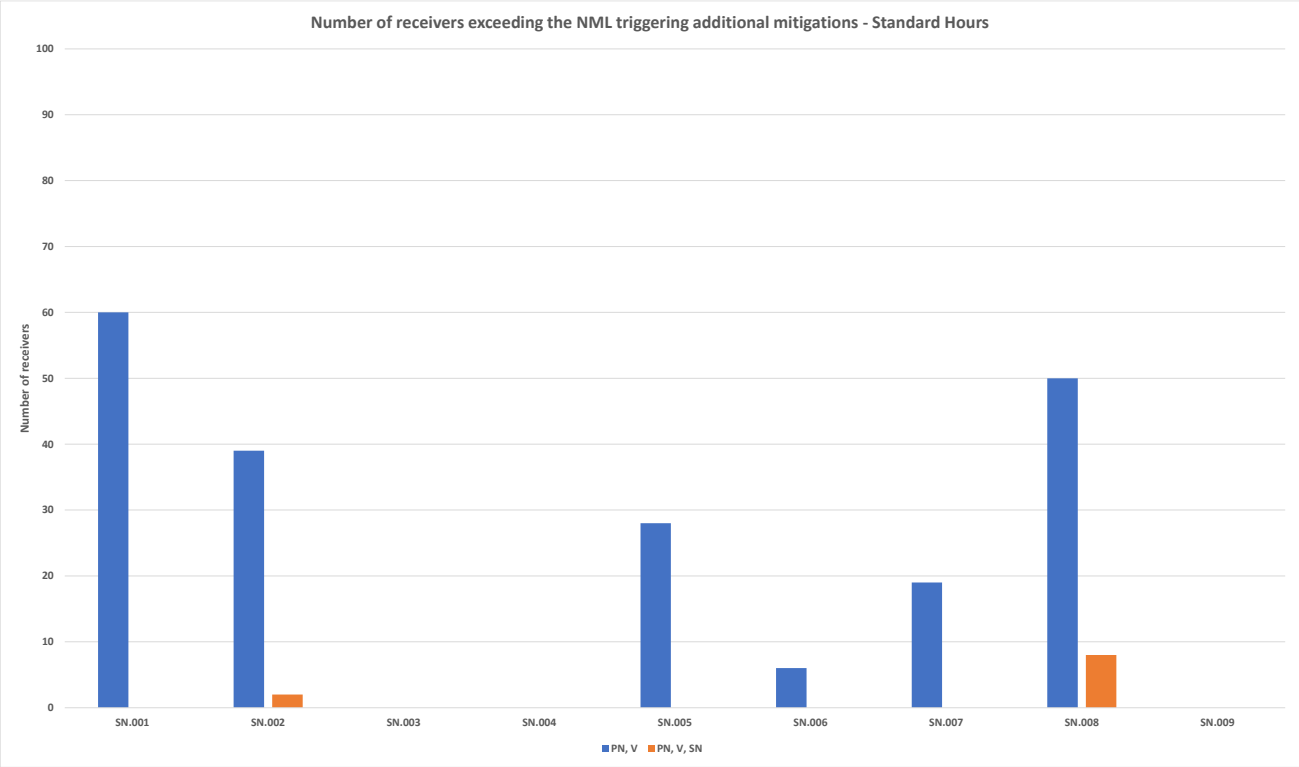

Figure 17 Additional mitigation – Standard Hours

Figure 18 below illustrates the additional mitigations during daytime out of hours works. This graph includes all receivers.

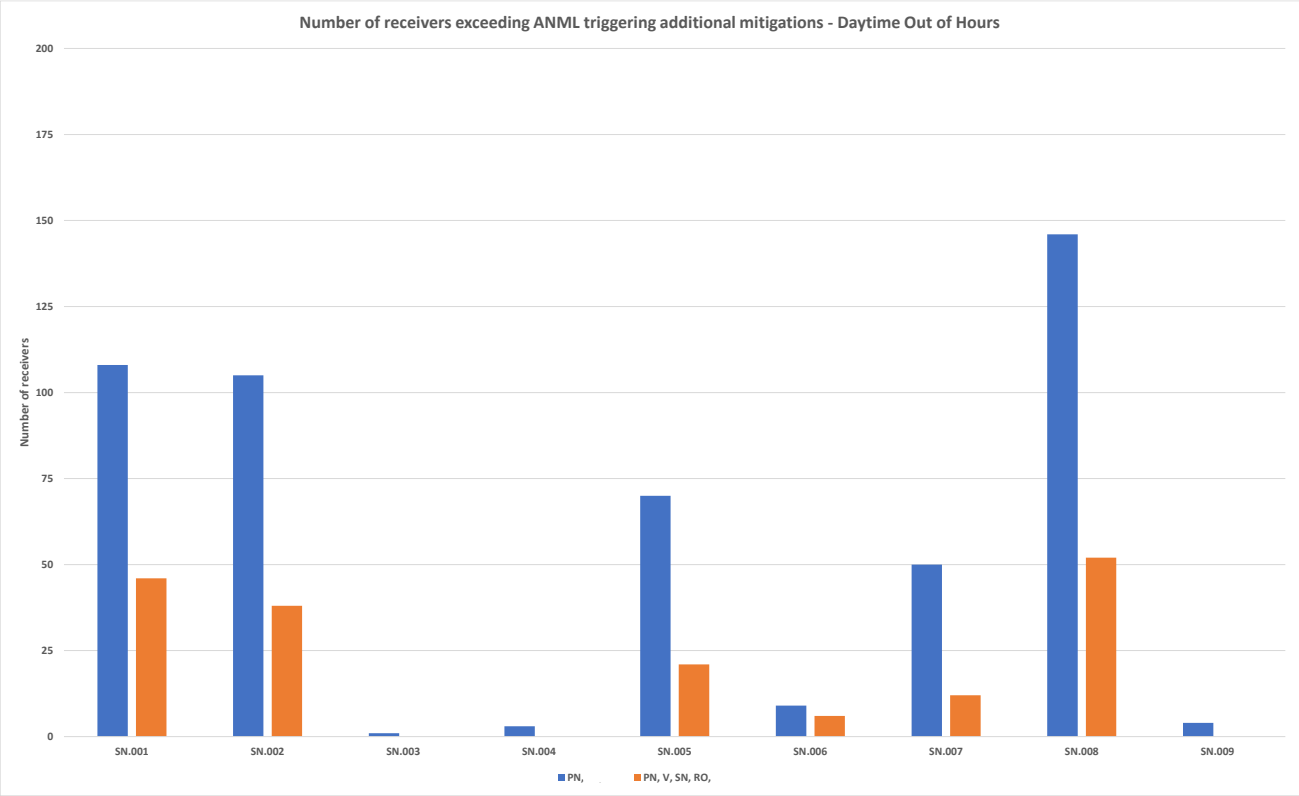

Figure 18 Additional mitigation – Daytime – Out of hours

Figure 19 below illustrates the additional mitigations during Sunday evening out of hours works. Only residential receivers are included.

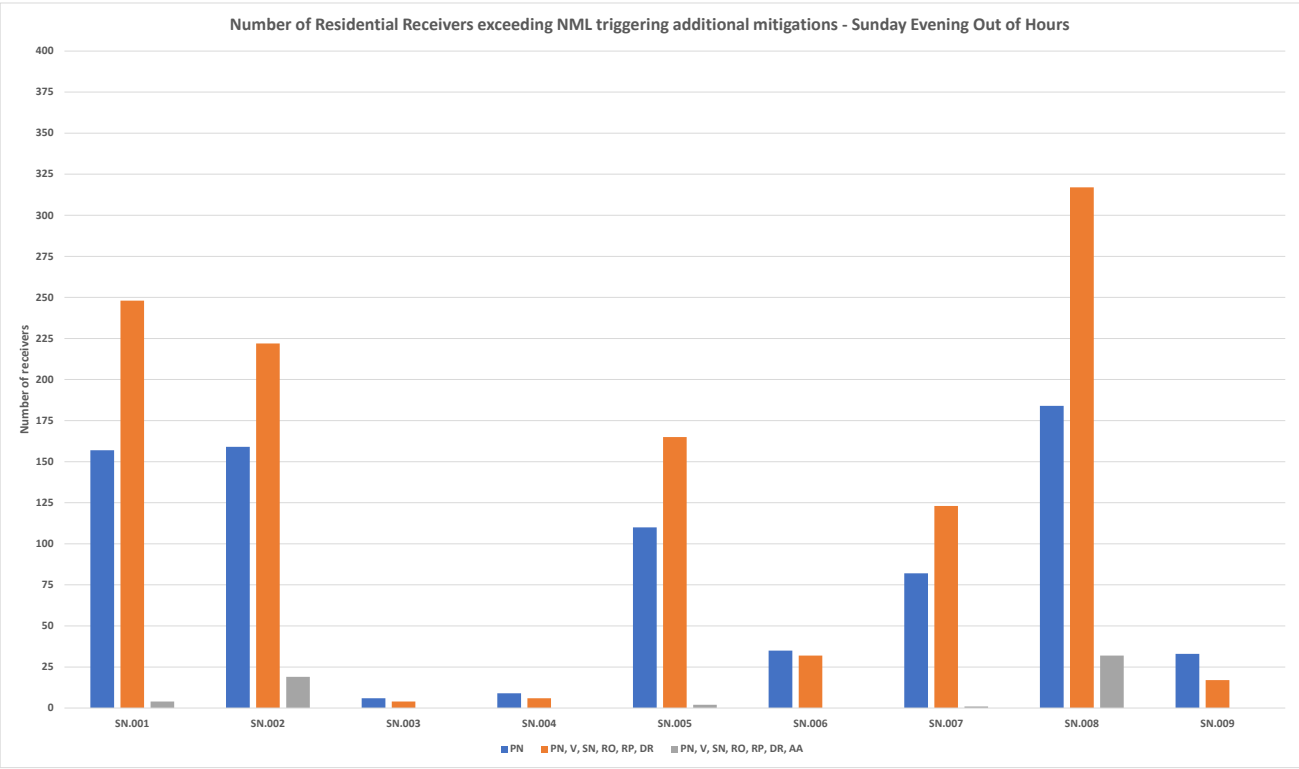

Figure 19 Additional mitigation – Sunday Evening – Out of hours

Figure 20 below illustrates the additional mitigations during Monday to Saturday evening out of hours works. Only residential receivers are included.

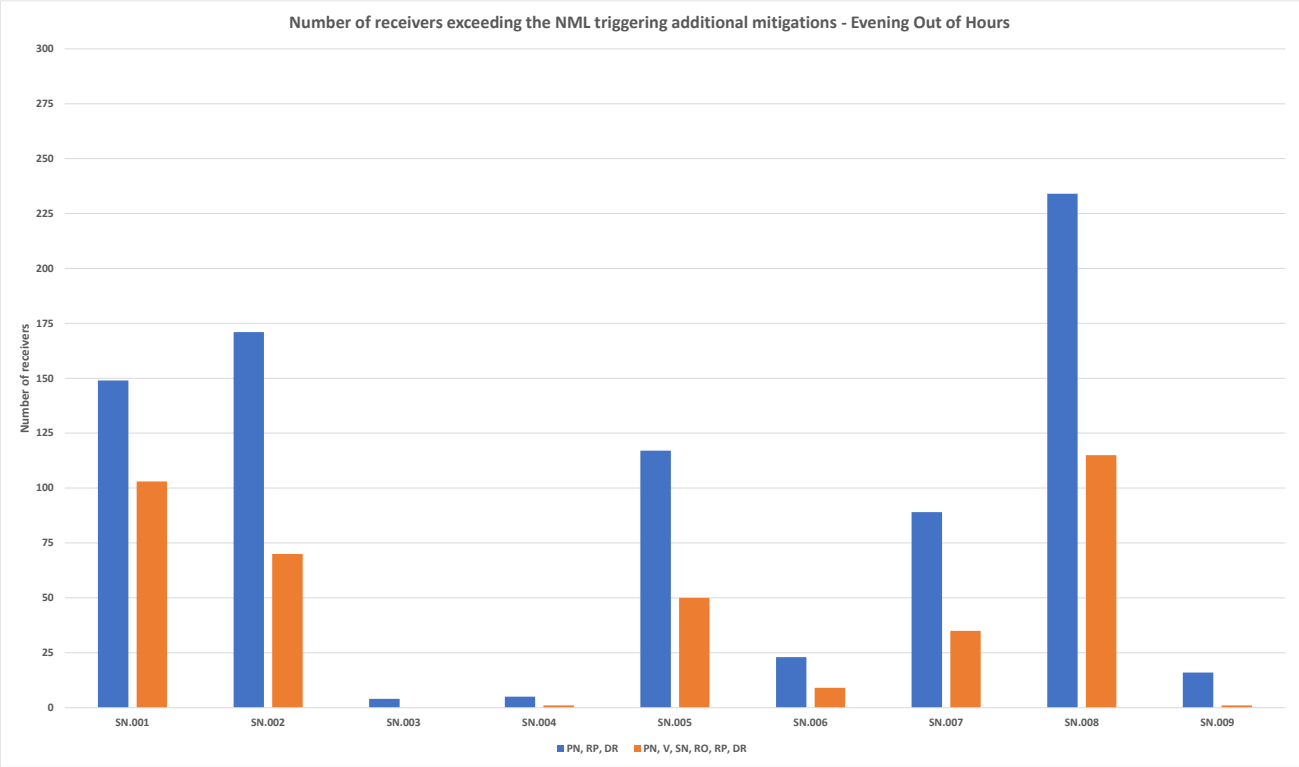

Figure 20 Additional mitigation – Evening – Out of hours

Figure 21 below illustrates the additional mitigations during Monday to Sunday night-time out of hours works. Only residential receivers are included.

