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NSW GOVERNMENT

M1 Pacific Motorway extension to Raymond Terrace

Environmental impact statement – Chapter 8: Noise and vibration

Transport for NSW | July 2021

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Contents

List of figures

List of tables

8. Noise and vibration

This chapter describes the potential noise and vibration impacts that may be generated by the construction and operation of the project and presents the approach to the management of these impacts.

The desired performance outcomes relating to noise and vibration, as outlined in the SEARs, are to:

- Minimise the adverse impacts of construction noise and vibration (including airborne noise, ground-borne noise and blasting) on acoustic amenity and the structural integrity of buildings and items including Aboriginal places and environmental heritage
- Manage increases in noise emissions affecting nearby properties and other sensitive receivers during operation of the project to protect the amenity and well-being of the community
- Manage increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project.

Table 8-1 outlines the SEARs that relate to noise and vibration and identifies where they are addressed in this EIS. The full assessment of noise and vibration impacts is provided in the Noise and Vibration Working Paper (**Appendix H**).

Table 8-1 SEARs (noise and vibration)

Secretary's requirement	Where addressed
2. Noise and Vibration – Amenity	
1. The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration.	Construction noise and vibration impacts are assessed in **Section 8.4**. Consideration of impacts to sensitive receivers including sleep disturbance during construction is detailed in **Section 8.4.3**. Operational road traffic noise is assessed in **Section 8.5**. The assessments were carried out in accordance with the relevant guidelines, as outlined in **Section 8.1**.
2. An assessment of construction noise and vibration impacts which must address:	
(a) the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant);	The nature of construction activities, including construction scenarios and construction work hours, is addressed in **Section 8.2.3**. Construction noise and vibration impacts are assessed in **Section 8.4**. For annoying characteristics, such as tonal or impulsive noise, penalties have been included in the source noise levels for plant and equipment, which are detailed in Appendix C of the Noise and Vibration Working Paper (**Appendix H**).
(b) the intensity and duration of noise and vibration impacts (both air and ground borne);	The intensity and duration of noise and vibration impacts (both air and ground borne) are assessed in **Section 8.4.3**, **Section 8.4.4** and **Section 8.4.6**. The proposed construction hours and program are detailed in **Section 8.2.3**.
(c) the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	The proposed construction hours and program is detailed in **Section 8.2.3**. The environmental management measures presented in **Section 8.6** recommend a Construction Noise Vibration Management Plan to be prepared, which would incorporate standard and additional mitigation measures from the relevant guidelines such as respite periods.

Secretary's requirement	Where addressed
(d) the potential for extended standard construction hours and/or works outside standard construction hours, including predicted levels, exceedances and number of potentially affected receivers and justification for the activity in terms of the Interim Construction Noise Guideline (DECCW, 2009);	The proposed construction hours and program, including extended construction hours and out-of-hours work, is detailed in **Section 8.2.3**. The impacts of the project during standard, extended, and out of hours work are assessed in **Section 8.4**.
(e) potential noise and vibration mitigation measures, including timing of implementation; and	Noise and vibration management measures, including timing of implementation, are provided in **Section 8.6**.
(f) a cumulative noise and vibration assessment inclusive of impacts from other major development projects preparing for or commencing construction in the vicinity of the proposal.	A cumulative assessment of road traffic noise has been carried out for the project. **Section 8.2.4** outlines the methodology used and results of the assessment are included in **Section 8.5.1** and **Section 8.5.2**. Further information on cumulative noise and vibration impacts is provided in **Chapter 23** (cumulative impacts) and Chapter 7 of the Noise and Vibration Working Paper (**Appendix H**).
3. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Blast impacts are assessed in **Section 8.4.7**. If required, blasting would be carried out in accordance with the guidelines outlined in **Section 8.1**.
3. Noise and Vibration – Structural	
1. The Proponent must assess construction and operation noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	The noise and vibration assessment has been carried out in accordance with the relevant guidelines, as outlined in **Section 8.1**. An assessment of vibration impacts from operational traffic is provided in **Section 8.5**. An assessment of construction vibration impacts to nearby buildings and structures is provided in **Section 8.4.6** The assessment included consideration of Aboriginal places and items of environmental heritage.
2. The Proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Blast impacts are assessed in **Section 8.4.7**. If required, blasting would be carried out in accordance with the guidelines outlined in **Section 8.1**.

8.1 Policy and planning setting

The following policies and documents were used to guide the development and implementation of the noise and vibration impact assessment:

- Construction noise and vibration:
  - Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime Services 2016b)
  - Interim Construction Noise Guideline (ICNG) (DECC 2009a)
  - Assessing Vibration: a technical guideline (DECC 2006)
  - British Standard BS 7385: Part 2-1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration (BSI 1993)
  - German Standard DIN 4150-3 (2016) Vibration in buildings – Part 3: Effects on structures (DIN 2016)
  - Australian Standard AS 2187.2-2006 Explosives – Storage and use – Part 2 Use of explosives (Australian Standard 2006)
  - Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (ANZECC 1990)
  - NSW Road Noise Policy (RNP) (DECCW 2011)
  - Noise Criteria Guideline (NCG) (Roads and Maritime Services 2015c)
  - Noise Policy for Industry (NSW Government 2017).
- Operational noise and vibration:
  - NSW RNP (DECCW 2011)
  - NCG (Roads and Maritime Services 2015c)
  - Application Notes – Noise Criteria Guideline (Roads and Maritime Services 2016c)
  - Noise Mitigation Guideline (NMG) (Roads and Maritime Services 2015d)
  - Noise Wall Design Guideline (Roads and Maritime Services 2016d)
  - At-Receiver Noise Treatment Guideline (Roads and Maritime Services 2017c)
  - Noise Model Validation Guideline (Roads and Maritime Services 2018c)
  - Environmental Noise Management Manual (ENMM) (RTA 2001)
  - Australian Standard AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors.

Further detail on the above legislation, policies and guidelines, and how they apply to the project, is provided in the Noise and Vibration Working Paper (**Appendix H**).

8.2 Assessment methodology

Assessment of the noise and vibration impacts involved the following key steps to identify project impacts during construction and operation:

- Identification of sensitive receivers and noise catchment areas (NCAs) (refer to **Section 8.2.1**)
- Noise monitoring to establish the existing background and ambient noise environment and to capture existing traffic noise levels (refer to **Section 8.2.2**)
- Identification of relevant criteria to inform the construction and operational noise and vibration assessments (refer to **Section 8.2.3** and **Section 8.2.4**)
- Noise modelling of construction and operational noise impacts (refer to **Section 8.2.3** and **Section 8.2.4**)
- Assessing the expected construction and operational noise and vibration impacts of the project (refer to **Section 8.4** and **Section 8.5**)
- Identification of noise management measures to address operational traffic noise impacts (refer to **Section 8.6**).

The detailed assessment methodology is provided in the Noise and Vibration Working Paper (**Appendix H**).

8.2.1 Study areas and noise catchment areas

To assess the noise and vibration impacts of the project, separate study areas were defined for construction and operation as shown on **Figure 8-1**.

The construction study area, for the assessment of construction noise and vibration, has been defined as 940 metres either side of the construction footprint. This represents the distance from construction work where construction noise would not adversely impact sensitive receivers.

The operational study area, for the assessment of operational traffic noise, has been defined as 600 metres either side of the project roads (measured from the centreline of the outermost traffic lanes). This study area was developed in accordance with the RNP and NCG.

Based on the study areas defined for the project, NCAs were established in order to categorise sensitive receivers into areas of similar acoustic environments. Noise sensitive receivers applicable to the project and the NCAs in which they have been grouped are identified and described in **Section 8.3.1**.

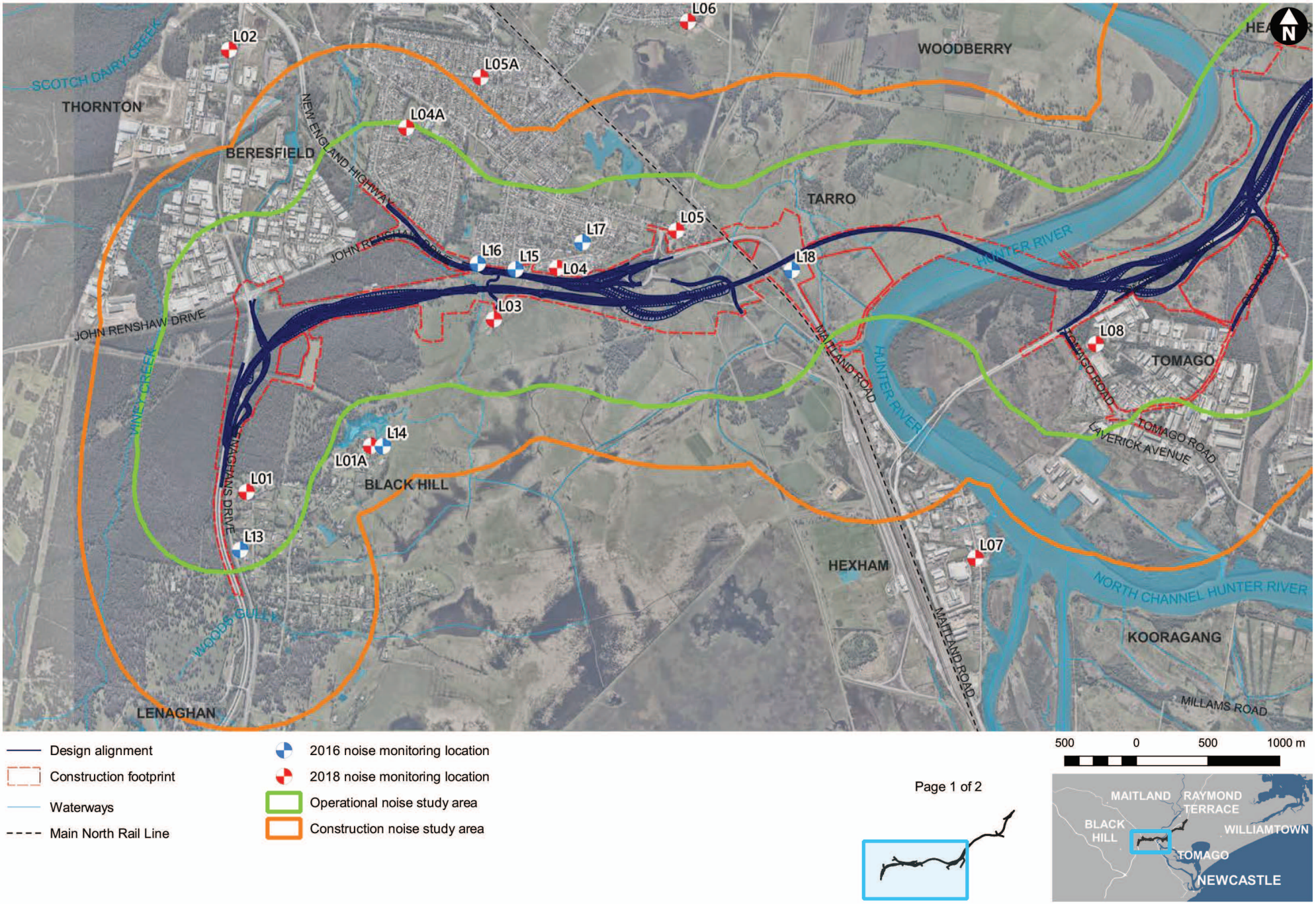

Figure 8-1 Study areas and noise monitoring locations (map 1 of 2)