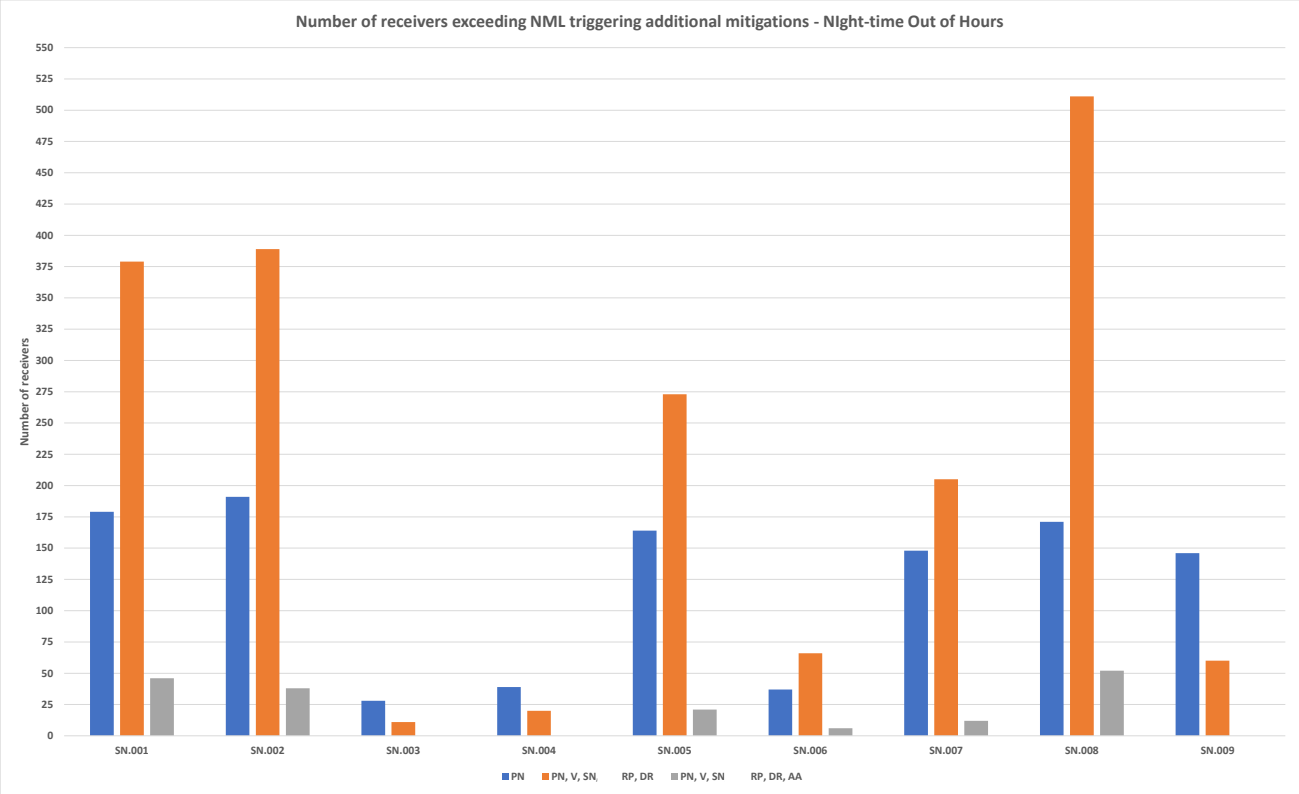

Figure 21 Additional mitigation – Night-time – Out of hours

5.1.2.2 Extent of additional mitigation measures

The following maps provide an illustrative overview of the extent of the necessary and required AMM project wide.

These properties trigger for additional mitigation due to the assumed background noise management levels during the assessment periods, the works proposed during this period, and, the proximity of the receivers to the works along the corridor alignment.

The extent of the additional mitigations are triggered on a project-wide, worst-case scenario basis driven by the predicted worst-case average noise levels. The mitigations are likely due to proximity of sensitive land uses to the works locations. Stockpiles, compounds, and the overall length of the works alignment over the duration of the projects anticipated construction timeframe.

Figure 22 Additional Noise Mitigation Measures, Daytime extent (all receivers)

Figure 23 Additional Noise Mitigation Measures, Daytime out of hours

Figure 24 Additional Noise Mitigation Measures, Sunday Evening out of hours

Figure 25 Additional Noise Mitigation Measures, Evening extent (residential receivers only)

Figure 26 Additional Noise Mitigation Measures, Night-time extent (residential receivers only)

5.2 Discussion

The spread of noise is influenced by diffraction and the lack of natural barriers or tall built environment. Any barrier effect these houses would have is minimal, triggering the additional mitigation presented over **Figure 22** for standard hours, **Figure 23** for Daytime out of hours**, Figure 24** for Sunday Evening out of hours, **Figure 25** for evening works, and **Figure 26** for night-time works.

Approximately 72 residential properties are triggered for Alternative Accommodation (AA) during most of the Sunday Evening (35) and weekday/Saturday/Sunday (72) night-time assessed works, however most of the properties are triggered during high-impact earthing works activities SN.008 (52).

However, works not trigging any AA are SN.003, SN.004, SN.009. Activities triggering AA would be due to the close proximity of the works locations to the facades of these properties. The AA trigger would only apply where works are occurring within a reasonable distance to these properties during these sensitive time periods.

5.2.1 Spread of Alternative Accommodation

Most of the Alternative Accommodation (AA) triggering is during high impact earthing works, these activities are proposed to occur during the night-time period, is anticipated to use high noise intensive plant equipment throughout various locations along the corridor alignment.

Approximately 52 residential properties are triggered for AA during these works, an illustrative overview of all impacted properties is presented below in **Figure 27**.

Figure 27 High impact earthing works (night-time) Alternate Accommodation

Approximately 46 residential properties are triggered for AA during SN.001 where site mobilisation and mobilisation activities are anticipated to be taken place at various locations throughout the corridor during relevant work hours.

Where works are occurring near identified properties in sensitive time periods, as presented in **Figure 28** below, AA maybe required during these works.

Figure 28 Residential properties triggered for AA (orange) during mobilization and demobilisation (SN.001)

5.2.2 Respite offer

Up to 332 properties are triggered for respite offer (RO) during works occurring in the Sunday Evening time period (18:00 onwards).

Figure 29 provides an overview of the properties triggered for respite where works may occur near these properties during this time period.

Figure 29 Respite Offer – Sunday Evening

5.2.2.1 Reasonable distance for respite offer and alternative accommodation

The NML for Evening (including Sundays) works is summarised below in **Table 27** with the distance limitations for RO eligibility. This distance is based on the location of the works. Properties outside of this distance in any direction from the works area are not eligible for respite offers.

Table 27 Distance to receivers eligible for RO

NCA	Area	Evening NML (RBL+5)	Noise level triggering Respite Offer (dBA L_{eq})	Conservative distance to works triggering RO (m)
NCA01	Yallah Residential / Commercial	50	55	200 (RO)
NCA02	Haywards Bay Residential	45	50	350
NCA03	Commercial	50	N/A	n/a
NCA04	Albion Park Rail Residential	45	50	350
NCA05	Albion Park Residential	45	50	350

Note: Distances presented are conservatively based, and do not include natural barriers or topography. Properties not triggered in **Section 5.1.2.2** are not automatically eligible based on this distance. This table only demonstrates the distances from the works at any specific location and which properties triggered in **Section 5.1.2.2** would be eligible at the time of those works, if those properties are located within the distances presented above
Properties triggered for RO in **Section 5.1.2.2** however located further than the distances provided above to the works in the evening period, are not eligible for RO

Where works are proposed and scheduled to be in one specific area (for example one pole location), the RO spread per NCA would be limited to the distances outlined above.

The distance for all NCAs where AA is eligible is 50 m. Properties further than 50 m away from night-time works area boundaries are not eligible for AA.

5.2.3 Recommendations

In accordance with the TfNSW CNVS, appropriate mitigation outlined in **Table 24** should be applied where feasible and reasonable. Additional recommendations are formulated as follows:

- Undertake attended noise monitoring during the works where works are anticipated to be in close proximity to noise sensitive receivers along the rail corridor between Yallah/Haywards Bay and Albion Park localities
  - In the event that noise levels exceed those tabulated in this report:
    - Noise management level or sleep disturbance exceedances would be responded to through review of equipment on site
    - Review of implemented mitigation (standard and project specific if relevant)
    - Review of sensitive-land use specific mitigation measures (if relevant)
    - Review of feasible and reasonable mitigation
  - Where noise levels do not exceed those tabulated in this report:
    - Apply the AMM mitigations tabulated in **Table 26**
  - During night-time works where complaints are received and noise monitoring demonstrates that noise levels exceed 25 dB above the relevant night-time NML, properties exceeding 50 m would be eligible for AA where those noise levels at that premises (if the source of the complaint) exceed the trigger level

- Vibration monitoring is not anticipated to be necessary unless the following circumstances arise:
  - In the event of any one (1) adverse community comment, complaint, or concern
  - Where any dilapidation report outlines conditional concerns for any structure not outlined in this report, and, where any vibration intensive plant equipment no longer operates within the prescribed safe working distances (refer to **Table 11**) of those structures
  - Where formulated as part of any one inclusive construction noise and vibration management plan (CNVMP) outlining the necessary requirements for monitoring
  - Vibration monitoring on any heritage (or other sensitive) structure/s is not anticipated to be necessary as works proposed are not anticipated to occur within the prescribed safe working distances, and, works are estimated to have vibration velocities lower than 2 mm/s (where vibration intensive plant are expected and anticipated, ie bored piling works).

It would be anticipated that the application of feasible and reasonable noise and vibration management practices would lower the noise levels presented in this report; noise model analysis does not factor in barriers, hording, or other generic or standard mitigations, the assessment only assesses the worst-case noise levels at the most reasonably close distance to a sensitive receiver's most habitable room.

5.2.4 Ground-borne Noise

Conservative noise calculations during bored piling works estimate regenerated noise at 15 m from the rail corridor may be between 39 and 41 dBA $L_{eq,15min}$. During the night-time period, 4-6 dB of GNML exceedances may be anticipated (nil during the daytime).

Table 28 below replicates the TfNSW Ground-borne noise Additional Mitigation Measures During the night-time, specific notification, verification monitoring, and, project notification measures are necessary where bored piling works are occurring within 20 m of residential land uses.

Table 28 Ground borne Noise Additional Mitigation Measures

Construction Hours	Receiver perception	Predicted dBA (L_{eq}) above GNML		Additional management measures
		Range (dB)		
Standard Hours Monday to Friday – 7 am to 6 pm Saturday – 8 am to 1 pm	Clearly audible	<10		PN
	Moderately intrusive	>10	20	PN,
	Highly Intrusive	>20		PN, V, SN
OOHW Period 1 Monday to Friday - 6 pm to 10 pm Saturday – 7 am to 8 am, 1 pm to 10 pm Sunday/PH – 8 am – 6 pm	Clearly audible	<10		PN
	Moderately intrusive	>10	20	PN, V, RO, SN
	Highly Intrusive	>20		PN, V, SN, RO, RP, DR
OOHW Period 2 Monday to Saturday – 12 am to 7 am, 10 pm to 12 am Sunday/PH – 12 am to 8am, 6 pm to 12 am	Clearly audible	<10		PN, V, SN
	Moderately intrusive	>10	20	PN, V, SN, AA, RP, DR
	Highly Intrusive	>20		PN, V, SN, AA, RP, DR

Note: Respite periods and duration reductions are not applicable when the works are carried out during OOH Period 1 Day only

Verification monitoring is recommended in the events of complaints only.

6 Conclusion

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for electrical upgrade works proposed to be undertaken within the rail corridor over a 2,300 m length, between Albion Park Station and approximately 200 m north of the Haywards Bay Drive road over-bridge under the More Trains More Services South Works Program.

A 3D noise model was built in SoundPlan™ to assess the potential impacts of the construction on the nearby noise sensitive receivers. This assessment found the following:

- Eight (8) residential receivers are predicted to exceed ICNG defined Highly Noise Affected criteria of >75 dB $L_{Aeq,15min}$
  - Triggered during high-impact Earthing Works
- Mitigation measures in accordance with the TfNSW Construction Noise and Vibration Strategy are required for surrounding sensitive land uses
- Approximately **716** residential receivers are predicted to exceed sleep disturbance screening criterion during night-time OOH works across the project, and **184** receivers are predicted experience at least one (1) sleep awakening event during night-time works, most notably during high noise impact works during Earthing Works (SN.008)
  - This is due to low density housing in this area not benefiting from any natural barriers or topographical conditions, low assumed background levels, proximity to works, line of sight to works, and the overall length of the alignment impacting a greater number of receivers
  - **72** residential properties are triggered for Alternative Accommodation during works throughout the various stages of construction. This is triggered by high noise impact night-time concreting works activities
    - **46** receivers during mobilisation (general alignment)
    - **38** during concrete works
    - **52** during high-impact earthing works (where bored piling is proposed)
    - Applicable only to properties within 50 m in any direction from work areas in eligible time periods (or unless any noise monitoring demonstrates eligibility)
  - Up to **332** properties are triggered for respite offers during Sunday evening works
    - **Section 5.2.2.1** describes the properties eligible for RO where the residential premises triggered for RO falls within a specific distance
      - Where works occurring on Sunday Evening period are localised to one area, the distances provided in **Section 5.2.2.1** limit the spread of RO eligibility
- Construction related traffic noise impacts are anticipated to exceed the RNP local road traffic noise target levels by up to 15 dB above the night-time target noise levels. Noise level impacts up to 65 dBA $L_{eq,1\ hour}$ are anticipated, however the existing traffic noise levels have not been established. Therefore, the screening assessment to determine whether construction traffic increases the existing traffic noise levels by 2 dB cannot be confidently progressed.
  - The existing rail line which includes passenger rolling stock would impact the existing ambient noise environment which would drive up the existing ambient noise environment
  - Assumed 'average noise levels' have not been adopted for this assessment
    - The background noise levels used for assessment purposes are presented in **Section 2**

- Noise monitoring prior to occupation is recommended to supplement the assumed background noise levels
- Noise monitoring during route use is recommended to establish the impact of construction traffic. More information is presented in **Section 4.2.7.2**

- Recommendations may include use of any stockpile areas located near sensitive receivers to be restricted to daytime/daytime OOH/evening operations only where reasonable and feasible

- No vibration impacts are anticipated due to the lack of vibration-intensive machinery or plant proposed for use
  - The likelihood of any adverse vibration related comment from within the community is unlikely
  - Truck use along the rail corridor would be the most vibration generating activity, predicted eVDV levels estimate vibration dosages of 0.2 $m/s^{1.75}$

Additional recommendations are formulated:

- Noise monitoring is recommended where identified within this report, and, during high impact noise activities occurring during the night-time period, to confirm noise levels predicted within the model
- In the event of noise or vibration complaints or adverse community comments or concerns:
  - Attended noise/vibration monitoring in accordance with the relevant standards, policies and guidelines
  - Noise management level or sleep disturbance exceedances would be responded via review of equipment on site
  - Review of implemented mitigation (standard and project specific)
  - Review of sensitive-land use specific mitigation measures
  - Review of feasible and reasonable mitigation
    - Further mitigation measures may be necessary should any attended noise monitoring noise levels measure greater $L_{Aeq,15min}$ noise levels than those predicted and presented in **Section 4.2.4**.
- Vibration monitoring may be necessary under the following conditions:
  - In the event of any one (1) adverse community comment, complaint, or concern
  - Where any dilapidation report outlines conditional concerns for any structure not outlined in this report, and, where any vibration intensive plant equipment no longer operates within the prescribed safe working distances (refer to **Table 11**) of those structures
  - Where formulated as part of any one inclusive construction noise and vibration management plan (CNVMP) outlining the necessary requirements for monitoring
  - Vibration monitoring on heritage structures is not anticipated to be necessary as no vibration intensive plant are anticipated to be in operation within the prescribed safe working distances.
- Vibration from bored piling works has the potential to produce regenerated ground-borne noise at some premises within 20 m from the rail corridor where bored piling locations may be located. These locations are not fully known at the time of formulating this report
  - Project specific notification, verification monitoring, and, project notification are necessary measures where bored piles are located within 20 m of any residential premises
  - Verification monitoring may only be undertaken in the event of complaints of regenerated noise during vibration intensive works (not anticipated, however bored piling may regenerate some noise)

- Verification monitoring would be undertaken within the habitable room of the complainant where feasible and reasonable – as far as practicable possible in the event of complaints.

- Community notifications (PN and SN) should be provided to all residents immediately adjacent to the rail corridor where works are anticipated to be undertaken. Should bored piling works be undertaken during the night-time period, additional notification may be necessary
  - 4-6 dB of GNML exceedances are anticipated, the regenerated noise may be audible within habitable rooms, and may be categorized as a low droning hum.

Appendix I – Glossary

1 Sound Pressure Level

Defined as:

$$L_p = 10log_{10}\left(\frac{p^2}{p_{ref}^2}\right)dB$$

In the above equation, p is the sound pressure fluctuation relative to atmospheric pressure, and *pref* is 20 microPascals (2 x 10-5 Pa), the approximate threshold of hearing.

Sound or noise is the sensation produced at the ear by small fluctuations in atmospheric pressure. Human ears are sensitive to changes to sound pressure over a wide range, from 20 microPascals to 60 Pascals, in lieu of using a linear scale to represent this range, a logarithmic scale is adopted to better handle

2 Sound Power Level

Sound power level cannot be directly measured using a microphone, it does not change with distance and is not influenced by atmospheric conditions. The sound power level refers to the total energy of the sound, and is reference to 1 Pico Watt.

3 Weighting and Loudness

The overall level of a sound is usually expressed as dB(A) and not dB. Weighting refers to the human ear's frequency response to sound. Typically, sound is measured with an A-weighted filter which reduces the significance of lower frequencies and very high frequencies, increasing the importance of mid-frequencies (500 Hz to 4 kHz), and being a good measure of the "loudness" of a sound.

A change of 1 to 2 dB(A) is difficult to detect, whilst a change of 3 to 5 dB(A) corresponds to a small but noticeable change. A 10 dB(A) change corresponds to a doubling or halving in apparent loudness.

4 Noise Metrics and Statistical Noise Levels

i) L_{Aeq} - The time averaged A-weighted sound pressure level for the interval, as defined in AS1005.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

ii) L_{Amin}/L_{Amax} - Minimum or Maximum A-weighted noise level detected during the measuring period. It refers to the minimum background noise detected or the maximum L*p* measured.

iii) L_{A90} - A-weighted noise level which is exceeded for 90% of the measuring period. It is usually used as the descriptor for background noise level during the measurement period.

iv) L_{A1} - Noise level which is exceeded for 1% of the measurement period.

v) L_{A10} - Noise level which is exceeded for 10% of the measurement period. The L_{A10} is often referred to as the average *maximum* noise level.

5 Background Noise

The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed.

6 Ambient Noise

Ambient noise of an environment: the all-encompassing sound associated with that environment, being a composite of sounds from many sources.

7 Vibration

The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related

8 Displacement

The change in position of an object, is a vector quantity. (Stress indicator).

9 Velocity

The rate of change of displacement, is a vector quantity. (Fatigue indicator).

10 Acceleration

The rate of change of velocity, is a vector quantity. (Indicator of force).

11 Frequency

The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.

12 Hertz

The unit of frequency or pitch of a sound. One hertz equals one cycle per second.

13 Peak Particle Velocity (PPV)

The greatest instantaneous particle velocity during a given time interval if measurements are made in 3-axis. The resultant Peak Particle Velocity (PPV) is the vector sum i.e. the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur.

14 Root Mean Square rms

The rms value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.

15 Vibration Dose Value VDV

The Vibration Dose Value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when the structure is occupied.

16 Peak

The peak is the maximum amplitude during a measurement period.

17 Peak to Peak P-P

The peak-to-peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.

18 Logarithmic Scale

Comparing frequency with large amplitude differences be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale, however a logarithmic scale shows prominent vibration components equally well at any amplitude.

19 Zero Crossing Frequency

Determining the apparent dominate frequency of a given sample can be achieved by using the Zero Crossing Frequency.

20 Primary Waves P Waves

Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

21 Secondary Waves S Waves

Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.

22 Rayleigh Waves R Waves

Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.

23 Accelerometer

A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs'.

24 Geophone

Geophones measure velocity by means of a magnetic core surrounded by an electrical coil. When the surface vibrates, the geophone housing moves however the coil stays stationary, thus the movement of the magnet in the coil causes an electrical current which is calibrated to velocity of vibration.

25 Filter

A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.

26 Short-term vibration

Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.

27 Long-term vibration

All types of vibration not covered by the definition of 'short-term vibration'

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Construction Noise and Vibration Impact Assessment

More Trains More Services - Croom Electrical Works

Prepared for: Transport for Tomorrow

Job Number: A301022.0167.01 v1.1f **| Date:** 11/08/2022

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	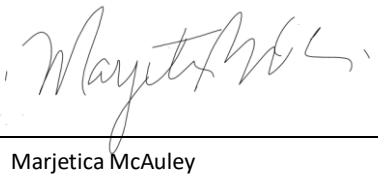	
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Contents

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Definitions

Some common terms and definitions are provided in the table below.

An **Acoustic Glossary** is provided in **Appendix I**.

Term / Abbreviation	Summary
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed
Attenuation	The reduction in the level of sound or vibration
CEMP	Construction Environmental Management Plan
CNVIA	Construction Noise and Vibration Impact Assessment
CNVMP	Construction Noise and Vibration Management Plan
Construction	Includes all work required to construct the More Trains More Services infrastructure, includes commissioning trials of equipment and temporary use of any part of the Project
dBA	Decibels using the A-weighted scale measured according to the frequency of the human ear
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DPIE	Department of Planning, Industry and Environment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
Environmental aspect	Defined by AS/NZS ISO 14001:2015 as an element of an organisation's activities, products or services that can interact with the environment
Environmental impact	Defined by AS/NZS ISO 14001:2015 as any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects
Environmental objective	Defined by AS/NZS ISO 14001:2015 as an overall environmental goal, consistent with the environmental policy, that an organisation sets itself to achieve
Environmental target	Defined by AS/NZS ISO 14001:2015 as a detailed performance requirement, applicable to the organisation or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives
EPA	NSW Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
ER	Environmental Representative
EPL	Environment Protection Licences under the POEO Act
Feasible and reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.

Term / Abbreviation	Summary
Heritage Item	A place, building, work, relic, archaeological site, tree, movable object or precinct of heritage significance that is listed under one or more of the following registers: the State Heritage Register under the Heritage Act 1977 (NSW), a state agency heritage and conservation register under section 170 of the Heritage Act 1977 (NSW), a Local Environmental Plan under the EP&A Act, the World, National or Commonwealth Heritage lists under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth), and an "Aboriginal object" or "Aboriginal place" as defined in section 5 of the National Parks and Wildlife Act 1974 (NSW)
Highly Noise Affected	As defined in the ICNG
Highly noise intensive works	Works which are defined as annoying under the ICNG, including: a) use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work; b) grinding metal, concrete or masonry; c) rock drilling; d) line drilling; e) vibratory rolling; f) bitumen milling or profiling; g) jackhammering, rock hammering or rock breaking; h) rail tamping and regulating; and i) impact piling.
ICNG	Interim Construction Noise Guideline (DECC, 2009)
$L_{Aeq,15\ min}$	The A-weighted equivalent continuous (energy average) sound pressure level of the construction works under consideration over a 15-minute period and excludes other noise sources such as from industry, road, rail and the community. Sometimes tabulated as Leq or dBA Leq.
MTMS	More Trains More Services
NPfI	Noise Policy for Industry (EPA, 2017)
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
Planning Secretary	Planning Secretary of the Department (or nominee, whether nominated before or after the date on which this approval was granted)
RBL	The Rating Background Level for each period is the medium value of the ABL (Assessment Background Level) values for the period over all of the days measured. There is therefore an RBL value for each period (day, evening and night)
Sensitive Land Uses	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres and passive recreation areas (including outdoor grounds used for teaching). Receivers that may be considered to be sensitive include commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, and retail spaces), and industrial premises as identified by the Planning Secretary Note: For the purpose of determining appropriate mitigation, a multi-storey residential flat building must not be counted as a single sensitive receiver.
SHR	State Heritage Register
Sleep Disturbance	Where the subject development / premises night-time L_{Amax} noise levels at a residential location exceed $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater
SPL SWL	Sound Pressure Level Sound Power Level
TfNSW	Transport for NSW
TfNSW CNVS	Transport for New South Wales Construction Noise and Vibration Strategy, Version 4.2 dated 23 April 2019, Program Management Office, Planning, Environment and Sustainability
TfT	Transport for Tomorrow
VML	Vibration Management Level

1 Introduction

1.1 Background

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for electrical upgrade works proposed to be undertaken within the rail corridor between the localities of Flinders and Croom.

The site is situated between approximately 1,700 m southeast of Oak Flats train station and 1,300 m northwest of Shellharbour Junction train station, the works are undertaken as part of the More Trains More Services South Works Program.

1.2 Project description

The More Trains More Services (MTMS) Program is a series of staged investments designed to progressively deliver service improvements across the network, as part of a broader transformation from a complex, constrained network, to a modern, simplified operation utilising world-class technology.