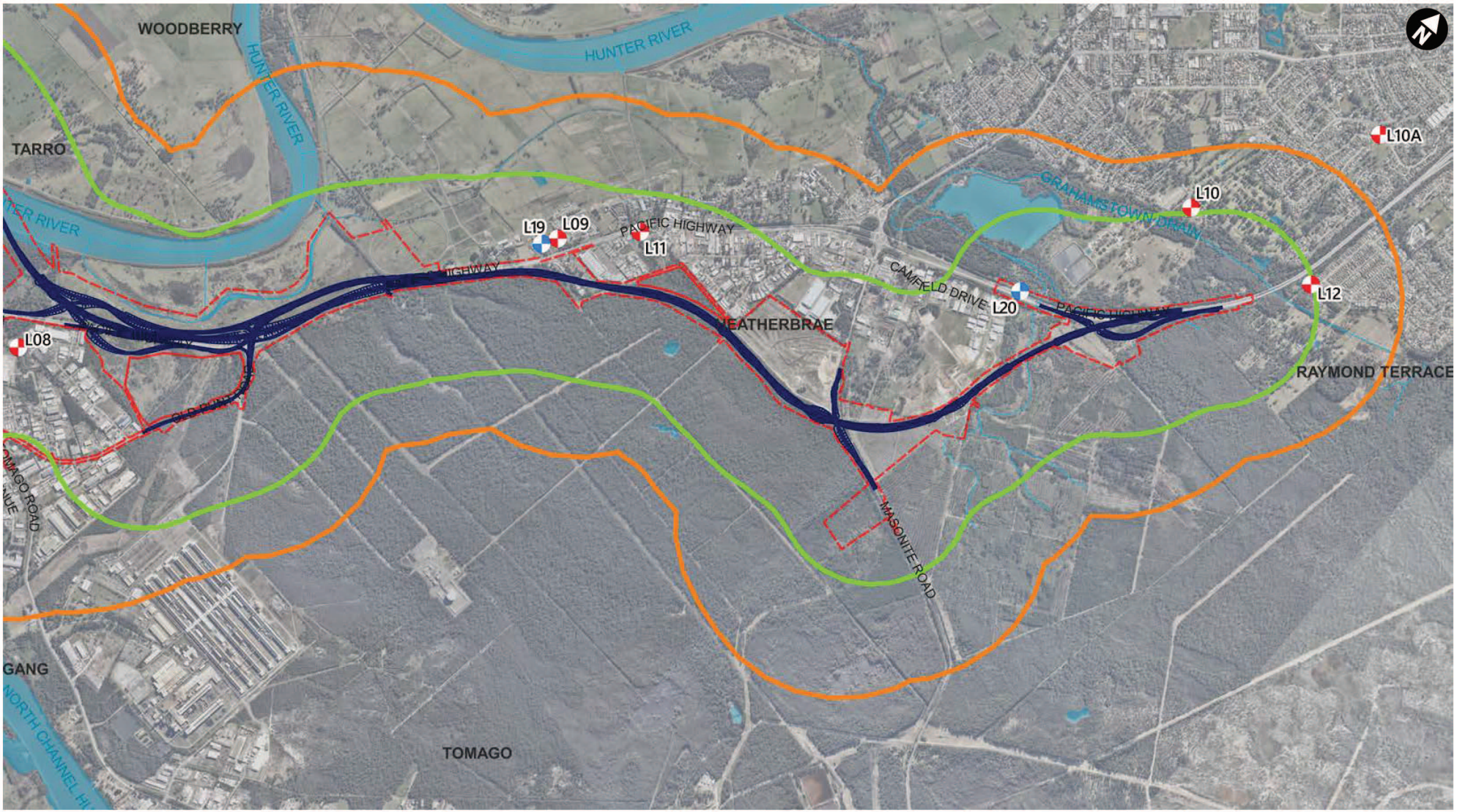

Figure 8-1 Study areas and noise monitoring locations (map 2 of 2)

8.2.2 Noise monitoring

To quantify the existing noise environment, noise monitoring was carried out in areas where receivers may potentially be affected by construction noise from the project. Noise monitoring was also carried out to determine the existing levels of road traffic noise along the project.

Long-term unattended noise monitoring was carried out at 11 locations within the construction study area between June and July 2018 to establish existing background and ambient noise levels. The long-term unattended background noise monitoring locations (L01 to L11) are shown on **Figure 8-1**.

In addition, long-term unattended noise monitoring of existing traffic noise levels was carried out in March 2016 at eight locations within the operational study area. Monitoring locations were selected based on their proximity to existing major roads to ensure that traffic noise was the main contributor to the noise levels measured. The 2016 data was included in the assessment given the Australian Government's travel restrictions in response to the declaration of the COVID-19 pandemic. The COVID-19 situation dramatically impacted traffic volumes, making it difficult to collect more recent traffic noise data for a "typical" period. Therefore, data from 2016 and 2018 was used to inform this assessment and is still considered representative of existing traffic and background noise levels respectively. The traffic noise monitoring locations (L13 to L20) are shown on **Figure 8-1**.

To determine correlations with the selected long-term measurement locations, short-term attended noise measurements were also collected concurrently with the long-term unattended noise monitoring. The short-term attended background noise measurement locations (L01A, L04A, L05A, L10A and L12) are shown on **Figure 8-1**.

Existing noise levels were measured in consistent 15-minute periods during the daytime, evening and night-time periods. Measurements affected by extraneous noise, wind (greater than five metres per second) or rain were excluded from the recorded data. The outcomes of noise monitoring carried out for the project are provided in **Section 8.3.2**.

8.2.3 Construction noise and vibration assessment methodology

Construction scenarios

To assess the likely impacts during project construction, 17 representative construction scenarios were developed. Construction scenarios for the assessment of noise impacts have been based on a 'realistic worst-case' scenario to determine the impacts from the noisiest 15-minute period that is likely to occur for each scenario, in accordance with the ICNG. The scenarios have been assessed as 'peak impact' or 'typical impact' work, where 'peak impact' work includes the use of noise intensive equipment like rock-breakers or concrete saws, and 'typical impact' work represents typical noise emissions from the project when noise intensive equipment is not in use. The 17 construction scenarios are shown in **Table 8-3**.

A full description of the construction activities comprising each construction scenarios is provided in the Noise and Vibration Working Paper (**Appendix H**).

Construction work hours

As described in **Section 5.4.13**, the standard hours for construction as noted in the ICNG are:

- Monday to Friday: 7am–6pm
- Saturday: 8am–1pm
- No work on Sunday or public holidays.

However, as the majority of construction work would be carried out away from residences and other sensitive receivers, extended construction work hours are proposed. Extended construction hours would reduce the volume of construction traffic on roads during peak hours, accelerate the construction program, reduce the longevity of impacts on receivers, and enable greater flexibility in project scheduling. The proposed extended construction work hours are:

- Monday to Friday: 6am–7pm
- Saturday: 7am–5pm
- Sunday and public holidays: 7am–5pm.

To ensure the health and safety of the public and construction crews, and to minimise disruption to existing traffic flows, some out-of-hours work would also be required during evening and night time periods, as described in **Section 5.4.13**. The activities that may need to be carried out during out-of-hours and relevant justifications, in accordance with the ICNG, are provided in **Table 8-2**.

Table 8-2 Justification for out-of-hours activities

Out-of-hours activity	Justification
Delivery of oversized plant and materials	Delivery of oversize and/or overmass equipment and materials to construction sites could occur after hours for safety reasons and to avoid disruptions and increase of heavy vehicles on the existing road network during peak volume. Such activities would be carried out in line with NSW Police, NSW Traffic Management Centre and Transport requirements.
Installation of traffic controls, such as concrete barriers	Some of these activities require works on or near major and local roads. As such, these activities would occur out-of-hours when traffic volumes are lower, to protect the health and safety of the public and construction crews and to minimise disruption to existing traffic flows. This work would be carried out in accordance with Transport for NSW and local council requirements. For utility works, where the utility authority only allows works to be carried out during a shutdown period, works would be coordinated with the utility authority and may occur out-of-hours.
Traffic switches between each construction phase	
Utility modifications, relocations or protection measures work	
Removal of existing static signage and installation of new signs	
Removal of existing traffic barriers and installation of temporary and permanent traffic barriers	
Removal of existing lane marking and application of new lane marking on existing roads	
Resurfacing of asphalt pavement on existing roads and concrete and asphalt pouring	
Operation of concrete and asphalt batching plants within ancillary facilities	Concrete and asphalt batching plants would be required to support out-of-hours works and project construction, particularly during construction of the viaduct.
Construction work interfacing with the M1 Pacific Motorway, New England Highway and the Pacific Highway, including construction of overbridge piers for the M1 Pacific Motorway entry and exit ramps and ramp tie-ins with the M1 Pacific Motorway, cross drainage below existing roads, pavement, surfacing, line markings, kerbs and traffic islands, traffic signs and signals	Completing or installing these items at night when traffic flows are low would minimise disruption to traffic and minimise any potential safety conflict between construction personnel and traffic. Such activities would be carried out in line with NSW Traffic Management Centre and Transport requirements.

Out-of-hours activity	Justification
Short-term traffic diversions along the existing road network (M1 Pacific Motorway, New England Highway, John Renshaw Drive, Masonite Road, and the Pacific Highway)	
Bridge construction work over the Main North Rail Line and existing roads including the New England Highway, Pacific Highway and Old Punt Road (including establishing temporary protection work, installation of girders, sealing of joints, establishing temporary screens to enable construction to continue on the deck, and removal of temporary work)	For bridge construction that can be carried out offline of the existing road network, construction can be carried out during normal working hours. Where bridge construction is required over the existing road network, activities would be carried out as out-of-hours work to ensure health and safety of public and construction workers, and to minimise disruption to motorists. Where bridge construction is required over the existing rail network, activities would be carried out during a rail shutdown, coordinated with the rail authority, and would require out-of-hours work. For the bridge over Hunter Region Botanic Gardens access road (B09), the access road would need to be closed for lifting of the girders. As the Hunter Region Botanic Gardens is only open during normal working hours, there is not expected to be any issues with closing the road out-of-hours. Any closures would be managed in consultation with Hunter Region Botanic Gardens.
Any work that does not cause noise emissions to be audible at any sensitive receiver	In locations where sensitive receivers are not susceptible to noise emissions, out-of-hours work would result in schedule benefits, flexibility in regard to programming of work around the various constraints of the project, such as capitalising on dry periods and thereby maximising construction on the flood plain, and reducing the impact to the existing road network by carrying out additional work during out-of-hours.
Emergency work to avoid the loss of lives, property and/or to prevent environmental harm.	To protect the health and safety of the public and construction crews any emergency work would be carried immediately which may include out-of-hours.

As outlined in **Chapter 5**, construction of the project is expected to start in 2023 with completion expected in 2028. Based on the proposed construction scenarios, construction work hours (standard, extended and out-of-hours) and construction program, indicative details of the construction work are presented in **Table 8-3**. In accordance with **Table 8-2**, out of hours work may also be carried out where that work does not cause noise emissions to be audible at any sensitive receiver. The indicative construction program based on the construction scenarios is presented in the Noise and Vibration Working Paper (**Appendix H**).