As part of the MTMS Program integrated infrastructure, fleet and operational changes will deliver service improvements on the T4 Eastern Suburbs & Illawarra (T4), T8 Airport & South (T8) and South Coast line.

The NSW Government is delivering the New Intercity Fleet (NIF) to replace the trains carrying customers from Sydney to the Central Coast, Newcastle, the Blue Mountains and the South Coast. Currently the majority of intercity trains operate as eight car trains however the NIF program would introduce 10-car trains.

The proposed electrical upgrades are required at the Croom site to support the operation of the NIF trains on the south coast.

1.3 Objectives

This Construction Noise and Vibration Impact Assessment (CNVIA) aims to achieve the following:

- Describe the proposed electrical works at Croom/Flinders
- Identify noise and vibration sensitive receivers adjacent to the proposals site location
  - Assign construction noise and vibration criteria
- Assess the potential noise and vibration impacts to the surrounding receivers within the community
- Establish and identify feasible and reasonable mitigation
- Establish project-specific mitigation measures per-receiver based on the predicted impact during each period of the proposed works schedule.

1.4 Proposed Works

The works proposed to be undertaken at the Croom location involve an anchor weight adjustment, and is proposed to be undertaken over a one-day period on one weekend rail possession during daytime and daytime out of hours.

The use of a telehandler would be utilised to move the anchor weight. The plant equipment would be delivered to the site via flat-bed delivery truck prior to site occupation.

1.5 Site location

The site is located on the boundary of the localities of Flinders and Croom within the Shellharbour LGA, and is situated along the rail corridor between approximately 1,700 m southeast of Oak Flats train station (ch.105.522 km) and 1,300 m northwest of Shellharbour Junction train station (ch. 108.887 km)

Figure 1 which follows provides an aerial overview of the site's location and anticipated alignment.

Figure 1 Site location, Croom and Flinders NSW

1.6 Guidelines and standards

In order to undertake the noise and vibration assessment required for TfT, local and international guidelines and standards were considered.

Relevant documents pertaining to the measurement, assessment, and management of noise and vibration in Australia are provided below in **Table 1**.

Table 1 Summary of relevant documents

Guideline / Standard	Published by	Relevance
AS 1055:2018 Acoustics – Description and measurement of environmental noise	Australian Standards	Measurement of noise
AS 2659.1-1998 Guide to the use of sound measuring equipment – Portable sound level meters	Australian Standards	Measurement of noise
AS 2436:2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites	Australian Standards	Management of Noise and Vibration on Construction Sites
AS/NZS 2107-2016: Acoustics - Recommended design sound levels and reverberation times for building interiors	Australian Standards	Internal sound level design for Management of Noise
Interim Construction Noise Guideline	Department of Climate Change, 2009	Management of Noise on Construction Sites
Noise Policy for Industry	Environment Protection Authority, 2017	Management of Industry Noise, measurement of noise
Transport for New South Wales Construction Noise and Vibration Strategy	Transport for New South Wales (TfNSW), 2019	Management of Noise and Vibration on Construction Sites
Road Noise Policy	Department of Energy, Climate Change and Water, 2011	Management of Road Traffic Noise, Construction Traffic, and Sleep Disturbance
Accessing Vibration: A Technical Guideline	Department of Conservation, 2006	Management of Vibration
BS 7385: Part 2-1993 Evaluation and measurement of vibration in buildings	British Standards	Management of Vibration
DIN4150-2016: Structural vibration Part 3: Effects of Vibration on Structures	German Standards	Management of Vibration

2 Existing Environment

The project's locality is considered Suburban/Urban as the nearby Princes Highway follows part of the works location and the receivers adjacent to the site.

The dominant ambient noise environment is considered to be natural fauna, road traffic noise from the nearby Princes Highway, rail traffic along the South Coast (SCO) rail line, and some ambient noise from nearby Albion Park Quarry industrial land use may be present within the area.

Background noise levels have been derived from AS1055.3:1997 *Acoustics – Description and measurement of environmental noise Part 3: Acquisition of data pertinent to land use*, reproduced from the TfNSW CNVS (2019) and presented below in **Table 2**.

Table 2 Typical background noise levels for different areas

Area type	Description	Rating Background Level (RBL)		
		Day	Evening	Night
Rural	Areas with negligible transportation	40	35	30
Suburban/Urban	Areas with low density transportation	45	40	35
Urban	Areas with medium density transportation OR some commerce or industry	50	45	40
Urban/Industrial	Areas with dense transportation OR with some commerce or industry	55	50	45

Note: AS1055:1997 is superseded and this table does not appear in the revised 2018 version of this Australian standard. Its use here is based on the TfNSW CNVS reproduction of this information for assessment purposes in lieu of noise monitoring or establishing of ambient noise levels for the purpose of establishing relevant construction noise management levels

Note: Day, Evening and Night-time as defined in the Noise Policy for Industry (NPfI)

2.1 Sensitive land uses

The project is surrounded by a diverse community of various sensitive receiver types and land uses. These include:

- Residential: villas, free standing houses, and townhouses
- Childcare Centre

The project is divided into two Noise Catchment Areas (NCAs), surrounding the project boundaries.

The NCA boundaries represent logical boundaries based on topography and the type of receivers applicable for that location.

An overview of the NCAs is provided below in **Table 3**, and an illustration is provided in **Figure 2**.

Table 3 Noise Catchment Area overview

NCA	Area type	Locality
NCA01	Suburban/Urban	Flinders – Predominately residential low-medium density, one child care centre is within this group of receivers
NCA02	Suburban/Urban	Croom – scattered residential, nearby Albion Park Quarry to the southwest

The category of the sensitive receivers is considered Suburban/Urban as their mixture is scattered throughout the landscape and not built-up in a medium or high-density setting.

Figure 2 below provide an overview of the surrounding sensitive receivers within the locality of Flinders and Croom.

A more detailed illustration of the proposed works and alignment location is provided in **Figure 1**.

2.1.1 Heritage

The project location does not pass through or is located near any known heritage or other sensitive structure.

Figure 2 Overview of Flinders and Croom sensitive receivers. Source: Nearmaps

3 Noise and Vibration Criteria

The EPA recommends management levels and goals when assessing the potential impacts of construction related noise and vibration.

Works under Transport for New South Wales reference relevant guidelines, policies, and standards tabulated in **Table 1** which provide the framework for management of noise and vibration from construction sites in New South Wales.

This section summarises the noise and vibration goals relevant to the construction works. The noise and vibration criteria varies over the different time periods defined throughout any one 24 hour period (generally more stringent criteria applies in more sensitive evening and night-time periods.

3.1 Airborne construction noise management levels

3.1.1 Residential receivers

Airborne construction noise which impacts residences and other sensitive land uses is assessed and managed through the Department of Environment and Climate Change Interim Construction Noise Guideline (2009).

Project Specific Noise Management Levels (NMLs) are established based on estimated noise level derived from the AS1055.3:1997 Standard, and the TfNSW CNVS Appendix B. The estimated background noise levels are considered conservative and are used for assessment purposes only.

Where noise levels are predicted (or measured) to exceed the NMLs, construction noise minimization practices are recommended to be investigated.

Table 4 below describes the noise management levels pertaining to residential receivers and how to apply them.

Table 4 Noise at residences using quantitative assessment (ICNG, 2009)

Time of Day	NML dB $L_{Aeq,15min}$	How to apply
Standard 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 $L_{Aeq(15\ minute)}$) is greater than the noise affect 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 level represents the point above which there may be a strong community reaction to noise. • Where noise is above the level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: o 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 o If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

The resulting Noise Management Levels (NMLs) for all residential noise-sensitive receivers is tabulated below in **Table 5**. These levels represent the noise levels in which projects potential impact, and subsequent noise monitoring (during works) is to be assessed against.

Table 5 Noise Management Level (dBA $L_{Aeq,15\ minute}$) for Residential Receivers

NCA	Area Usage	Standard	Out of Hours (RBL +5)			Sleep Disturbance
		Day	Day	Evening	Night-time	
NCA01	Suburban/Urban	55	50	45	40	n/a
NCA02	Suburban/Urban	55	50	45	40	n/a

Note: Sleep Disturbance screening is based on RBL+15 (refer to **Definitions**)
Note: NMLs based on TfNSW CNVS and AS1055 estimated noise levels

The works at Croom are not anticipated to be undertaken during the evening or night-time period. Assessment of sleep disturbance or awakening events is not applicable.

3.1.2 Other sensitive land uses and commercial receivers

The project is surrounded by a number of non-residential land uses. **Table 6** below outlines the NMLs for other sensitive receivers.

Table 6 Noise at sensitive land uses (other than residential) using quantitative assessment

Land use	Management level $L_{Aeq,15\ minute}$ (applicable when properties are in use)
Industrial Premises	External noise level 75 dBA
Offices, retail outlets and other commercial properties	External noise level 70 dBA
Classrooms at school and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community centres	Refer to the recommended 'maximum' internal levels outlined in AS2107 for specific uses

Other noise-sensitive receivers not defined in the ICNG require noise level criteria derived from AS 2107:2016.

The AS 2107 noise level criteria are generally provided as internal levels, and an internal-to-external correction of +10 dB has been applied to assume a conservative noise level with an open window for ventilation.

Table 7 NMLs for 'Other Sensitive Receivers' based on AS2107

Land use	Noise Management Level $L_{Aeq,15\ minute}$	
	Internal	External
Childcare Centre	60 dBA play area 40 dBA sleeping area	70 dBA play area 50 dBA sleeping area
Public Buildings	50 dBA	60 dBA
Café/Bar or Restaurant	50 dBA	60 dBA
Hotel	40 dBA	50 dBA

3.1.3 Maximum allowable Sound Power Levels

The Transport for New South Wales (TfNSW) Construction Noise and Vibration Strategy (CNVS) provides guidance's for the maximum allowable sound power levels from plant equipment. These noise levels are not used for assessment purposes, only when undertaking sound power level testing for plant equipment on site if necessary or as required.

All plant and equipment used on site during construction activities must be below or equal to the allowable noise levels to achieve compliance.

These guidelines are replicated below in **Table 8**.

Table 8 Maximum Allowable noise levels from plant equipment, TfNSW CNVS

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Asphalt – Truck & Sprayer		106	81
Backhoe		111	86
Chainsaw – petrol[4]	4-5hp	114	89
Compactor		106	81
Compressor		109	84
Crane – Fixed		113	88
Crane – Franna	20 tonne	98	73
Crane – Mobile		113	88
Crane – Truck mounted	20 to 60 tonne	108	83
Crusher – Rock[4]		118	93
Dozer	CAT D9	116	91
Dozer	CAT D10	121	96
Elevated work platform – scissor lift		98	73
Elevated work platform		97	77
Excavator – tracked	3 tonne	90	65
Excavator – tracked	6 tonne	95	70
As above + hydraulic hammer[4]		115	90
Excavator – tracked	10 tonne	100	75
As above + hydraulic hammer[4]		118	93
Excavator – tracked	20 tonne	105	80
Excavator – tracked	30 tonne	110	85
As above + hydraulic hammer[4]		122	97
Excavator – tracked	40 tonne	115	90
Grader		113	88
Generator – diesel/ petrol	6kW	103	78
Generator – attenuated	30kW	92	67
Grinder[4]		105	80
Jackhammer		113	88
Lighting Tower		80	55
Lighting – Daymakers		98	73
Light Vehicle – 4WD		103	78
Line Marking Truck		108	83
Loader – Front-end (wheeled)	23 tonne	112	87
Loader – Skidsteer	1/2 tonne	107	82

Equipment	Approximate size/ weight/ model	Highest Permissible Sound Power Level L_{eq} dBA [1,2,3]	Highest Permissible Sound Pressure Level L_{eq} dBA at 7 m
Loaders – Skidsteer	1 tonne	110	85
Loader – Tracked	0 to 50 kW	115	90
Loaders – Tracked	200 to 300 kW	121	96
Pavement Laying Machine		114	89
Pavement Profiler		117	92
Pile Driver – Vibratory[4]		121	96
Piling Rig – Bored		112	87
Piling Rig – Impact[4]		134	109
Pump – Concrete		109	84
Rattle gun (hand held)		104	79
Roller – smooth drum		107	82
Roller – large pad foot		109	84
Roller – Vibratory[4]	10 tonne	109	84
Saw – Concrete[4]		118	93
Scraper		113	88
Truck – Concrete		109	84
Truck – Dump	15 tonne	110	85
Truck – Medium rigid	20 tonne	103	78
Truck – road truck/ truck & dog	30 tonne	108	83
Truck – Vacuum (NDD or non-destructive digger)		109	84
Tub Grinder/Mulcher	40-50hp	116	91
Vibrator – Concrete[4]		113	88
Water Cart		107	82
Welding equipment		110	85
Wrench – Impact		111	86

Note 1 The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7 m) from the plant or equipment

Note 2: The SWLs presented in the above table have been compiled from a selection of field measurements conducted by Heggies Pty Ltd between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW, as well as various TfNSW Noise & Vibration impact assessments and the RMS Construction Noise & Vibration Guideline (August, 2016)

Note 3: Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites

Note 4: Equipment with special audible characteristics.

3.1.4 Construction related traffic

Some truck usage may be used to haul equipment to and from the site to facilitate the activities associated with the Program. Guidance for construction related traffic on TfNSW project is taken from the CNVS which outlines that:

"additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario".

Noise monitoring has not been undertaken, therefore the existing ambient traffic noise has not been established. To assess the potential impact of truck use, a screening assessment has been undertaken to determine if any potential impact to the sensitive receivers is likely.

Referring to **Table 9** below, screening noise levels for construction traffic have been established for the proposal where construction traffic is anticipated to be present on local roads.

Table 9 Target construction road traffic noise

Existing road category	Target noise level, dB	
	Day **07:00 hrs to 22:00 hrs**	**Night** **22:00 hrs to 07:00 hrs**
Local	$L_{Aeq,\ 1\ hour}$, 55 (external)	$L_{Aeq,\ 1\ hour}$, 50 (external)

Note: Works are not anticipated to be undertaken in the Night-time period

Should the road traffic noise levels increase by more than 2 dB due to construction traffic, additional mitigation options should be considered and investigated.

3.2 Construction vibration guidelines

Generally, construction which produces vibration may be grouped into three categories:

- Human Comfort – in which the occupants of a building are disturbed
- Building Contents – in which highly sensitive equipment or other machinery may be affected
- Structural or cosmetic damage – in which the integrity of the buildings structure may be compromised, or weak non-structural components may be damaged.

3.2.1 Effects of vibration on structures

The levels of vibration required to cause cosmetic damage to buildings is significantly higher than the vibration levels in which humans would find tolerable.

Damage caused as a result of vibration can occur due to short-term vibration (vibration which does not occur often enough to cause structural fatigue nor produce resonance) or long-term vibration (all other types of vibration).

Where the potential for structural damage may occur, dilapidation assessments may be necessary to be undertaken prior to and during, or following, construction.

Structural damage vibration guidelines are provided below, derived from British Standard BS 7385 for transient vibration.

3.2.1.1 Transient vibration

BS 7385 provides recommendations in vibration limitations regarding transient vibration. The limits outlined below in **Table 10** are conservative and are judged to give a minimum risk to which vibration may cause damage to buildings.

Table 10 Transient vibration, British Standard BS 7385-3: 1993

Type of Building	Peak component particle velocity (PPV) in frequency range of predominant pulse	
	4 Hz – 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
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: Values referred to are at the base of the building

3.2.1.2 Safe working distances

As a guide, minimum working distances for typical items of vibration intensive plant are listed below in **Table 11**. This data is provided by TfNSW's Construction Noise and Vibration Strategy (CNVS, v4.2 2019).

The minimum working distances are quoted for both cosmetic damage (BS 7385 and DIN4150) and human comfort (Assessing Vibration – A Technical Guideline).

The minimum working distances for cosmetic damage are recommended to be complied with at all times, unless otherwise approved by the relevant authority.

The distances provided in **Table 11** are indicative and would vary depending on the plant or item used for the works, as well as the geotechnical conditions within the surrounding earth.

Table 11 Recommended minimum working distances from vibration intensive plant (TfNSW CNS)

Plant Item	Approximate Size / Weight / Model	Minimum Distance for Cosmetic Damage (BS7385)	Minimum Distance for Human Response (DEC Assessing Vibration)	Heritage (DIN4150)
Vibratory Roller	1-2 tonne	5 m	15 – 20 m	11 m
	2-4 tonne	6 m	20 m	14 m
	4-6 tonne	12 m	40 m	27 m
	7-13 tonne	15 m	100 m	33 m
	13-18 tonne	20 m	100 m	44 m
	>18 tonne	25 m	100 m	55 m
Small Hydraulic Hammer	300 kg (5 to 12t excavator)	2 m	7 m	5 m
Medium Hydraulic Hammer	900 kg (12 to 18t excavator)	7 m	23 m	16 m
Large Hydraulic Hammer	1600 kg (18 to 34t excavator)	22 m	73 m	49 m
Pile Driver – Vibratory	Sheet piles	2 to 20 m	20 m	15 m
Piling Rig - Bored	≤ 800 mm	2 m (nominal)	N/A	6 m
Piling Rig – Hammer	12 t down force	15 m	50 m	45 m
Jackhammer	Hand held	1 m	Avoid contact with structure	3 m

Note: Distances are indicative only, where heavy machinery falls within safe working distances, attended vibration monitoring should be undertaken to confirm vibration levels

Note: Heritage safe working distances are conservative

Generally, vibration monitoring is recommended where construction works within these distances to particular sensitive structures are to occur. The monitoring would verify the minimum working distances at specific locations, which then may be applied to establish a buffer zone surrounding the proposed alignment.

Where the vibration monitoring demonstrates exceedances of the structural/cosmetic damage criteria (refer to **Section 3.2**), alternative construction methodology may be required, such as selection of equipment designed to produce less vibration (where feasible and reasonable).

In such case, construction works are not recommended to continue until attended vibration measurements confirm any risk of cosmetic damage, particularly to heritage structures and or other structures found to be structurally unsound by a qualified structural engineer.

3.2.1.3 Vibration screening

With the guideline values from BS7385 outlined in **Table 10**, conservative vibration damage screening levels per receiver type have been established based on the potentially worst-case scenario of any vibration intensive plant equipment being in use at any point along the works alignment within the rail corridor.

- Reinforced or framed structures: 25 mm/s
- Unreinforced or light framed structures: 7.5 mm/s.

At locations where the predicted and/or measured vibration levels are greater than those listed above, a more detailed condition assessment of the structure and the construction activities near the structure would be required to determine the applicable safe vibration level for that structure.

3.2.2 Human comfort

Construction activities which have the potential to create ground-borne vibrations may impact sensitive receivers near the project works. Humans are responsive to vibration and some discomfort may arise due to various activities, their intensity and duration.

Structural or cosmetic damage to buildings due to vibration only occur at extreme levels, relative to what humans find tolerable.

For human comfort and exposure to vibration, the NSW document *Assessing Vibration: A Technical Guideline* (DEC, 2006) provides the relevant guidance's derived from British Standards.

Table 12 below tabulates the Vibration Dose Values for human comfort. These values represent a guideline for the total accumulation of vibration energy during a 16 hour day-time period.

Table 12 Vibration Dose Values (VDV) for Intermittent Vibration ($m/s^{1.75}$)

Location	Period	Preferred value, VDV $m/s^{1.75}$	Maximum value VDV $m/s^{1.75}$
Critical areas	Day or Night	0.1	0.2
Residences	Day	0.2	0.4
	Night	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night	0.4	0.8
Workshops	Day or Night	0.8	1.6

Note: Daytime is 07:00 hrs to 22:00 hrs

Table 13 below reproduces the preferred and maximum weighted rms **α** acceleration vibration for continuous and impulsive vibration.

Table 13 Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2)

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y- axis	z-axis	x- and y-axis
Continuous Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night	0.020	0.014	0.040	0.028
Workshops	Day or night	0.04	0.029	0.080	0.058
Impulsive Vibration, m/s^2					
Critical areas	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.30	0.21	0.60	0.42
	Night	0.10	0.071	0.20	0.14
Offices, schools, educational institutions, and places of worship	Day or night	0.64	0.46	1.28	0.92
Workshops	Day or night	0.64	0.46	1.28	0.92

3.3 Ground-borne noise

Ground-borne noise impacts are generally caused by high-vibration intensive plant equipment such as tunneling machines. The ICNG provides guidance for the management of ground-borne noise (GNML), these recommendations are tabulated below in **Table 14** applicable only to residential receivers.

Table 14 Ground-borne noise management levels

Evening 18:00 hrs to 22:00 hrs	Night-time 22:00 hrs to 07:00 hrs
40 dB $L_{Aeq,15min}$	35 dB $L_{Aeq,15min}$

Note: During the Daytime period (07:00 hrs to 18:00 hrs), the human comfort vibration objectives only apply

The internal noise levels are to be assessed at the centre of the most-affected habitable room. For a limited number of discrete, ongoing ground-borne noise events, such as drilling or rock-hammering, the L_{Amax} noise descriptor using a slow response on the sound level meter may be better than the L_{Aeq} noise descriptor (15 min) in describing the noise impacts.

The level of mitigation of ground-borne noise would depend on the extent of impacts and also on the scale and duration of works. Any restriction on the days when construction work is allowed would take into account whether the community:

- Has identified times of day when they are more sensitive to noise (for example Sundays or public holidays)
- Is prepared to accept a longer construction duration in exchange for days of respite.

The proposed methodology along the alignment by Croom, or any other part of the Electrical Works MTMS program do not have any tunnelling machines or subjectively high-vibration intensive equipment.

4 Construction Noise and Vibration Impact Assessment

A range of small and large plant equipment is proposed to be utilised in order to undertake the appropriate constructions activities associated with the Project.

This section summarises the anticipated construction scenarios and associated predicted noise and vibration impacts. These are as follows:

- Noise impacts within the community
- Vibration impacts
  - Human comfort
  - Heritage or other sensitive structures.

4.1 Noise

4.1.1 Proposed activities

The proposed construction activities have been divided into 3 construction scenarios in which the works are anticipated to be completed in over one weekend railway possessions throughout June 2022 to June 2023.

The potential impacts associated with these key activities are assessed based on the type of work that is being carried out, and the time of day/week the works are scheduled to occur over.

Construction works are anticipated to be completed in various stages with the construction activities expected to be completed by mid 2023.

It is expected that the activities proposed may be required to work outside the standard daytime hours. The anticipated hours of works are as follows.

Monday to Friday Saturday	Daytime Standard Hours	07:00 hrs to 18:00 hrs 08:00 hrs to 13:00 hrs
Saturday	Daytime Out of Hours	07:00 hrs to 08:00 hrs 13:00 hrs to 18:00 hrs

Out of hours works and weekend rail Possessions are proposed for works which cannot reasonably be undertaken throughout the normal working-week. The works proposed at Croom do not include evening or night-time works.

An illustrative overview is provided below in **Table 15**.

Table 15 Periods of works, including out of hours

Hour Commencing	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Monday																								
Tuesday																								
Wednesday																								
Thursday	OOWH Period 2								Standard Hours										OOWH Period 1 (Evening)					
Friday																								
Saturday																								
Sunday									OOWH Period 1 (Day)										OOWH Period 2					
Public Holidays																								

Table 16 below provides a general outline of the construction scenarios and their corresponding activity.

Table 16 Work Scenarios for assessment purposes

Scenario ID	Scenario	Activity	Tentative Duration	Proposed Hours of Work				
				Day	Out of Hours Period 1		Out of Hours Period 2	
					Day	Evening	Evening	Night
SN.001	Site Establishment / Demobilisation	Typical Impact	One week and weekend possession June 2022 to June 2023	✓	✓	×	×	×
SN.002	Anchor Weight Adjustment	Typical Impact	One weekend possession June 2022 to June 2023	✓	✓	×	×	×
SN.003	Anchor Weight Adjustment	High Impact	One weekend possession June 2022 to June 2023	✓	✓	×	×	×

Note: Subject to change or alterations

4.2 Noise model

4.2.1 Calculation methodology

Noise levels have been predicted using 3D predictive software SoundPLAN ver8.2. The prediction model was undertaken using the Industrial Noise ISO 9613 algorithms.

Buildings and the local terrain have been digitised within the model to represent the land surrounding the Project's alignment boundaries.

Data was sourced from Geoscape building footprint database, NSW Spatial Services, and aerial imaging sourced via Nearmaps.

4.2.2 Source noise levels

The Sound Power Levels (SWL) for general and typical construction equipment is provided in **Table 17**. The levels tabulated below are derived from global standard databases.

Construction scenarios, locations, and proposed equipment were provided to us, and confirmed with the Construction manager and TfT prior to running the assessment. The percentage of on-time is based on standard practices and experience.

Table 17 Sound Power Levels (SWL) for the construction equipment

Scenario Number	Scenario Name	Description of Activity	Equipment	Number of Equipment	Percentage of on-time per 15 minutes	Resultant overall SWL L_{Aeq}	Scenario SWL L_{Aeq}
SN.001	Site Establishment / Demobilisation	Typical Impact	Hand Tools	1	33%	89	105
			Vehicle (light commercial)	1	33%	101	
			Delivery Truck	1	33%	103	
SN.002	Anchor Weight Adjustment	Typical Impact	Hand Tools	1	33%	89	102
			Vehicle (light commercial)	1	33%	101	
			Telehandler	1	67%	90	
SN.003	Anchor Weight Adjustment	High Impact	Telehandler	1	67%	90	106
			Hand Tools	1	67%	92	
			Truck	1	67%	105	

4.2.3 Results overview

The predicted noise levels are analysed in accordance with the policies, guidelines and standards outlined in **Table 1**, and are presented below.

The following tables and figures provide the maximum worst-case $L_{Aeq,15min}$ noise level predicted from the most impacted sensitive receiver for each NCA during all approved construction hour periods.

During most of the construction works, it is reasonable to expect that the noise levels would be lower than the predicted noise levels, as the noise model does not take into account any implemented mitigation measures.