Table 8-3 Construction scenarios, indicative work durations and periods

ID	Scenario	Indicative duration (months)	Comments
1	Pre-construction and site establishment	20	Carried out during the day period and evening and night out of hours. Out of hours work includes infrequent Road Occupancy Licence (ROL) work for road connections
2	Ancillary facility (establishment)	13	As above
3	Ancillary facility (operation)	50	The operation of some ancillary facilities would be carried out during the day period and would also include evening and night out of hours work.

ID	Scenario	Indicative duration (months)	Comments
4	Batch plant operation	7	As above
5	Clearing, grubbing and demolition	21	Typically carried out during day period*, however some infrequent evening and night out of hours work would be required for work associated with the existing road network.
6	Utility work	40	Carried out during the day period with evening and night out of hours work limited to utility work associated with the existing road network and shutdowns for work on operational assets
7	Bulk earthwork (cuttings)	10	Typically carried out during day period
8	Blasting	10	Carried out during day period
9	Bulk earthwork (fill)	40	Typically carried out during day period
10	Concrete pavement (including pavement drainage)	24	Carried out during the day period with evening and night out of hours work limited to tie-in to existing road network or infrequent out of hours work periods for extended concrete pours
11	Asphalt pavement (including pavement drainage)	28	Carried out during the day period with evening and night out of hours work limited to widening and tie-in to existing road network or infrequent out of hours work periods for extended asphalt laying
12	Bridge work (excluding piling)	26	Carried out during the day period with evening and night out of hours work required for extended concrete pours, work near existing road and rail network, and where the work does not cause noise emissions to be audible at sensitive receivers.
13	Piling for bridges and bridge approaches	23	Carried out during the day period with evening and night out of hours work limited to work on existing road network
14	Roadside furniture and finishing work	28	Carried out during the day period with evening and night out of hours work limited to where work are required to be carried out on existing road network
15	Traffic management and control	26	Traffic management and control for all day period and out of hours work on existing road network
16	Landscaping	11	Typically carried out during day period
17	Cross drainage	17	Carried out during the day period with evening and night out of hours work limited to installation of cross drainage beneath the existing road network

* The ‘day period’ includes standard construction hours and daytime out-of-hours periods

Construction noise modelling

A noise model of the construction study area was used to predict noise levels from construction work to all surrounding receivers. Noise sources, receiver locations, buildings, structures and topographical features were digitised in the noise model to develop a three-dimensional representation of the construction study area and surrounding areas. The ICNG (DECC 2009a) is used to assess and manage impacts from construction noise on residences and 'other' sensitive land uses in NSW. The ICNG contains procedures for determining project specific noise management levels (NMLs) for sensitive receivers based on the existing background noise in the area.

Residential receivers

The NMLs for residential receivers, set in accordance with the ICNG are provided in **Table 8-4**. The NMLs are not mandatory limits, however where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions are to be investigated.

Construction noise impacts on residential receivers are assessed using these NMLs, set with reference to time of day and background noise (referred to as Rating Background Level (RBL)). NMLs developed for the project are provided in **Section 8.4.1**.

Table 8-4 Noise management levels for residential receivers in accordance with the ICNG

Time of day	NML
Recommended standard hours: • Monday to Friday: 7am–6pm • Saturday: 8am–1pm • No work on Sundays or public holidays	Noise affected: RBL + 10dB
	Highly noise affected: 75dB(A)
Outside recommended standard hours	Noise affected: RBL + 5dB

Non-residential receivers

NMLs for other noise-sensitive receiver locations located within the construction study area, including commercial and industrial premises, are provided in **Table 8-5**. These NMLs are absolute levels and are independent of the existing background and ambient noise environment, in accordance with the ICNG.

Table 8-5 NMLs at other noise sensitive land uses

Land use	NML
Classrooms at schools, and other educational institutions	Internal noise level 45 dB(A)[2]
Places of worship	Internal noise level 45 dB(A)[2]
Childcare centre	External noise level 50 dB(A)[6]
Active recreation areas (e.g. sports fields/activities which generate their own noise and are generally less sensitive to external noise)	External noise level 65 dB(A)
Passive recreation areas (e.g. area used for low intensity and low noise producing activities which could be impacted by external noise such as reading or meditation)	External noise level 60 dB(A)
Commercial premises (including offices and retail outlets)	External noise level 70 dB(A)[5]

Land use	NML
Industrial premises	External noise level 75 dB(A)[5]

1. NMLs apply when receiver areas are in use only
2. As per the ICNG and NPfI, it has been assumed that the difference between an internal noise level and the external noise level is 10 dB(A), assuming windows are open for adequate ventilation. An external NML would be defined on this basis.
3. Medical centres and similar are classified as commercial premises
4. Community centres have been assessed to an external noise level of 60 dB(A). Depending on the intended use of the centre, the noise management level may vary
5. The NML applies at the most affected occupied point on the premises
6. Specific criteria for childcare centres are not provided in the ICNG. The NML for childcare centres has been developed with consideration of Association of Australian Acoustical Consultants Guideline for Child Care Centre Acoustics Assessment (2013) and a conservative 10 dB(A) reduction from external to internal noise levels.

Sleep disturbance

A night-time sleep disturbance 'screening criterion' noise goal of the RBL +15 dB(A) is used to identify the receivers where there is potential for sleep disturbance. Where predicted maximum noise levels are above the screening level, more detailed analysis is required.

A sleep disturbance screening assessment has been carried out for the residential receivers within each NCA potentially impacted by the various construction scenarios and is provided in the Noise and Vibration Working Paper (**Appendix H**). Sleep disturbance impacts of the project are described in **Section 8.4.3**.

Construction road traffic noise

The construction road traffic noise calculations were carried out using the Calculation of Road Traffic Noise (CoRTN) (UK Department of Transport 1988) algorithms to predict the change in road traffic noise levels due to construction traffic.

Construction traffic movements along the proposed routes have been compared to the future traffic volumes during the peak construction period to determine if the additional traffic would increase noise levels by more than 2 dB(A) at residential receivers.

Where the predicted increase in traffic noise level is greater than 2 dB(A), further assessment is required using the NCG (Roads and Maritime Services 2015c), and all feasible and reasonable noise mitigation and management measures would be implemented. Where increases are 2 dB(A) or less then no further assessment is required.

When determining feasible and reasonable mitigation measures, consideration has been given to the actual noise levels associated with construction traffic and whether these levels comply with the following road traffic noise criteria from the RNP:

- 60 dB(A) $L_{Aeq(15\ hour)}$ day and 55 dB(A) $L_{Aeq(9\ hour)}$ night for freeway/arterial/sub-arterial roads
- 55 dB(A) $L_{Aeq(1\ hour)}$ day and 50 dB(A) $L_{Aeq(1\ hour)}$ night for local roads.

Ground-borne construction noise

Ground-borne or regenerated noise as a result of construction activities is usually associated with vibration generating equipment, such as rock hammers, operating near residential buildings.

Table 8-6 summarises the CNVG ground-borne construction noise objectives for residential receivers during the evening and night periods, which are consistent with the ICNG.

Table 8-6 Ground-borne noise objectives at residential premises

Period	Time	Internal $L_{Aeq(15\ minute)}$ ground-borne noise management level
Evening	6.00pm to 10.00pm	40 dB(A)
Night	10.00pm to 7.00am	35 dB(A)

Construction vibration

Construction vibration was assessed against three main types of impact:

- Disturbance to building occupants (human exposure)
- Potential damage to buildings (structural and cosmetic damage to buildings)
- Potential damage to buried utilities.

The CNVG provides recommended minimum working distances for typical vibration intensive plant and equipment, presented in **Table 8-7**. The minimum working distances are indicative only and potential vibration experienced by receivers would be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure.

Table 8-7 Recommended minimum working distances for vibration intensive plant and equipment

Plant item	Rating/activity description	Recommended minimum working distances		
		Cosmetic damage		Human response [3]
		Structurally sound [1] (e.g. residential & light commercial)	Structurally unsound [2] (e.g. unsound heritage structures)	
Vibratory roller	< 50kN (typically 1-2t)	5m	11m	15m to 20m
	< 100kN (typically 2-4t)	6m	13m	20m
	< 200kN (typically 4-6t)	12m	15m	40m
	< 300kN (typically 7-13t)	15m	31m	100m
	> 300kN (typically 13-18t)	20m	40m	100m
	> 300kN (typically > 18t)	25m	50m	100m
Small hydraulic hammer	300kg – 5 to 12t excavator	2m	5m	7m
Medium hydraulic hammer	900kg – 12 to 18t excavator	7m	15m	23m
Large hydraulic hammer	1600kg – 18 to 34t excavator	22m	30m[4]	73m

Plant item	Rating/activity description	Recommended minimum working distances		
		Cosmetic damage		Human response [3]
		Structurally sound [1] (e.g. residential & light commercial)	Structurally unsound [2] (e.g. unsound heritage structures)	
Vibratory pile driver	Sheet piles	2m to 20m	5m to 30m	20m to 50m
Pile boring	≤ 800mm	2m	5m	5m
Jackhammer	Handheld	1m	3m	5m
Blasting operations[4]		Based on charge size – see Note 4		

1. Referenced from either the CNVG or against the criteria in the British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2
2. Criteria referenced from DIN 4150-3:2016 Vibration in buildings – Effects on structures (including heritage items)
3. Referenced from either the CNVG or the criteria referenced in the EPA's Assessing Vibration: a technical guideline (December 2006)
4. To be determined during test blasts to establish appropriate propagation characteristics for the site and increase the accuracy of blasting predictions.

Human exposure

Generally, if vibration levels are maintained so that they do not disturb building occupants, there is limited potential for structural damage to buildings. Criteria for human exposure are therefore more stringent than those to prevent structural damage.

In accordance with 'Assessing Vibration; a technical guideline' (DECC 2006), vibration impacts have been assessed as either:

- Continuous: Continued interruption for a defined period
- Impulsive: A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration. It can also consist of a sudden application of several cycles at approximately the same amplitude, providing the duration is short
- Intermittent: interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude.

Further to the recommended minimum working distances for vibration intensive plant and equipment presented in **Table 8-7**, human exposure vibration impacts are assessed based on the type of building and the types of activities a building is designed for. The 'preferred' and 'maximum' vibration levels for maintaining human comfort in residences and other sensitive receivers for continuous, impulsive and intermittent vibration are provided in Section 3.5.1 of the Noise and Vibration Working Paper (**Appendix H**).

Structural and cosmetic damage to buildings and heritage items

Potential structural damage of buildings by vibration is typically managed by ensuring vibration impacting the structure does not exceed certain limits and standards. As outlined in the CNVG, guidance for cosmetic damage of structures is provided in the British Standard BS 7385: Part 2, while German Standard DIN 4150-3 has criteria of particular reference for heritage structures. There is no current Australian Standard for assessing structural building damage caused by vibration.

Heritage items are considered on a case by case basis, and care should be taken as these structures can be difficult to repair in the case of damage. Where a structure is found to have defects, or is structurally unsound following an inspection, maximum vibration criteria are to be established for that specific structure for construction work to not further damage the structure.

The recommended minimum working distances for vibration intensive plant and equipment provided in **Table 8-7** have been developed with consideration of the guidance provided in BS 7385 and DIN 4150-3 and have been used to assess the potential impacts of the project on structural and cosmetic damage (refer to **Section 8.4.6**). Vibratory guideline values for structural and cosmetic damage are further outlined in the Noise and Vibration Working Paper (**Appendix H**).

Damage to utilities

Section 5.3 of DIN 4150: Part 3 sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. As part of detailed design, these vibration limits will be considered to minimise damage to any buried utilities potentially impacted by the construction work.

Recommended vibration goals for electrical cables and telecommunication utilities such as fibre optic cables range from 50mm/s to 100mm/s. Although cables may sustain these vibration levels, the utilities they are connected to, such as transformers and switch blocks, may not. If such equipment is encountered during the construction process, an individual vibration assessment will be carried out addressing impact on the utility, and consultation with the utility provider, to confirm specific vibration requirements.

Blasting

Australian Standard AS 2187.2-2006 Explosives – Storage and use – Part 2 Use of explosives has been adopted to assess overpressure and vibration impacts from blasting during construction. **Table 8-8** provides the recommended airblast limits for human comfort and damage to structures, as outlined in AS 2187.2-2006. **Table 8-9**, also reproduced from AS 2187.2-2006, provides the ground vibration limits for human comfort and damage to structures.

Table 8-8 Recommended airblast limits for human comfort and structural damage

Category	Type of blasting operations	Peak sound pressure level, dBL
Recommended airblast limits for human comfort (Table J5.4(A), AS 2187.2)		
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	115 dBL for 95 per cent blasts per year. 120 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Sensitive site[1]	Operations lasting for less than 12 months or less than 20 blasts	120 dBL for 95 per cent blasts. 125 dBL maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	125 dBL maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation
Recommended airblast limits for control of damage to structures (Table J5.4(B), AS 2187.2)		
Structures that include masonry, plaster and plasterboard in their construction and also unoccupied structures of reinforced concrete or steel construction	All blasting	133 dBL maximum unless agreement is reached with the owner that a higher limit may apply

Category	Type of blasting operations	Peak sound pressure level, dBL
Service structures, such as pipelines, powerlines and cables located above the ground	All blasting	Limit to be determined by structural design methodology

1. A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people
2. The recommendations in Table J5.4(A) and Table J5.4(B) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

Table 8-9 Ground vibration limits for human comfort

Category	Type of blasting operations	Peak component particle velocity, mm/s
Ground vibration limits for human comfort (Table J4.5(A), AS 2187.2)		
Sensitive site[1]	Operations lasting longer than 12 months or more than 20 blasts	5mm/s for 95 per cent blasts per year 10mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Sensitive site[1]	Operations lasting for less than 12 months or less than 20 blasts	10mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	25mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation
Ground vibration limits for control of damage to structures (Table J4.5(B), AS 2187.2)		
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction	All blasting	Frequency-dependent damage limit criteria Table J4.4.2.1
Unoccupied structures of reinforced concrete or steel construction	All blasting	100mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Service structures, such as pipelines, powerlines and cables	All blasting	Limit to be determined by structural design methodology

1. A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people
2. The recommendations in Table J4.5(A) are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions
3. The recommendations in Table J4.5(A) and Table J4.5(B) do not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations, which may necessitate taking additional measurements on the structure itself, to detect any magnification of ground vibrations that might occur within the structure. Particular attention should be given to the response of suspended floors.

For the assessment of vibration impact due to blasting on buried pipelines, the screening levels used to assess vibration impact from general construction activities on buried pipework (as outlined in DIN 4150-3) were adopted.

To assess the likelihood of damage to unsound heritage structures due to blasting, and in the absence of specific unsound structure limits or limits for structures with particular sensitivity to vibration impacts, the structural damage screening level from general construction vibration impacts on unsound heritage structures (as outlined in DIN4150-03) were adopted for vibration impacts due to blasting.

The potential blasting impacts of the project are assessed in **Section 8.4.7**.

8.2.4 Operational noise and vibration assessment methodology

Operational road traffic noise and vibration

As required by the RNP and NCG, operational traffic noise impacts were based on the following scenarios:

- 'No Build': the assessment scenario if the project were not to go ahead
- 'Build': the assessment scenario with the project constructed and operating.

The RNP and NCG require noise to be assessed at project opening and for a future design year, typically 10 years after opening. For this project, the opening year is 2028 and the design year is 2038.

Residences may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the project would influence traffic noise levels. The most stringent applicable criteria would be used in the assessment for each facade of the residence.

For assessment purposes, a receiver building has been defined as a residential or non-residential building that has noise sensitive areas potentially impacted by operational road traffic noise. An individual receiver building is considered as a single receiver for the purposes of this assessment. For example, one double-storey residential building is represented by one receiver building.

Transition zones

The project consists of both redeveloped roads and new roads. A road is 'redeveloped' where the proposed alignment is in an existing road corridor and the existing road is not substantially realigned. A road is classified as being 'new' if the alignment is in an undeveloped corridor (e.g. a bypass) or is substantially realigned from the existing road.

The NCG requires transition zones to be applied at the point where road categories change from new to redeveloped, or vice versa, to provide a smooth transition in noise criteria. As such, the project contains the 'new road', 'redeveloped road' and 'transition zone' noise categories. The location of new, redeveloped roads and transition zones applicable to the project, as described above, are shown in Appendix D of the Noise and Vibration Working Paper (**Appendix H**).

Traffic noise criteria for residential receivers

A summary of the applicable traffic noise criteria in accordance with the NCG for residential receivers is presented in **Table 8-10**.

Table 8-10 NCG criteria for residential receivers

Road category	Type of project / land use	Assessment criteria, dB(A)	
		Daytime (7am–10pm)	Night time (10pm–7am)
Freeway / arterial / sub-arterial roads	Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15\ hour)}$ 55 (external)	$L_{Aeq(9\ hour)}$ 50 (external)
	Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial road corridors	$L_{Aeq(15\ hour)}$ 60 (external)	$L_{Aeq(9\ hour)}$ 55 (external)
	Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a Transition Zone[1]	Between $L_{Aeq(15\ hour)}$ 55-60 (external)	Between $L_{Aeq(9\ hour)}$ 50-55 (external)
	Existing residences affected by increases in traffic noise of 12dB(A) or more from new freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15\ hour)}$ 42-55 (external)	Between $L_{Aeq(9\ hour)}$ 42-50 (external)
	Existing residences affected by increases in traffic noise of 12dB(A) or more from redevelopment of existing freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15\ hour)}$ 42-60 (external)	Between $L_{Aeq(9\ hour)}$ 42-55 (external)

1. The applicable noise criteria for a particular receiver would be dependent on its location relative to where the new road joins the redeveloped road (transition zone). Refer to Section 7.1 and Table 1 of the Transport for NSW 'Noise Criteria Guideline' for further information
2. The criteria at each facade are determined from the existing traffic noise level plus 12 dB(A)

Traffic noise criteria for non-residential receivers

A summary of the applicable traffic noise criteria for non-residential sensitive land uses receivers, in accordance with the NCG, is presented in **Table 8-11**. Further descriptions and considerations for each sensitive land use is provided in the Noise and Vibration Working Paper (**Appendix H**).

Table 8-11 NCG criteria for non-residential sensitive land uses

Existing sensitive land use	Assessment criteria, dB(A)	
	Daytime (7am–10pm)	Night time (10pm–7am)
School classrooms	$L_{Aeq(1\ hour)}$ 40 (internal) when in use	–
Places of worship	$L_{Aeq(1\ hour)}$ 40 (internal)	$L_{Aeq(1\ hour)}$ 40 (internal)
Open space (active use)	$L_{Aeq(15\ hour)}$ 60 (external) when in use	–
Open space (passive use)	$L_{Aeq(15\ hour)}$ 55 (external) when in use	–
Childcare facilities	Sleeping rooms LAeq(1 hour) 35 (internal) Indoor play areas LAeq(1 hour) 40 (internal) Outdoor lay areas LAeq(1 hour) 55 (external)	–

Maximum road traffic noise levels

Maximum noise levels generated by road traffic have the potential to cause disturbance to sleep. The purpose of a maximum noise level assessment is to determine where maximum noise levels are likely to change as a result of a project. Guidance for assessing maximum noise levels is provided in Practice Note iii of the ENMM (RTA 2001).

The assessment considers the extent to which the maximum noise levels for individual passing vehicles exceed the L_{Aeq} noise level for each hour of the night; where a maximum noise level event occurs when:

- L_{Amax} noise levels are greater than 65 dB(A)
- $L_{Amax} - L_{Aeq(1\ hour)} \geq 15$ dB(A).

Operational road traffic vibration

Vibration emissions from traffic travelling on roads typically occur where there are irregularities in the road surface (e.g. potholes). As the new and upgraded roads associated with the project would be designed and constructed to avoid road irregularities, operational ground-borne noise and tactile vibration impacts from operation traffic are not expected.

The potential for operational ground-borne noise and tactile vibration impacts on nearby sensitive receivers from traffic on project roads is presented in Appendix D of the Noise and Vibration Working Paper (**Appendix H**)). Vibration impacts from traffic travelling on the new and upgraded roads are considered negligible and are unlikely to result in ground-borne noise or tactile vibration impacts to sensitive receivers directly next to these roads, and as such, have not been assessed further.

Heritage buildings

There are no specific operational road traffic criteria for heritage buildings. The assessment of operational road traffic noise is based on the use of a receiver, rather than the classification of the receiver. For example, if a heritage building is used for residential purposes, then it is assessed as a residential receiver.

Therefore, heritage buildings identified in this study have been assessed accordingly for road traffic noise impacts based their use, where applicable.

Operational noise modelling

Operational road traffic noise impacts were assessed for the roads associated with the project. To conduct the road traffic noise assessment, a number of specific traffic scenarios were required to be modelled and compared. The assessment considers both the 'Build' (with the project) and 'No Build' (without the project) scenarios for the year of opening (assumed to be 2028) and 10 years after opening (2038) Descriptions of the scenarios modelled are provided in **Table 8-12**. Detailed noise modelling results for the scenarios and the assessment against the NCG requirements are provided in Appendix D of the Noise and Vibration Working Paper (**Appendix H**).

Table 8-12 Traffic noise modelling scenarios

Modelled scenario	Description
2028 Opening year	
'Do minimum 2028'	**'No Build'** opening year of the project but **WITHOUT** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.
'With project 2028'	**'Build'** opening year of the project **WITH** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.

Modelled scenario	Description
2038 Design year (10 years after opening)	
'Do minimum 2038'	**'No Build'** design year of the project but **WITHOUT** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.
'With project 2038'	**'Build'** design year of the project **WITH** the project constructed and operating, including other network enhancements unrelated to the project that may already be committed or recognised as likely to be committed.

Operational traffic noise mitigation

The NMG provides three triggers where a receiver may qualify for consideration of additional noise mitigation. These are:

- Trigger 1: the predicted 'Build' noise level exceeds the NCG controlling criterion and the noise level increase due to the project is greater than 2.0 dB(A)
- Trigger 2: the predicted 'Build' noise level is 5.0 dB(A) or more above the NCG controlling criterion and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project
- Trigger 3: the noise level contribution from the road project is acute (daytime $L_{Aeq\ (15hour)}$ 65 dB(A) or higher, or night-time $L_{Aeq\ (9hour)}$ 60 dB(A) or higher) even if noise levels are dominated by a non-project road.