4.2.3.1 Noise management level exceedances (project wide)

Table 18 summarises the number of residential receivers and other sensitive land use which are predicted to experience noise levels which exceed their relevant Noise Management Level, including receivers which would experience noise levels exceeding 75 dBA ($L_{Aeq,15min}$).

Table 18 Project wide overview of NML exceedances

Works Scenario	Number of Receivers exceeding relevant Noise Management Level			
	Number of Receivers	Standard Daytime		Out of Hours Period 1
		Day	HNA	Daytime
SN.001	1055	22	0	49
SN.002		20	0	27
SN.003		22	0	51

Note: HNA (Highly Noise Affected) only applies to residential receivers during standard hours
Note: NML Exceedances for residential land use is based on assumed background noise levels discussed in **Section 3.1**
Note: Daytime OOH include all receivers

4.2.3.2 Extent of NML exceedances

The results are broken down into four (4) subsets as follows:

NML	-	Noise levels 1 to 10 dB above NML (1 – 5 dB for out of hours)	
	-	Noise levels 11 to 20 dB above NML (5 – 15 dB for out of hours)	
	-	Noise levels 21 to 30 dB above NML (15 – 25 dB for out of hours)	
	-	Noise levels greater than 30 dB above NML (>25 dB for out of hours)	
>75 dBA	-	Highly Noise Affected, noise levels exceed 75 dBA ($L_{Aeq,15min}$) (Residential land use only)	

Note: The above color code is an arbitrary scheme and not designed to flag exceedances based on their range, rather a category highlight.

The extent and distribution of the NML exceedances are tabulated and illustrated below in **Table 19**.

Table 19 Distribution of NML exceedances

Scenario	Number of Receivers								
	Total	HNA >75 dBA	Distribution of NML exceedances						
			Day				Daytime Out of Hours		
			0 – 10 dB	10 – 20 dB	20 -30 dB	>30 dB	1 – 5 dB	5 – 15 dB	15 - 25 dB	>25 dB
SN.001	1055	0	17	-	-	-	15	19	-	41
SN.002			20	-	-	-	3	20	-	-
SN.003			16	3	-	-	18	16	3	-

Note: HNA refers to Highly Noise Affected, based on the ICNG definition
Note: All exceedances are considered conservative worst-case

A bar graph illustration of the above table is provided below in **Figure 3** and tabulates the spread of the exceedances across all work periods, and all receivers.

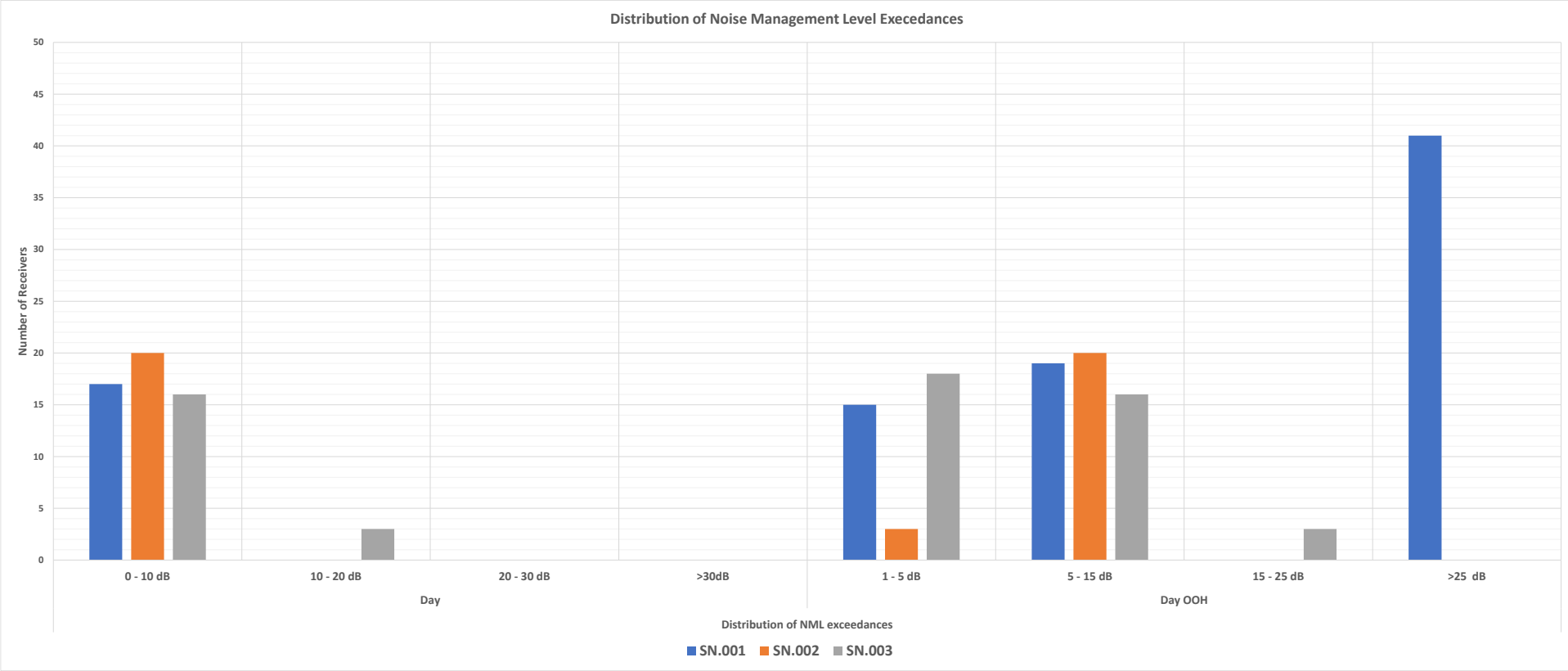

Figure 3 Extent of NML exceedances

Figure 4 below tabulates the number of receivers predicted to exceed their relevant NML during standard working hours.

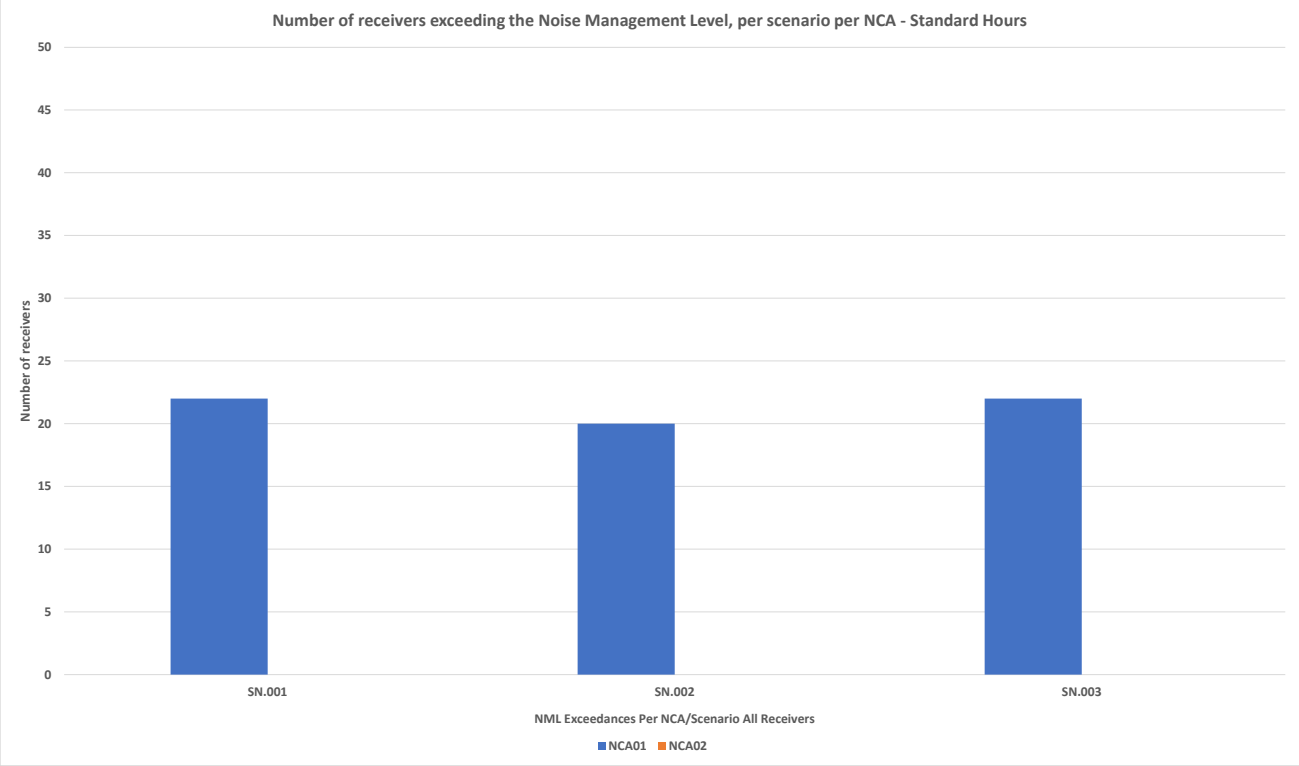

Figure 4 All sensitive receivers exceeding their relevant NML – standard hours

Figure 5 below tabulates day-time out of hours NML exceedances (all receivers).

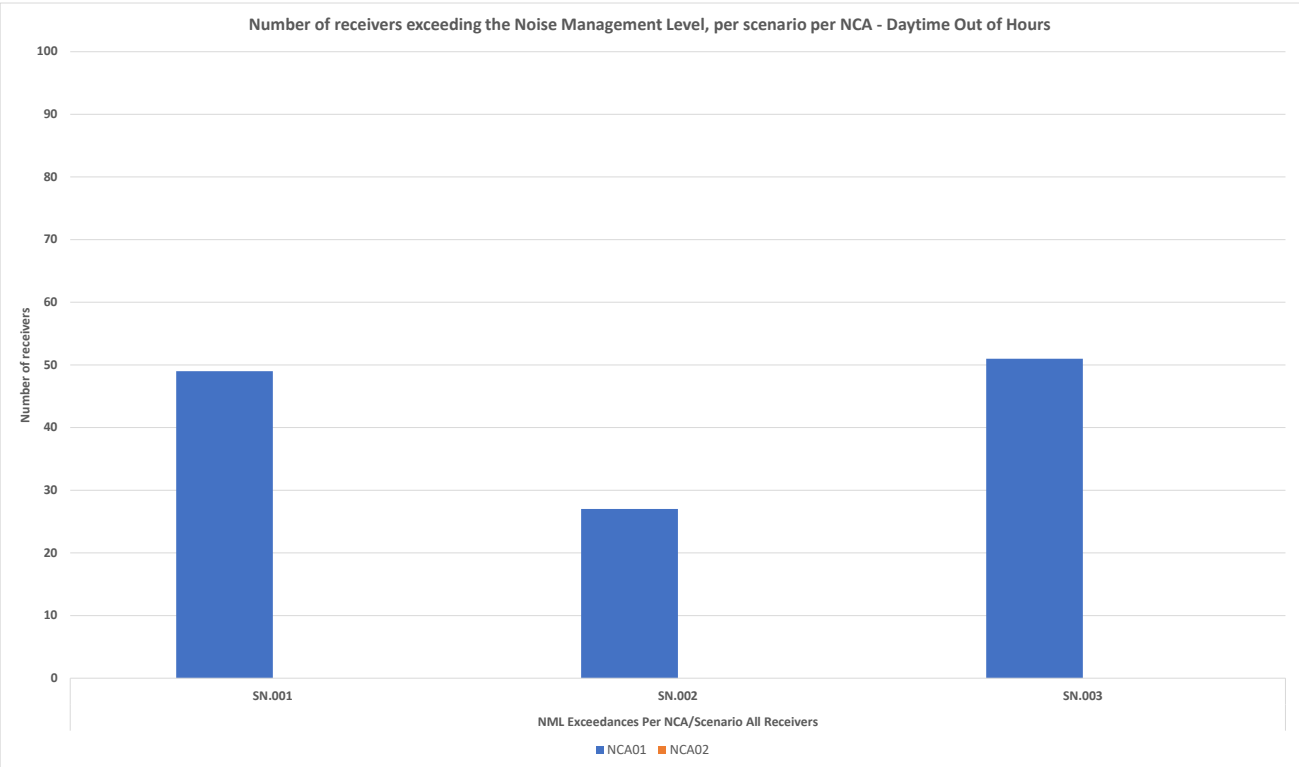

Figure 5 Receivers predicted to exceed their relevant NML during daytime OOH works

4.2.3.3 Highly Noise Affected

No residential land use properties are predicted to exceed the Highly Noise Affected criteria of noise levels exceeding 75 dBA $L_{eq,15min}$.

4.2.4 Worst-case average noise levels

This section provides a tabulated and illustrative overview of the noise models predicted worst-case scenario noise levels, project-wide.

Table 20 below presents the worst-case scenario noise level (dBA $L_{eq,15min}$) for each NCA per each scenario for residential receivers and one (1) childcare centre located within NCA01 during all periods of work.