Potential noise mitigation measures are identified for receivers that qualify for consideration of noise mitigation measures, in the order of preference, are as follows:

1. Quieter pavement surfaces
2. Noise mounds
3. Noise walls
4. At property treatments.

Operational traffic noise management measures, and their applicability to the project, are further discussed in **Section 8.5.2** and **Section 8.6**.

8.3 Existing environment

Most of the project traverses large open land spaces with minimal nearby residential receivers. Semi-rural residential receivers are located in the Black Hill area at the southern end of the project. In the Tarro area, suburban residential receivers, including a caravan park and other sensitive receivers, are located north of the New England Highway. Towards the northern end of the project, in Heatherbrae and Raymond Terrace, suburban residential receivers including caravan parks and motels are located to the west of the existing Pacific Highway. The suburban residential areas in Heatherbrae and Raymond Terrace are located at large distances (greater than 800 metres) from the project, where noise impacts are unlikely to be substantial.

Concentrated areas of commercial and industrial receivers are located in Beresfield, Tomago and Heatherbrae. In Heatherbrae the commercial and industrial receiver buildings provide a buffer between the project and the nearest residential receivers.

The existing acoustic environment surrounding the project varies, with the acoustic environment in the residential areas mostly influenced by noise from:

- Roads: Predominantly the major arterial roads and motorway including the M1 Pacific Motorway, John Renshaw Drive, New England Highway and the Pacific Highway
- Local transport activities: Especially in commercial and industrial areas, where the noise generated by these activities can contribute to higher ambient noise levels which locally mask road traffic noise.

8.3.1 Noise sensitive receivers and noise catchment areas

To assess noise and vibration impacts, the project has been divided into 19 NCAs (including sub-NCAs) which collectively make up the construction study area. The NCAs were selected to group noise sensitive receivers into areas with similar acoustic environments. Various receiver types and land uses are located within each NCA. A description of each NCA is provided in **Table 8-13**. The location of each NCA is shown on **Figure 8-2**.

Noise and vibration sensitive receivers within each NCA are generally separated into the following major categories:

- Residential receivers (including caravan parks)
- Other sensitive (non-residential) receivers, including:
  - Schools
  - Places of worship
  - Childcare centres
  - Active recreation areas (e.g. sports fields/activities which generate their own noise and are generally less sensitive to external noise)
  - Passive recreation areas (e.g. areas used for low intensity and low noise producing activities which have the potential to be impacted by external noise, such as reading or meditation).
- Commercial premises (including offices and retail outlets)
- Industrial premises.

All sensitive receivers within the construction and operation study areas, based on the above major categories, are identified in the Noise and Vibration Working Paper (**Appendix H**).

Table 8-13 Noise catchment areas

NCA	Description
NCA01A	Located in Black Hill, directly to the west and east of the M1 Pacific Motorway and the project. Rural residential receivers and a single non-residential receiver are located within this NCA. The noise environment is typically dominated by traffic noise from the M1 Pacific Motorway.
NCA01B	Located in Black Hill, east of the M1 Pacific Motorway and south of the project. Rural residential receivers are located within this NCA. The noise environment includes distant traffic noise from the M1 Pacific Motorway.
NCA02	Located in Beresfield, north of John Renshaw Drive and the project. Commercial and industrial receivers and a single non-residential receiver are located within this NCA. The noise environment includes general industrial noise and traffic noise from John Renshaw Drive.
NCA03	Located in Beresfield, north of John Renshaw Drive and the project. Commercial and industrial receivers are located within this NCA. The noise environment includes general industrial noise and traffic noise from the New England Highway.

NCA	Description
NCA04A	Located in Beresfield and Tarro, directly to the north of the New England Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. The noise environment is typically dominated by traffic noise from the New England Highway.
NCA04B	Located in Beresfield and Tarro, north of the New England Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. The noise environment includes distant traffic noise from the New England Highway.
NCA05A	Located in Tarro, directly to the north of the New England Highway and the project. Suburban residential receivers and some industrial receivers are located within this NCA. The noise environment includes traffic noise from the New England Highway.
NCA05B	Located in Beresfield and Tarro, north of the New England Highway and the project. Suburban residential receivers and seven non-residential receivers are located within this NCA. The noise environment includes distant traffic noise from the New England Highway.
NCA06	Located in Woodberry, north and west of the New England Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. The noise environment includes distant traffic noise from the New England Highway.
NCA07	Located in Black Hill and Tarro, directly south of the New England Highway and the project. Two rural residential receivers and some industrial receivers are located within this NCA. The noise environment is dominated by traffic noise from the New England Highway.
NCA08	Located in Hexham, directly west of the New England Highway, east of the Pacific Highway and south of the project. Four residential receivers and numerous commercial and industrial receivers are located within this NCA. The noise environment is dominated by general industrial noise and traffic noise from the New England Highway and Pacific Highway.
NCA09	Located in Tomago, directly south of the Pacific Highway and the project. One residential receiver and a caravan park are located within this NCA. The noise environment is dominated by nearby industrial noise and traffic noise from the Pacific Highway.
NCA10	Located in Tomago, southeast of the Pacific Highway and the project. Commercial and industrial receivers are located within this NCA. The noise environment includes general industrial noise and traffic noise from the Pacific Highway.
NCA11	Located in Tomago, east of the Pacific Highway and the project. One non-residential receiver is located within this NCA. The noise environment is typically dominated by traffic noise from the Pacific Highway.
NCA12	Located in Heatherbrae, directly east of the Pacific Highway and west of the project. Residential receivers and commercial and industrial receivers are located within this NCA. The noise environment is dominated by general industrial noise and traffic noise from the Pacific Highway.
NCA13	Located in Raymond Terrace, directly east and west of the Pacific Highway and at the northern end of the project. Residential receivers and commercial and industrial receivers are located within this NCA. The noise environment includes traffic noise from the Pacific Highway.
NCA14A	Located in Heatherbrae, directly west of the Pacific Highway and the project. Residential receivers, two non-residential receivers and commercial and industrial receivers are located within this NCA. The noise environment is typically dominated by traffic noise from the Pacific Highway.
NCA14B	Located in Raymond Terrace, northeast of the Pacific Highway and the project. Suburban residential receivers and two non-residential receivers are located within this NCA. The noise environment includes traffic noise from the Pacific Highway.
NCA14C	Located in Raymond Terrace, east and west of the Pacific Highway and at the northern end of the project. Suburban residential receivers and one non-residential receiver are located within this NCA. The noise environment is typically dominated by traffic noise from the Pacific Highway.

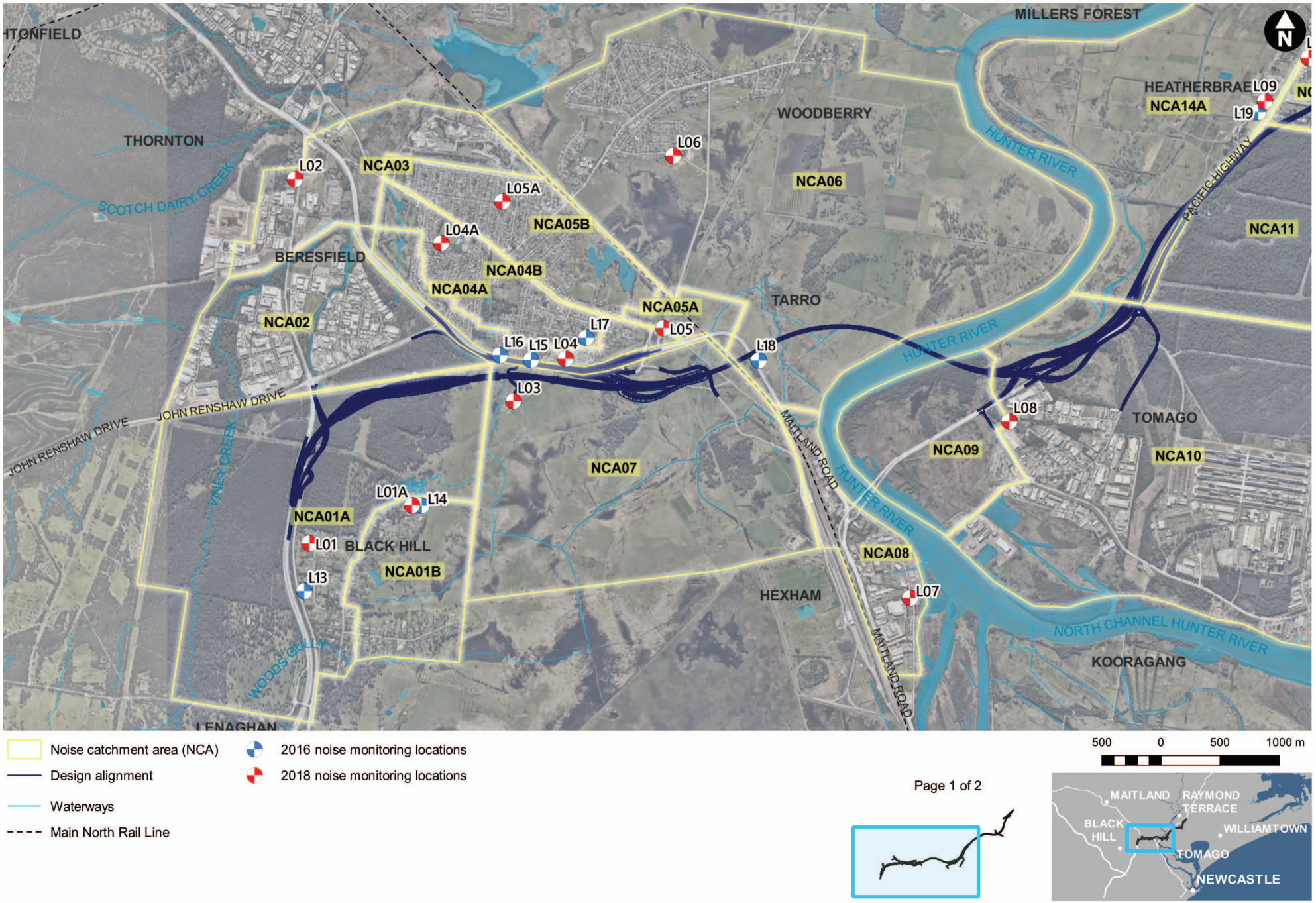

Figure 8-2 Noise catchment areas (map 1 of 2)