Table 20 Residential worst-case noise level overview, per NCA per scenario

NCA / Scenario	Worst Case Predicted Noise Levels, dBA $L_{eq,15min}$		
	SN.001	SN.002	SN.003
Residential			
NCA01	65	63	67
NCA02	39	33	40
Child Care			
NCA01	42	38	42
NCA02	-	-	-

Figure 6 on the following page provides an overview of the per-receiver worst-case scenario maximum noise levels, dBA L_{eq},15min project wide.

Figure 6 Project-wide worst-case scenario noise levels dBA $L_{eq,15min}$

4.2.5 Discussion

The works are isolated to a short section of rail corridor approximately 130 – 145 m in length. Noise impacts are concentrated to residential receivers along this alignment, located along Whittaker Street and Bush Street. These properties shield residential receivers to the north and southeast.

The existing rail noise wall (assumed to be approximately 1.8 m in height) stretches south of Bush Street's residential premises, northbound to the rail corridor access point on College Avenue. The wall has some shield effect to the adjacent receivers, however the rail line appears to be elevated to some degree at the location the proposed works would be located.

4.2.5.1 NCA01 – Flinders

The proposed anchor weight adjustment works are not anticipated to have any meaningful impact. Some short-term noise impacts are anticipated at residential receivers within close proximity to the works in which the use of trucks and one (1) telehandler is proposed for use as a single location.

The predicted worst-case scenario noise levels are up to 67 dBA $L_{eq,15min}$ as residential receivers are in close proximity to the works. The noise is not anticipated to be prolonged, as telehandlers have a sound power level of approximately 92 dBA and are not noise intensive in nature.

The worst-case anticipated noise impacts would be due to the use of any truck haulage during the works where the use of trucks would be low frequency where plant equipment would be delivered to the site.

It is anticipated that the noise would decrease once the plant equipment has been successfully delivered, and the primary noise generating activity would be general telehandler use (SN.002 would be the likely noise levels on a worst-case basis for most of the works).

Upon completion of the anchor weight adjustment activities, the truck would remove the telehandler, temporary noise impacts as identified within this report (SN.003) would be likely for a short period of time as this plant equipment would be loaded onto the flatbed trucks, where SN.001 would then be the dominate activity.

4.2.5.2 NCA02 – Croom

No impacts are anticipated.

4.2.6 Construction Traffic

Construction related traffic enroute to the rail entrance via Pioneer Drive and College Avenue are anticipated to experience traffic noise levels of up to 63 dBA $L_{eq,1\ hour}$ during the daytime period, and, when traffic is utilizing the dirt road within the corridor the noise levels anticipated are up to 59 dBA $L_{eq,1\ hour}$ during the daytime period.

These noise levels would be experienced during the daytime period during the delivery of a single Telehandler plant equipment. No further traffic is anticipated along the route nor is an alternative route feasible. It is reasonable to conclude that a single truck arriving and departing up to 12 hours in time difference would not have any meaningful impact on the community.

The predicted worst-case noise levels however represent up to 8 dB above the RNP local road noise criteria of 55 dBA $L_{eq,1\ hour}$ (external). The nearby Princes Highway would contribute to the ambient noise environment and would likely have existing noise levels close to the predicted construction traffic noise levels.

There is no anticipated 2 dB screening level increase, and no impact is anticipated.

As works are only anticipated to be undertaken during a single day, an inclusive noise monitoring program may be implemented to confirm construction noise levels, and, construction traffic (if applicable).

4.3 Vibration

The safe working distances outlined in **Section 3.2.1.2** and presented in **Table 11** are considered to be stringently conservative for continuous vibration. Works within the safe working distances does not guarantee that any impact would occur, rather that consideration regarding methodology and potential impacts may be required.

The distances provided in **Table 11** are generally estimations for vibration intensive equipment such as rollers and piling equipment.

The works outlined within this assessment are not anticipated to include any vibration intensive plant within the rail corridor, no vibration impacts are anticipated to any adjacent receiver.

5 Environmental Mitigation Measures

5.1 Standard mitigation

The Transport for New South Wales CNVS provides a base framework for all feasible and reasonable noise management and mitigation practices.

The strategies outlined below in **Table 21** describe various work practices to minimise noise on work sites. These items summarise the most effective measures, designed to manage and lower noise impacts from construction works.

Table 21 Standard Mitigation Measures

Action Required	Applies to	Details
Management Measures		
Implementation of any project specific mitigation measurement required	Airborne Noise Ground-borne noise and vibration	In addition to the measures set out in this table, any project specific mitigation measures identified in the environmental assessment documentation (e.g. EA, REF, submissions or representations report) or approval or licence conditions must be implemented
Operation of plant equipment	Airborne Noise	All plant and equipment on site to be operated in a proper and efficient manner by an appropriately qualified and competent operator
Implement community consultation measures	Airborne Noise Ground-borne noise and vibration	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website • Project Infoline • Construction Response Line • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings and • Community Based Forums (if required by approval conditions)
Register of noise sensitive receivers	Airborne Noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan

Action Required	Applies to	Details
Construction Respite Periods	Airborne Noise Ground-borne noise and vibration	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site Inductions	Airborne Noise Ground-borne noise and vibration	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 high noise generating activities • 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	Airborne Noise	• No swearing or unnecessary shouting or loud stereos/radios; on site. • No dropping of materials from height; throwing of metal items; and slamming of doors. • No excessive revving of plant and vehicle engines • Controlled release of compressed air.
Monitoring	Airborne Noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.

Action Required	Applies to	Details
Attended vibration measurements	Ground-borne noise and vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances
Update Construction Environmental Management Plans	Airborne Noise Ground-borne noise and vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies
Building Condition Surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage
Source Controls		
Construction hours and scheduling	Airborne Noise Ground-borne noise and vibration	Where feasible and reasonable, construction would be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods
Construction respite periods	Airborne Noise Ground-borne noise and vibration	High noise and vibration generating activities may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block
Equipment selection	Airborne Noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	Airborne Noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in **Table 8**
Rental plant and equipment	Airborne Noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in **Table 8**
Plan worksites and activities to minimise noise and vibration	Airborne Noise Ground-borne noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site
Non-tonal reversing alarms	Airborne Noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work

Action Required	Applies to	Details
Minimise disturbance arising from delivery of goods to construction sites	Airborne Noise	• Loading and unloading of materials/deliveries is to occur as far as possible from NSRs • Select site access points and roads as far as possible away from NSRs • Dedicated loading/unloading areas to be shielded if close to NSRs • Delivery vehicles to be fitted with straps rather than chains for unloading, wherever feasible and reasonable
Use and siting of plant	Airborne Noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Construction related traffic	Airborne Noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on mobile plant	Airborne Noise	Where possible reduce noise from mobile plant through additional fittings including: • Residential grade mufflers • Damped hammers such as “City” Model • Rammer Hammers • Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Airborne Noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Airborne Noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘In-service test procedure’ and standard.

Action Required	Applies to	Details
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne Noise	Stationary noise sources would 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	Airborne Noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant

5.1.1 Additional noise mitigation measures

In accordance with the TfNSW CNVS, the implementation of standard mitigation measures, and compliance with maximum sound power levels for plant and equipment, construction hour management, and standard community consultation measures outlined within the CNVS should reduce the noise and any potential vibration impacts on nearby sensitive receivers.

The TfNSW CNVS provides guidance for Transport Projects where exceedances of the construction noise and vibration management levels are likely to, or are predicted to, occur. These measures are summarised from the CNVS and presented below in **Table 22**.

Table 22 Description of Additional Mitigation Measures

Measure	Description	Abbreviation
Periodic Notification	For each I&S project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the I&S Community Engagement Team in cases where AMM are not triggered as shown in **Table 23**, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the I&S Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended.	V

Measure	Description	Abbreviation
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	SN
Respite Offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre- purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all I&S projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative Construction Methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week, except where there is a Duration Respite. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6). Note; this management measure does not apply to OOHW Period 1 – Days.	RP
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all I&S projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with I&S Community Engagement Representatives.	DR

5.1.2 Applying additional mitigation measures

Additional Mitigation Measures (AMM) are recommended to be considered to offset impacts where the application of standard and project-specific mitigation measures (outlined in **Table 21**) are taken into consideration when assessing the potential noise and vibration impacts, however the relevant NMLs are still predicted to be exceeded.

Table 23 below tabulates the thresholds for each time period and range of noise above the predicted L_{eq} impact to the surrounding sensitive receivers.

Table 23 Additional Mitigation Measures

Construction Hours	Receiver perception	Predicted dBA (L_{eq}) above RBL		Predicted dBA (L_{eq}) above ANML		Additional management measures
		Range (dB)		Range (dB)		
Standard Hours Monday to Friday – 7 am to 6 pm Saturday – 8 am to 1 pm	Noticeable	5	10	0		-
	Clearly audible	>10	20	<10		-
	Moderately intrusive	>20	30	>10	20	PN, V
	Highly Intrusive	>30		>20		PN, V
	>75 dBA Leq	n/a		n/a		PN, V, SN
OOHW Period 1 Monday to Friday - 6 pm to 10 pm Saturday – 7 am to 8 am, 1 pm to 10 pm Sunday/PH – 8 am – 6 pm	Noticeable	5	10	<5		-
	Clearly audible	>10	20	>5	15	PN, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR
OOHW Period 2 Monday to Saturday – 12 am to 7 am, 10 pm to 12 am Sunday/PH – 12 am to 8am, 6 pm to 12 am	Noticeable	5	10	<5		PN
	Clearly audible	>10	20	>5	15	PN, V, SN, RO, RP, DR
	Moderately intrusive	>20	30	>15	25	PN, V, SN, RO, RP, DR
	Highly Intrusive	>30		>25		PN, V, SN, RO, RP, DR, AA

Notes PN = Project Notification SN = Specific Notification, Individual Briefings, or phone call
V = Verification Monitoring AA = Alternative Accommodation RP = Respite Period
DR = Duration Reduction RO = Project Specific Respite Offer

Additional notes to **Table 23** include the following:

- SWLs used for the purpose of estimating noise impact shall be increased by 5 dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics.
- Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 7 am-8 am and 1 pm-6 pm, Sundays / Public Holidays 8 am-6 pm)
- Respite offers during OOHW Period 2 are only applicable for evening periods (i.e. Sundays / Public Holidays 6 pm-10 pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

5.1.2.1 Overview of additional mitigation measures

Under the TfNSW CNVS, noise levels predicted to exceed the Airborne Noise Management Levels (ANML) require specific additional mitigation measures, summarised above in Section

The extent of the additional noise mitigations (AMM) is broken down per each scenario in the following figures during each assessed time period.

Figure 7 below illustrates an overview of the AMM per scenario during standard construction hours for all receivers impacted by the works.

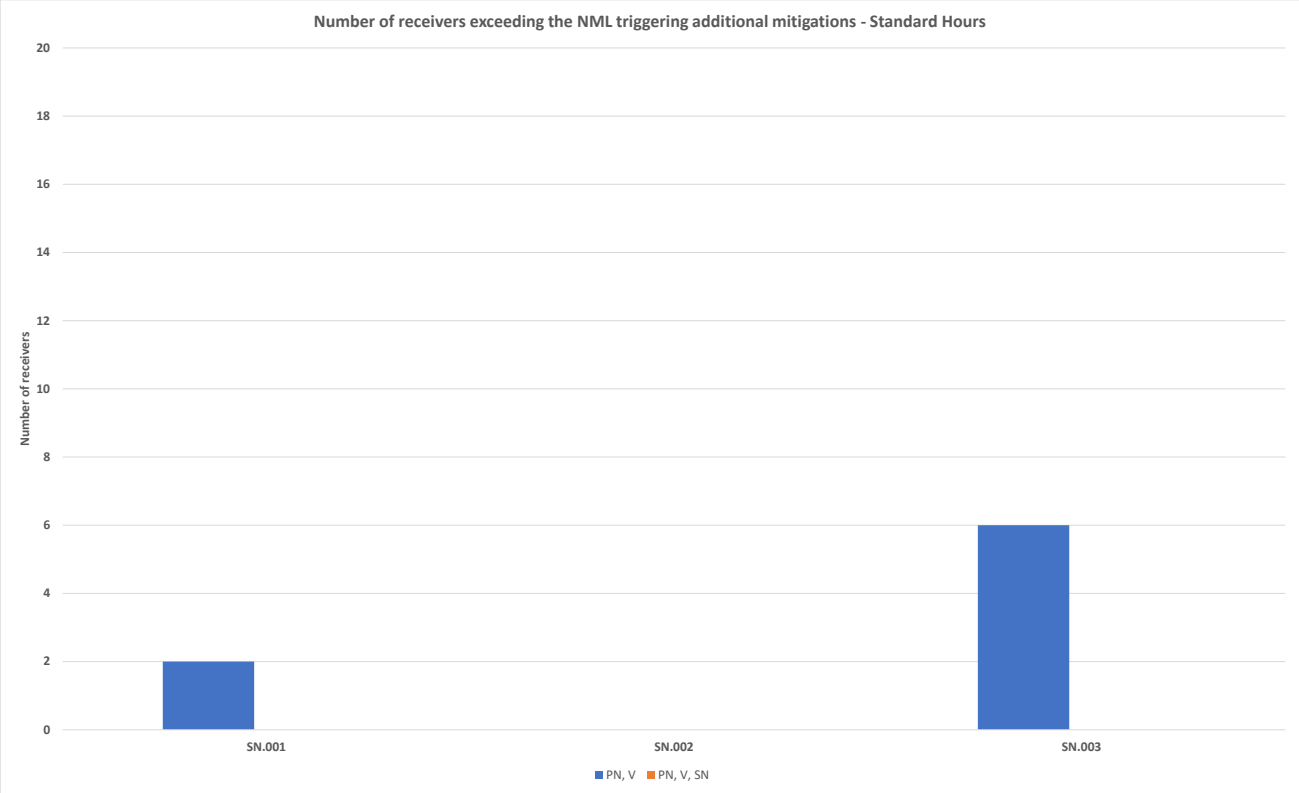

Figure 7 Additional mitigation – Standard Hours

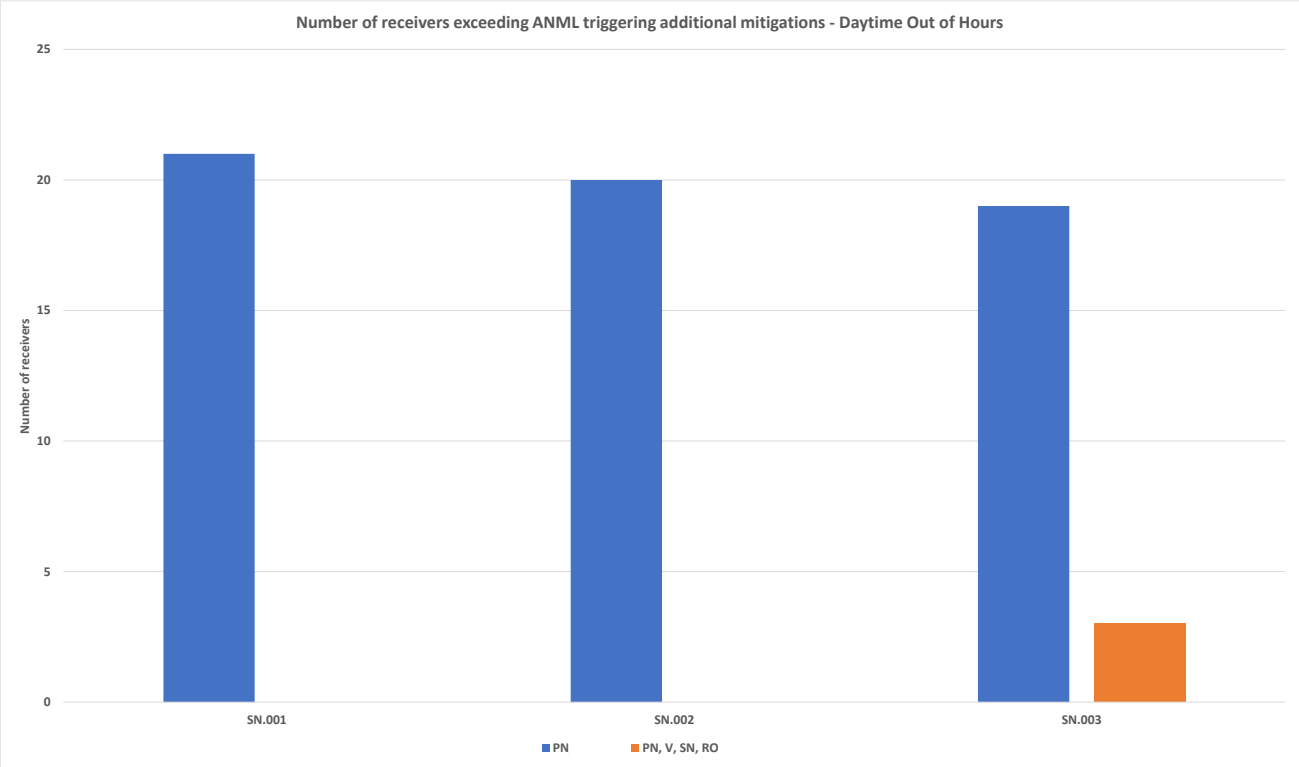

Figure 8 Additional mitigation (all receivers)– Daytime – Out of hours

5.1.2.2 Extent of additional mitigation measures

The following maps provide an illustrative overview of the extent of the necessary and required AMM.

Figure 9 Additional Noise Mitigation Measures, Daytime extent (all receivers)

Figure 10 Additional Noise Mitigation Measures, Daytime out of hours

5.2 Discussion

Most of the impacted noise sensitive receivers are in close proximity to the alignment where works would be undertaken.

The existing rail noise wall has some impact to shield the adjacent receivers, however the rail line is elevated above ground level which may have some plant equipment direct line-of-sight to some of the upper facades or floors of the adjacent receivers.

Generally, project notification and verification monitoring additional noise mitigation measure is triggered as out-of-hours daytime works is anticipated to be undertaken. While the proposed works are only expected to be undertaken within a single day, additional mitigation such as respite offer may not be necessarily feasible or reasonable given the short-duration of the works.

Three properties are triggered for Respite Offers (RO) during the most noise-intensive works (SN.003 anchor weight adjustment) and may not be necessary required as the works only trigger during truck use (where in use), and only trigger the mitigation measure by 2 dB (17 dB above NML – or 67 dBA $L_{eq,15min}$).

During this activity (telehandler being loaded onto the back of a flatbed truck), it's reasonably expected to be a short-term activity as the site is gradually shut-down and demobilization of all contractors and other vehicles and plant equipment would be carried out.

5.2.1 Recommendations

In accordance with the TfNSW CNVS, appropriate mitigation outlined in **Table 21** should be applied where feasible and reasonable. Additional recommendations are formulated as follows:

- Respite Offers triggered at the three identified properties considered based on feasibility and reasonableness for the works undertaken and the duration of the works, and, the realistic most reasonable time period in which that activity triggering RO occurs (truck use for removal of plant equipment)
- Undertake attended noise monitoring during the works where works are anticipated to be in close proximity to noise sensitive receivers along the rail corridor in Flinders (where feasible)
  - In the event that noise levels exceed those tabulated in this report:
    - Review of implemented mitigation (standard and project specific if relevant)
    - Review of sensitive-land use specific mitigation measures (if relevant)
    - Review of feasible and reasonable mitigation
  - Where noise levels do not exceed those tabulated in this report:
    - Apply the AMM mitigations tabulated in **Table 23**
- Vibration monitoring is not anticipated to be necessary

It would be anticipated that the application of feasible and reasonable noise and vibration management practices would lower the noise levels presented in this report; noise model analysis does not factor in barriers, hording, or other generic or standard mitigations with the exception of the existing rail noise wall, the assessment only assesses the worst-case noise levels at the most reasonably close distance to a sensitive receiver's most habitable room.

6 Conclusion

ADE Consulting Group Pty Ltd (ADE) was commissioned by Transport for Tomorrow (TfT, the 'Client') to undertake a Construction Noise and Vibration Impact Assessment (CNVIA) for electrical upgrade works proposed to be undertaken within the rail corridor between the localities of Flinders and Croom, approximately 1,700 m southeast of Oak Flats train station and 1,300 m northwest of Shellharbour Junction train station, the works are undertaken as part of the More Trains More Services South Works Program.

A 3D noise model was built in SoundPlan to assess the potential impacts of the construction on the nearby noise sensitive receivers. This assessment found the following:

- There are no residential receivers predicted to exceed ICNG defined Highly Noise Affected criteria of >75 dB $L_{Aeq,15min}$
- Mitigation measures in accordance with the TfNSW Construction Noise and Vibration Strategy are required for surrounding sensitive land uses where identified in this report
  - Predicted noise impacts on a conservative worst-case basis are anticipated to be up to 67 dBA $L_{eq,15min}$ or 17 dB above the NML
- Construction related traffic noise impacts are predicted to be up to 63 dBA $L_{eq,1\ hour}$, impacts are anticipated within the local communities however ambient noise monitoring has not been undertaken
  - The Princes Highway is in close proximity to the route and would likely contribute to the prevailing noise environment
  - Traffic is not anticipated to have any impact, however an inclusive noise monitoring program may be implemented for the works which includes verification monitoring and truck noise
- There are no vibration impacts anticipated due to the lack of vibration intensive plant, or length of duration of works and the time of day of works
  - Vibration monitoring is not anticipated to be necessary
  - There are no regenerated noise impacts anticipated
- Respite offers are triggered (by 2 dB) at three properties immediately adjacent to the works locations. The trigger is likely due to the use of a truck to load up the telehandler at the completion of the works. This activity is not realistically prolonged and would be a short-term noise event at the completion of the days activity, respite offers may not be a feasible, reasonable, or realistic mitigation option.

Additional recommendations are formulated:

- Noise monitoring is recommended where identified within this report to confirm noise levels predicted within the model per TfNSW AMM, and, to confirm construction traffic noise levels
  - No alternate traffic route is feasible or reasonable, no further recommendations are formulated as works are not anticipated to exceed one (1) day in duration
- In the event of noise or vibration complaints or adverse community comments or concerns:
  - Review of implemented mitigation (standard and project specific)
  - Review of sensitive-land use specific mitigation measures
  - Review of feasible and reasonable mitigation

Appendix I – Glossary

1 Sound Pressure Level

Defined as:

$$L_p = 10log_{10}\left(\frac{p^2}{p_{ref}^2}\right)dB$$

In the above equation, p is the sound pressure fluctuation relative to atmospheric pressure, and *pref* is 20 microPascals (2 x 10-5 Pa), the approximate threshold of hearing.

Sound or noise is the sensation produced at the ear by small fluctuations in atmospheric pressure. Human ears are sensitive to changes to sound pressure over a wide range, from 20 microPascals to 60 Pascals, in lieu of using a linear scale to represent this range, a logarithmic scale is adopted to better handle

2 Sound Power Level

Sound power level cannot be directly measured using a microphone, it does not change with distance and is not influenced by atmospheric conditions. The sound power level refers to the total energy of the sound, and is reference to 1 Pico Watt.

3 Weighting and Loudness

The overall level of a sound is usually expressed as dB(A) and not dB. Weighting refers to the human ear's frequency response to sound. Typically, sound is measured with an A-weighted filter which reduces the significance of lower frequencies and very high frequencies, increasing the importance of mid-frequencies (500 Hz to 4 kHz), and being a good measure of the "loudness" of a sound.

A change of 1 to 2 dB(A) is difficult to detect, whilst a change of 3 to 5 dB(A) corresponds to a small but noticeable change. A 10 dB(A) change corresponds to a doubling or halving in apparent loudness.

4 Noise Metrics and Statistical Noise Levels

i) L_{Aeq} - The time averaged A-weighted sound pressure level for the interval, as defined in AS1005.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

ii) L_{Amin}/L_{Amax} - Minimum or Maximum A-weighted noise level detected during the measuring period. It refers to the minimum background noise detected or the maximum L*p* measured.

iii) L_{A90} - A-weighted noise level which is exceeded for 90% of the measuring period. It is usually used as the descriptor for background noise level during the measurement period.

iv) L_{A1} - Noise level which is exceeded for 1% of the measurement period.

v) L_{A10} - Noise level which is exceeded for 10% of the measurement period. The L_{A10} is often referred to as the average *maximum* noise level.

5 Background Noise

The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed.

6 Ambient Noise

Ambient noise of an environment: the all-encompassing sound associated with that environment, being a composite of sounds from many sources.

7 Vibration

The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related

8 Displacement

The change in position of an object, is a vector quantity. (Stress indicator).

9 Velocity

The rate of change of displacement, is a vector quantity. (Fatigue indicator).

10 Acceleration

The rate of change of velocity, is a vector quantity. (Indicator of force).

11 Frequency

The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.

12 Hertz

The unit of frequency or pitch of a sound. One hertz equals one cycle per second.

13 Peak Particle Velocity (PPV)

The greatest instantaneous particle velocity during a given time interval if measurements are made in 3-axis. The resultant Peak Particle Velocity (PPV) is the vector sum i.e. the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur.

14 Root Mean Square rms

The rms value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.

15 Vibration Dose Value VDV

The Vibration Dose Value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when the structure is occupied.

16 Peak

The peak is the maximum amplitude during a measurement period.

17 Peak to Peak P-P

The peak-to-peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.

18 Logarithmic Scale

Comparing frequency with large amplitude differences be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale, however a logarithmic scale shows prominent vibration components equally well at any amplitude.

19 Zero Crossing Frequency

Determining the apparent dominate frequency of a given sample can be achieved by using the Zero Crossing Frequency.

20 Primary Waves P Waves

Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

21 Secondary Waves S Waves

Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.

22 Rayleigh Waves R Waves

Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.

23 Accelerometer

A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs'.

24 Geophone

Geophones measure velocity by means of a magnetic core surrounded by an electrical coil. When the surface vibrates, the geophone housing moves however the coil stays stationary, thus the movement of the magnet in the coil causes an electrical current which is calibrated to velocity of vibration.

25 Filter

A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.

26 Short-term vibration

Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.

27 Long-term vibration

All types of vibration not covered by the definition of 'short-term vibration'

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