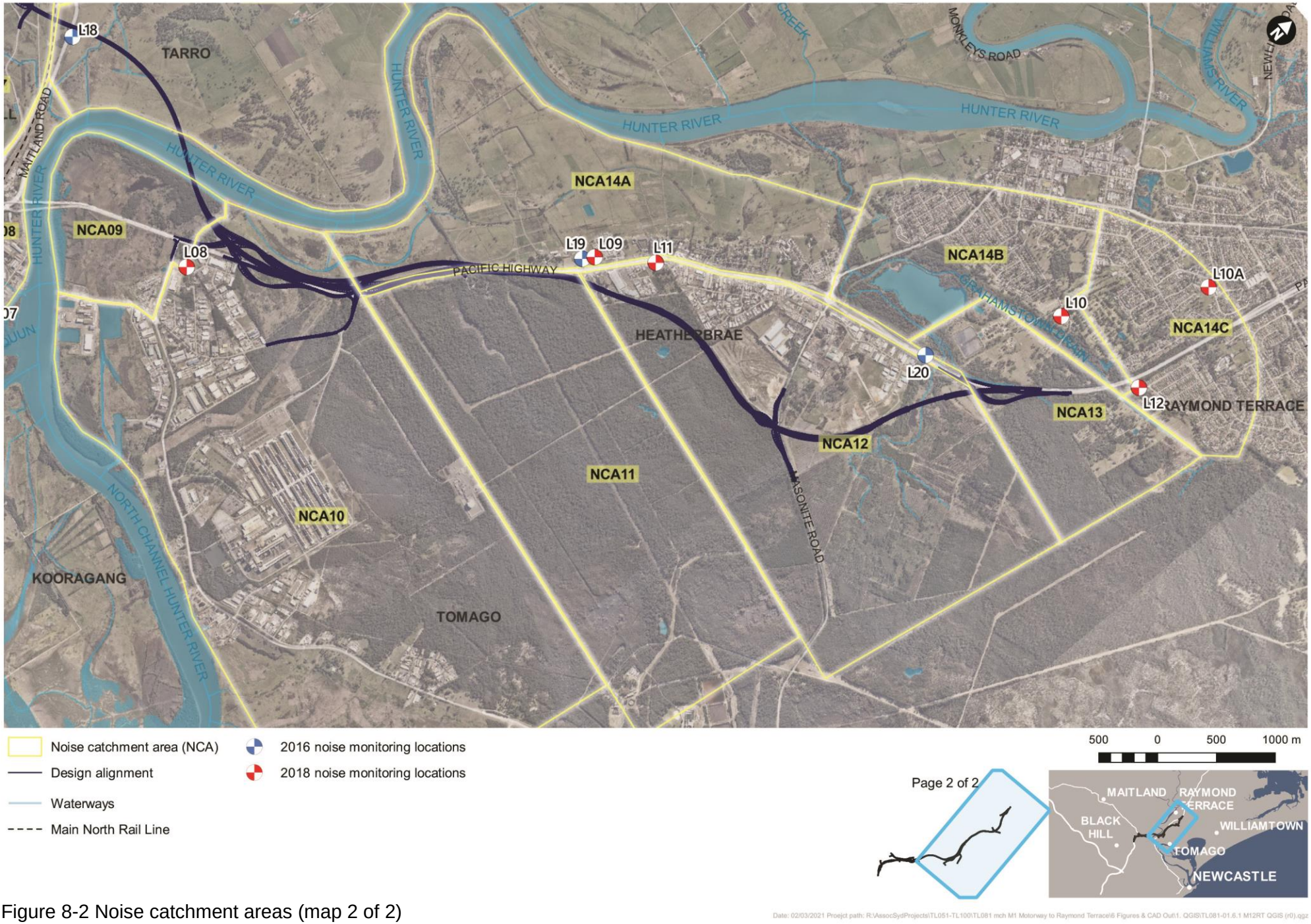

Figure 8-2 Noise catchment areas (map 2 of 2)

8.3.2 Existing noise levels

Existing background noise environment

As outlined in **Section 8.2.2**, noise monitoring was carried out along the project to quantify the existing noise environment. The results of background noise monitoring (locations shown on **Figure 8-1**) are summarised in **Table 8-14**.

Table 8-14 Summary of background noise monitoring results

ID	NCA	Address	Measured L_{A90} RBL[1], dB(A)				
			Morning shoulder[2]	Day[3]	Evening[4]	Evening shoulder[5]	Night[6]
L01	NCA01A	23 Cahill Close, Black Hill	56	54	53	56	45
L01A	NCA01B	24 Walter Parade, Black Hill	46	44	43	46	35
L02	NCA03	54 Weakleys Drive, Beresfield	37	37	40	40	37
L03	NCA07	51 New England Highway, Tarro	53	53	51	51	46
L04	NCA04A	1/15 Quarter Sessions Road, Tarro	59	57	54	57	46
L04A	NCA04B	22 Lenox Street, Beresfield	48	46	43	46	35
L05	NCA05A	11 Anderson Drive, Tarro	51	50	44	47	37
L05A	NCA05B	49 Beresford Avenue, Beresfield	44	43	37	40	30
L06	NCA06	61 Redbill Drive, Woodberry	44	38	40	42	38
L07	NCA08	179 Old Maitland Road, Hexham	45	41	43	41	44
L08	NCA09	838 Tomago Road, Tomago	56	53	52	55	47
L09	NCA14A	2213 Pacific Highway, Heatherbrae	52	53	49	52	41
L10	NCA14B	14 Elizabeth Avenue, Raymond Terrace	41	37	40	41	37
L10A	NCA14C	15 Brown Street, Raymond Terrace	46	42	45	46	42

ID	NCA	Address	Measured L_{A90} RBL[1], dB(A)				
			Morning shoulder[2]	Day[3]	Evening[4]	Evening shoulder[5]	Night[6]
L11	NCA12	2264 Pacific Highway, Heatherbrae	62	63	52	57	43
L12	NCA13	53 Martens Avenue, Raymond Terrace	46	42	45	47	42

1. RBL periods based on the extended construction work hours presented in **Section 8.2.3**
2. Morning shoulder: 6am–7am Monday to Friday
3. Day: 7am–6pm Monday to Saturday and 8am–6pm Sundays & Public Holidays
4. Evening: 6pm–10pm Monday to Sunday and Public Holidays
5. Evening shoulder: 6pm–7pm Monday to Friday
6. Night: 10pm–7am Monday to Saturday and 10pm–8am Sundays and Public Holidays
7. Background noise levels for locations L01A, L04A, L05A, L10A and L12 based on correlation with nominated long-term monitoring locations, as discussed in **Section 8.2.2**.

Existing traffic noise

As outlined in **Section 8.2.2**, noise monitoring of existing traffic noise levels was carried out within the operational study area to quantify existing traffic noise levels. The results of traffic noise monitoring are summarised in **Table 8-15**. Monitoring locations are shown on **Figure 8-1**.

Table 8-15 Monitored road traffic noise levels

ID	NCA	Address	Monitored traffic noise levels, dB(A)	
			$L_{Aeq(15\ hour)}$ Day (7am–10pm)	$L_{Aeq(9\ hour)}$ Night (10pm–7am)
L13	NCA01A	11 Cahill Close, Black Hill	56	53
L14	NCA01B	23 Walter Parade, Black Hill	50	45
L15	NCA04A	70 New England Highway, Tarro	74	72
L16	NCA04A	44 Sapphire Drive Beresfield	64	60
L17	NCA04B	11 Central Avenue, Tarro	57	51
L18	NCA06	Proposed interchange at Tarro	72	70
L19	NCA14A	2209 Pacific Highway, Beresfield	62	59
L20	NCA13	Pacific Highway (north of Raymond Terrace interchange)	75	72

8.4 Assessment of potential construction impacts

8.4.1 Noise management levels

In order to characterise potential construction noise impacts of the project, NMLs and sleep disturbance screening levels for each NCA (refer to **Section 8.3.1**) were established. NMLs were based on the results of background noise monitoring carried out for the project (refer to **Section 8.3.2**) and the CNVG criteria presented in **Table 8-4**. The NMLs for each NCA are presented in **Table 8-16**.

Residential receivers are considered 'noise affected' where construction noise levels are greater than the NMLs. The noise affected level represents the point above which there may be some community reaction to noise. If construction noise is equal to or above $L_{Aeq(15\ minute)}$ 75 dB(A) at any residence at any time, that residential receiver is considered to be highly noise affected. Where predicted and/or measured construction noise levels exceed NMLs, feasible and reasonable noise mitigation and/or management measures, as presented in the CNVG, would be considered in order to meet the NMLs.

Table 8-16 Construction NMLs and sleep disturbance screening levels for residential receivers

NCA[1, 2]	Monitoring location	$L_{Aeq(15\ minute)}$ NML, dB(A)						Sleep disturbance screening level (RBL + 15dB)[9]
		Standard hours (RBL + 10dB)	Extended / out of hours (RBL + 5dB)					
		Day[3]	Morning shoulder[4]	Day[5]	Evening[6]	Evening shoulder[7]	Night[8]	
NCA01A	L01	64	59	59	58	58	50	60
NCA01B	L01A	54	49	49	48	48	40	50
NCA03	L02	47	42	42	45	45	42	52
NCA04A	L04	67	62	62	59	59	51	61
NCA04B	L04A	56	51	51	48	48	40	50
NCA05A	L05	60	55	55	49	49	42	52
NCA05B	L05A	53	48	48	42	42	35	45
NCA06	L06	48	43	43	43	43	43	53
NCA07	L03	63	58	58	56	56	51	61
NCA08	L07	51	46	46	48	46	48	59
NCA09	L08	63	58	58	57	57	52	62
NCA12	L11	73	67	68	57	57	48	58
NCA13	L12	52	47	47	47	47	47	57
NCA14A	L09	63	58	58	54	54	46	56
NCA14B	L10	47	42	42	42	42	42	52

NCA[1, 2]	Monitoring location	$L_{Aeq(15\ minute)}$ NML, dB(A)						Sleep disturbance screening level (RBL + 15dB)[9]
		Standard hours (RBL + 10dB)	Extended / out of hours (RBL + 5dB)					
		Day[3]	Morning shoulder[4]	Day[5]	Evening[6]	Evening shoulder[7]	Night[8]	
NCA14C	L10A	52	47	47	47	47	47	57

1. Refer to **Section 8.3.1** and **Figure 8-2** for location of NCAs
2. NCA02, NCA10 and NCA11 comprise of commercial and industrial type receivers and are not presented in this table
3. Day standard construction hours: 7am–6pm Monday to Friday and 8am–1pm Saturday
4. Morning shoulder: 6am–7am Monday to Friday. Where morning shoulder RBL is higher than day RBL, the day RBL is adopted
5. Day out-of-hours: 7am–8am and 1pm–6pm Saturday, and 8am–6pm Sunday and public holidays
6. Evening: 6pm–10pm Monday to Sunday and Public Holidays. Where the evening RBL is higher than the day RBL, the day RBL is adopted
7. Evening shoulder: 6pm–7pm Monday to Friday. Where the evening shoulder RBL is higher than the evening RBL, the evening RBL is adopted
8. Night: 10pm–7am Monday to Saturday and 10pm–8am Sundays and Public Holidays. Where the night RBL is higher than the evening RBL, the evening RBL is adopted
9. Sleep disturbance assessed for night time period only
10. Caravan parks assessed as residential type receivers.

8.4.2 Predicted worst-case noise impacts

Due to the large number and size of work areas, and the variability of the types of construction activities associated with the project, the assessment of construction noise impacts is based on a ‘worst case’ construction scenario. However, the reality of construction noise impacts is that they would vary greatly depending on the location of the construction work within the work area, the distance between the noise sources and the nearby receivers, the noise intensity of the work, the time of day these specific activities take place, existing attenuation and the changing noise character with all these variables.

For the majority of work, the construction noise impacts would frequently be lower than predicted in the ‘worst-case’ scenario, which is typically only experienced for a short period of time when noisy equipment is in use. **Figure 8-3** shows the noise levels which would be experienced at a sensitive receiver near major construction work on a full day, and how construction noise levels would vary over the work period.

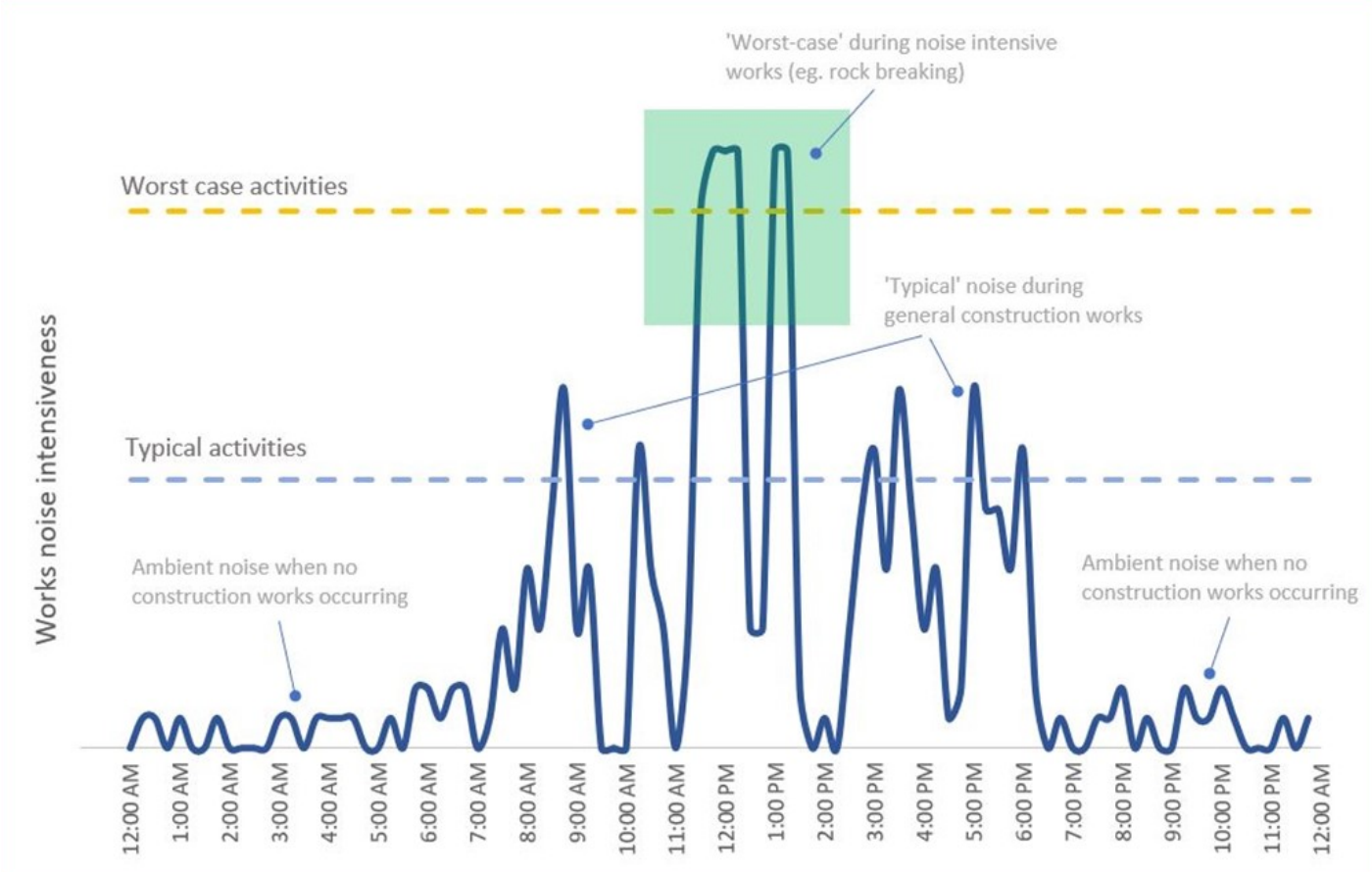

Figure 8-3 Example of indicative construction noise over a full day

The results in the following sections are based on the predicted noise impacts at the most affected receivers in each NCA and are representative of the worst-case (peak impact) and typical (typical impact) scenarios, as described in **Section 8.2.3** and shown on **Figure 8-3**. The worst-case (peak impact) scenario assumes that:

- All the equipment identified within a scenario would operate simultaneously, while in reality only some equipment would operate at the same time
- The equipment operates at its loudest (full load), in its worst case orientation without consideration of directivity, while in reality equipment would only operate at full load in rare instances and for short periods of time
- All plant are operating in one location, while in reality plant may be scattered around the work area
- All plant are at the closest location to each receiver, while in reality plant would move around the work area and noise levels would reduce as plant moves away from a receiver.

Predicted noise impacts are based on the exceedance of the NML, as per the exceedance bands presented in **Table 8-17**, and in accordance with the CNVG. The likely subjective perception from the community for each exceedance band is also shown on **Table 8-17**.

Table 8-17 NML exceedance bands and corresponding perception of impacts

Symbol	Perception	Exceedance of NML	
		Standard hours	Extended hours and out of hours
•	Noticeable	No exceedance	Less than 5 dB(A)
●	Clearly audible	1 dB(A) to 10 dB(A)	5 dB(A) to 15 dB(A)
◆	Moderately intrusive	11 dB(A) to 20 dB(A)	16 dB(A) to 25 dB(A)
■	Highly intrusive	Greater than 20 dB(A)	Greater than 25 dB(A)

* Based on Table C.1 of the CNVG

Predicted noise impacts in the following sections are based on a scenario where no noise and vibration management measures have been implemented. Therefore, once mitigated, the construction noise impacts would be reduced.

These results are considered conservative and noise levels during actual construction work are likely to be lower. The actual noise emissions from the work and resulting noise levels at nearby receivers would be influenced by:

- The location/distance of the plant/equipment with respect to the receiver
- The on/off time of the plant/equipment
- The intensity with which the plant/equipment is working.

In general, construction work would not occur continuously at a location and it is expected that there would be relatively long periods where construction noise levels are much lower than the worst-case levels presented in this assessment. There would also be many instances when no noisy work is occurring.

8.4.3 Construction airborne noise impacts

Residential receivers

The predicted construction noise impacts (with no noise mitigation) at residential receivers in each NCA are described in the following sections. Impacts are described for standard hours, extended hours and out-of-hours periods (as described in **Section 8.2.3**). Detailed noise level predictions and summaries of the number of receivers predicted to experience 'noticeable', 'clearly audible', 'moderately intrusive' and 'highly intrusive' unmitigated noise levels are provided in Appendix C of the Noise and Vibration Working Paper (**Appendix H**).

The predicted unmitigated construction noise impacts are presented for the most affected receivers within each NCA. Receivers which are further away and/or shielded from the work would have lower noise impacts. Where noise impacts are predicted, the methods for controlling the impacts through the use of construction noise management measures are discussed in more detail in **Section 8.6**.

Impacts during standard construction hours

Unmitigated construction noise impacts during standard construction hours and the likely community perceptions in each NCA are presented in **Table 8-18**. Impacts have been separated into the construction scenarios developed for this assessment, as outlined in **Section 8.2.3**.

Table 8-18 Predicted construction noise exceedances standard daytime – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (no exceedance)		● Clearly audible (1 dB to 10 dB)					◆ Moderately intrusive (11 dB to 20 dB)						■ Highly intrusive (> 20 dB)				
1	Pre-construction and site establishment	Peak impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	•	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	•	●	•
6	Utility work	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	•	●	•
7	Bulk earthwork – cuttings	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Bulk earthwork – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	●	•	•	•	•	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	•	•	•	•	●	●	•	•	•	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•

* NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

From the results presented in **Table 8-18**, residential receivers are expected to experience the following key noise and vibration impacts during standard construction hours:

- The highest impacts are during ‘peak impact’ activities, which is due to all plant and equipment assessed as operating concurrently, including noise intensive equipment such as rock hammers or concrete saws. For most scenarios, the ‘peak impact’ activities would only occur for a relatively short period. Noise levels during the ‘typical impact’ activities would be lower, impact fewer receivers, and are more indicative of the typical construction noise impacts experienced by receivers
- The highest impacts at residential receivers are generally in catchments where receivers are located close to the construction footprint. This includes NCA04A and NCA08, which are directly to the north and west of the construction footprint, respectively. Receivers in NCA04A are within suburban areas and are densely distributed, resulting in a relatively large number of receivers being impacted by construction noise in this NCA
- ‘Highly intrusive’ noise levels (i.e. greater than 20 dB exceedance) are predicted in NCA04A during clearing, grubbing and demolition work, utility work and bridge piling work during ‘peak impact’ activities. This is due to residential receivers in NCA04A being close to the construction footprint at the Tarro Interchange
- Noise impacts from batch plant operations (concrete and asphalt), bulk earthwork (fill) and asphalt pavement work are not predicted to exceed the NMLs at any residential receiver during peak or typical impact activities. Noise impacts from bulk earthwork (cuttings) and concrete pavement work are not predicted to exceed the NMLs at any residential receivers during typical activities
- Clearing, grubbing and demolition work, and utility work generally impact the highest amount of residential receivers and have the highest exceedances. This is because this work would be carried out over the entire length of the project
- Construction noise impacts are predicted to be ‘Noticeable’ (i.e. no exceedance of NML) at all residential receivers in NCA01A, NCA03, NCA05B, NCA06, NCA12, NCA13 and NCA14C for all construction work scenarios during standard construction work hours.

Impacts during extended hours

Unmitigated construction noise impacts during extended hours and the likely community perceptions in each NCA are presented in **Table 8-19**, **Table 8-20** and **Table 8-21**. Noise impacts are presented for each of the construction scenarios during the morning shoulder, daytime out-of-hours and evening shoulder periods (as described in **Section 8.3.2**), respectively.

Table 8-19 Predicted construction noise exceedances morning shoulder – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)		● Clearly audible (5 dB to 15 dB)					◆ Moderately intrusive (16 dB to 25 dB)						■ Highly intrusive (> 25 dB)				
1	Pre-construction and site establishment	Peak impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	•	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	•	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
6	Utility work	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
7	Bulk earthwork – cuttings	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Bulk earthwork – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	•	•	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	•	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•

* NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 8-20 Predicted construction noise exceedances daytime out-of-hours – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)		● Clearly audible (5 dB to 15 dB)					◆ Moderately intrusive (16 dB to 25 dB)						■ Highly intrusive (> 25 dB)				
1	Pre-construction and site establishment	Peak impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	•	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	•	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
6	Utility work	Peak impact	•	•	•	■	●	•	•	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	●	●	●	•	•	●	●	•
7	Bulk earthwork – cuttings	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
9	Bulk earthwork – fill	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	•	•	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	•	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	•	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•

* NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 8-21 Predicted construction noise exceedances evening shoulder – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)		● Clearly audible (5 dB to 15 dB)					◆ Moderately intrusive (16 dB to 25 dB)						■ Highly intrusive (> 25 dB)				
1	Pre-construction and site establishment	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	◆	◆	•	•	•	●	•	•
		Typical impact	•	•	•	●	●	●	•	•	●	●	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	●	●	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
6	Utility work	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
7	Bulk earthwork – cuttings	Peak impact	•	•	•	●	●	•	●	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
9	Bulk earthwork – fill	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	●	●	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	●	•	•	•	•	●	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	●	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	●	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•

* NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Summarised from **Table 8-19**, **Table 8-20** and **Table 8-21**, residential receivers are expected to experience the following key noise and vibration impacts during extended construction hours:

- Similar to the impacts during standard working hours, the highest impacts are during the 'peak impact' activities, with 'peak impact' activities only occurring for a relatively short period. Noise levels during the 'typical impact' activities would be lower, impact fewer receivers, and are more indicative of the typical construction noise impacts experienced by receivers
- The highest impacts at residential receivers are generally in catchments where receivers are located close to the construction footprint. This includes NCA04A, NCA04B and NCA08, where receivers are located directly next to the New England Highway at Tarro and Hexham. In addition, receivers in NCA04A and NCA04B are located within densely populated suburban areas, resulting in relatively large number of receivers being impacted by construction noise
- During the morning shoulder and daytime out-of-hours periods, 'Highly intrusive' noise levels (i.e. greater than 25 dB exceedance of NML) are predicted in NCA04A during clearing, grubbing and demolition work, utility work and bridge piling work when 'peak impact' activities are being carried out
- Noise impacts during the morning shoulder and daytime out-of-hours periods from batch plant operations (concrete and asphalt), bulk earthwork (fill) and asphalt pavement work are predicted to be 'Noticeable' (i.e. less than 5 dB exceedance of NML) at all residential receivers in all NCAs during peak or typical impact activities. Noise impacts from bulk earthwork (cuttings) and concrete pavement work are predicted to be 'Noticeable' at all residential receivers during typical impact activities
- During the evening shoulder period, 'Highly intrusive' noise levels are predicted in NCA04A during the following scenarios:
  - Pre-construction and site establishment during peak activities
  - Clearing, grubbing and demolition work during peak and typical activities
  - Utility work during peak and typical activities
  - Bridge piling work during peak activities.
- Noise impacts from batch plant operations (concrete and asphalt) during the evening shoulder period are predicted to be 'Noticeable' at all residential receivers in all NCAs during peak or typical activities
- During extended construction hours, pre-construction site establishment work, clearing, grubbing and demolition work, utility work and bridge piling work generally impact the highest number of residential receivers and result in the highest exceedances. This is because this work would be carried out over the entire length of the project
- Construction noise impacts are predicted to be 'Noticeable' at all residential receivers in NCA01A, NCA03, NCA05B, NCA06, NCA12 and NCA14C for all construction work scenarios during the extended work hours. During the morning shoulder and daytime out-of-hours periods, all residential receivers in NCA05B also have 'Noticeable' noise impacts
- When compared to standard construction hours, the morning shoulder and daytime out-of-hours periods during the extended hours would typically have similar impacts at residential receivers. Some NCAs may experience additional construction noise impacts during the morning shoulder and daytime out-of-hours periods, however, the additional impacts are considered to be 'Noticeable' only. Therefore, noise impacts from the proposed construction work scenarios during the morning shoulder and daytime out-of-hours periods would be similar to the impacts during standard construction hours
- For the evening shoulder period, most construction work scenarios would have similar construction noise impacts as the standard construction hours period. Some NCAs may experience additional 'Noticeable' or 'Moderately intrusive' impacts during the evening shoulder period when compared to the standard construction hours period
- Additional 'Highly intrusive' construction noise impacts may be experienced at NCA04A during the evening shoulder period for pre-construction site establishment work (peak impact), clearing, grubbing and demolition work (typical impact) and utility work (typical impact), when compared to standard construction hours.

Impacts during out of hours work

Unmitigated construction noise impacts during extended hours and the likely community perceptions in each NCA are presented in **Table 8-22** and **Table 8-23**. These noise impacts are presented for each of the construction scenarios during the evening (7pm–10pm) and night time (10pm–6am) periods, respectively.

Table 8-22 Predicted construction noise exceedances evening – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)		● Clearly audible (5 dB to 15 dB)					◆ Moderately intrusive (16 dB to 25 dB)						■ Highly intrusive (> 25 dB)				
1	Pre-construction and site establishment	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
2	Ancillary facility – establishment	Peak impact	•	•	•	◆	●	●	•	•	◆	◆	•	•	•	●	•	•
		Typical impact	•	•	•	●	●	●	•	•	●	◆	•	•	•	•	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	●	●	●	•	•	●	◆	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	●	◆	•	•	•	•	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	●	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
6	Utility work	Peak impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	●	●	•	•	●	●	•
7	Bulk earthwork – cuttings	Peak impact	•	•	•	●	●	•	●	•	•	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
9	Bulk earthwork – fill	Peak impact	•	•	•	•	●	•	•	•	•	•	•	•	•	●	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	•	●	●	●	•	●	•	•	•	●	●	●	•
		Typical impact	•	•	•	•	•	•	•	•	●	•	•	•	•	●	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	•	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	•	•	•	■	●	●	●	•	•	●	●	•	●	•	●	•
		Typical impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
15	Traffic management and control	Peak impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	●	•	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	•	•	•	◆	●	●	•	•	•	●	●	•	•	●	•	•
		Typical impact	•	•	•	◆	•	•	•	•	•	•	•	•	•	•	•	•
17	Cross drainage	Peak impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	●	•	•	•	•	•

* NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

Table 8-23 Predicted construction noise exceedances night time – residential receivers

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
Key:	• Noticeable (< 5 dB)		● Clearly audible (5 dB to 15 dB)					◆ Moderately intrusive (16 dB to 25 dB)						■ Highly intrusive (> 25 dB)				
1	Pre-construction and site establishment	Peak impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
		Typical impact	•	•	•	■	●	●	●	•	●	•	●	•	•	●	•	•
2	Ancillary facility – establishment	Peak impact	•	●	•	■	◆	◆	●	•	◆	◆	●	•	•	●	•	•
		Typical impact	•	•	•	◆	●	●	•	•	●	●	•	•	•	●	•	•
3	Ancillary facility – operation	Peak impact	•	•	•	◆	◆	●	●	•	●	◆	•	•	•	●	•	•
		Typical impact	•	•	•	◆	●	●	•	•	●	●	•	•	•	●	•	•
4A	Batch plant operation (concrete batch plant)	Peak impact	•	•	•	•	●	●	●	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
4B	Batch plant operation (asphalt batch plant)	Peak impact	•	•	•	•	●	●	●	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	Clearing, grubbing, and demolition	Peak impact	●	●	•	■	◆	◆	◆	•	●	●	◆	•	●	◆	●	•
		Typical impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
6	Utility work	Peak impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
		Typical impact	●	●	•	■	◆	◆	●	•	●	●	◆	•	•	◆	●	•
7	Bulk earthwork – cuttings	Peak impact	●	●	•	●	◆	●	●	•	•	•	●	•	●	◆	●	•
		Typical impact	●	•	•	●	●	●	●	•	•	•	•	•	•	●	•	•
9	Bulk earthwork – fill	Peak impact	●	●	•	●	●	●	●	•	•	•	•	•	•	◆	•	•
		Typical impact	•	•	•	●	●	●	●	•	•	•	•	•	•	●	•	•

ID	Scenario	Activity	NCA01A	NCA01B	NCA03	NCA04A	NCA04B	NCA05A	NCA05B	NCA06	NCA07	NCA08	NCA09	NC012	NCA13	NCA14A	NCA14B	NCA14C
10	Concrete pavement (including pavement drainage)	Peak impact	•	•	•	●	◆	●	●	•	●	•	●	•	●	◆	●	•
		Typical impact	•	•	•	●	●	●	●	•	●	•	•	•	•	●	•	•
11	Asphalt pavement (including pavement drainage)	Peak impact	•	•	•	●	●	●	●	•	•	•	●	•	•	•	•	•
		Typical impact	•	•	•	●	●	●	●	•	•	•	•	•	•	•	•	•
12	Bridge work (excluding piling)	Peak impact	●	•	•	■	◆	●	●	•	•	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	●	•	•	•	●	•	•	•	•	•
13	Piling for bridges and bridge approaches	Peak impact	●	●	•	■	◆	◆	◆	•	●	●	◆	•	●	●	●	•
		Typical impact	●	•	•	■	◆	●	●	•	•	•	●	•	•	•	•	•
14	Roadside furniture and finishing work	Peak impact	●	•	•	■	◆	●	●	•	●	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	●	•	•	•	●	•	•	●	•	•
15	Traffic management and control	Peak impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
		Typical impact	•	•	•	◆	●	•	•	•	•	•	•	•	•	•	•	•
16	Landscaping	Peak impact	●	•	•	■	◆	●	●	•	●	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	•	•	•	•	●	•	•	●	•	•
17	Cross drainage	Peak impact	•	•	•	■	◆	●	●	•	●	•	●	•	•	●	•	•
		Typical impact	•	•	•	■	●	●	●	•	●	•	●	•	•	●	•	•

* NCA02, NCA10 and NCA11 comprise of commercial and industrial receivers and hence, are not included this table

From the results presented in **Table 8-22** and **Table 8-23**, residential receivers are expected to experience the following key noise and vibration impacts during out-of-hours construction work:

- Similar to impacts during 'standard working hours' and 'extended hours', the highest impacts are during the 'peak impact' activities, however for most scenarios, the 'peak impact' activities would only occur for a relatively short period. Noise levels during the 'typical impact' activities would be lower, impact fewer receivers, and are more indicative of the typical construction noise impacts experiences by receivers
- The highest impacts at residential receivers are generally in catchments where receivers are located close to the construction footprint. This includes NCA04A and NCA04B, which are directly to the north of the New England Highway at Tarro
- During the evening period, 'highly intrusive' noise levels (i.e. greater than 25 dB exceedance of NML) are predicted in NCA04A during the following scenarios:
  - Pre-construction and site establishment during 'peak impact' activities
  - Clearing, grubbing and demolition work during peak and typical impact activities
  - Utility work during peak and typical impact activities
  - Bridge piling work during 'peak impact' activities.
- During the night time period, 'Highly intrusive' noise levels are predicted in NCA04A during the following scenarios:
  - Pre-construction and site establishment during peak and typical impact activities
  - Ancillary facility establishment work during 'peak impact' activities
  - Clearing, grubbing and demolition work during peak and typical impact activities
  - Utility work during peak and typical impact activities
  - Bridge work (non-piling) during peak and typical impact activities
  - Bridge piling work during peak and typical impact activities
  - Roadside furniture and finishing work, landscaping work and cross drainage work during peak and typical impact activities.
- Noise impacts during the evening and night time periods from batch plant operations (concrete and asphalt) are predicted to be 'Noticeable' (i.e. less than 5 dB exceedance of NML) for all residential receivers during typical activities
- During out-of-hours, the following activities generally impact the highest number of residential receivers and with the highest exceedances; pre-construction site establishment work, ancillary facility establishment work, clearing, grubbing and demolition work, utility work, bridge work (non-piling), bridge piling work, roadside furniture and finishing work, landscaping work and cross drainage work
- Noise impacts during out-of-hours construction are predicted to be 'Noticeable' at all residential receivers in NCA03, NCA06, NCA12 and NCA14C for all construction work. All residential receivers in NCA01A would also experience 'Noticeable' noise impacts during the evening period.

Highly noise affected residential receivers

As outlined in **Section 8.4.1**, residential receivers that are subject to noise levels of 75 dB(A) or more are considered to be highly noise affected. For the project, all highly noise affected residential receivers (up to 24 in total) are located within NCA04A, in Tarro, where construction work is closest to receivers.

The location of residential receivers likely to be highly noise affected, regardless of construction scenario or activity, are shown on **Figure 8-4**. However, in reality, the construction work would occur in isolated locations and the number of highly noise affected receivers during any single work scenario would be less than shown. The Noise and Vibration Working Paper (**Appendix H**) further identifies which residential receivers are predicted to potentially be highly noise affected during the different construction scenarios and activities.

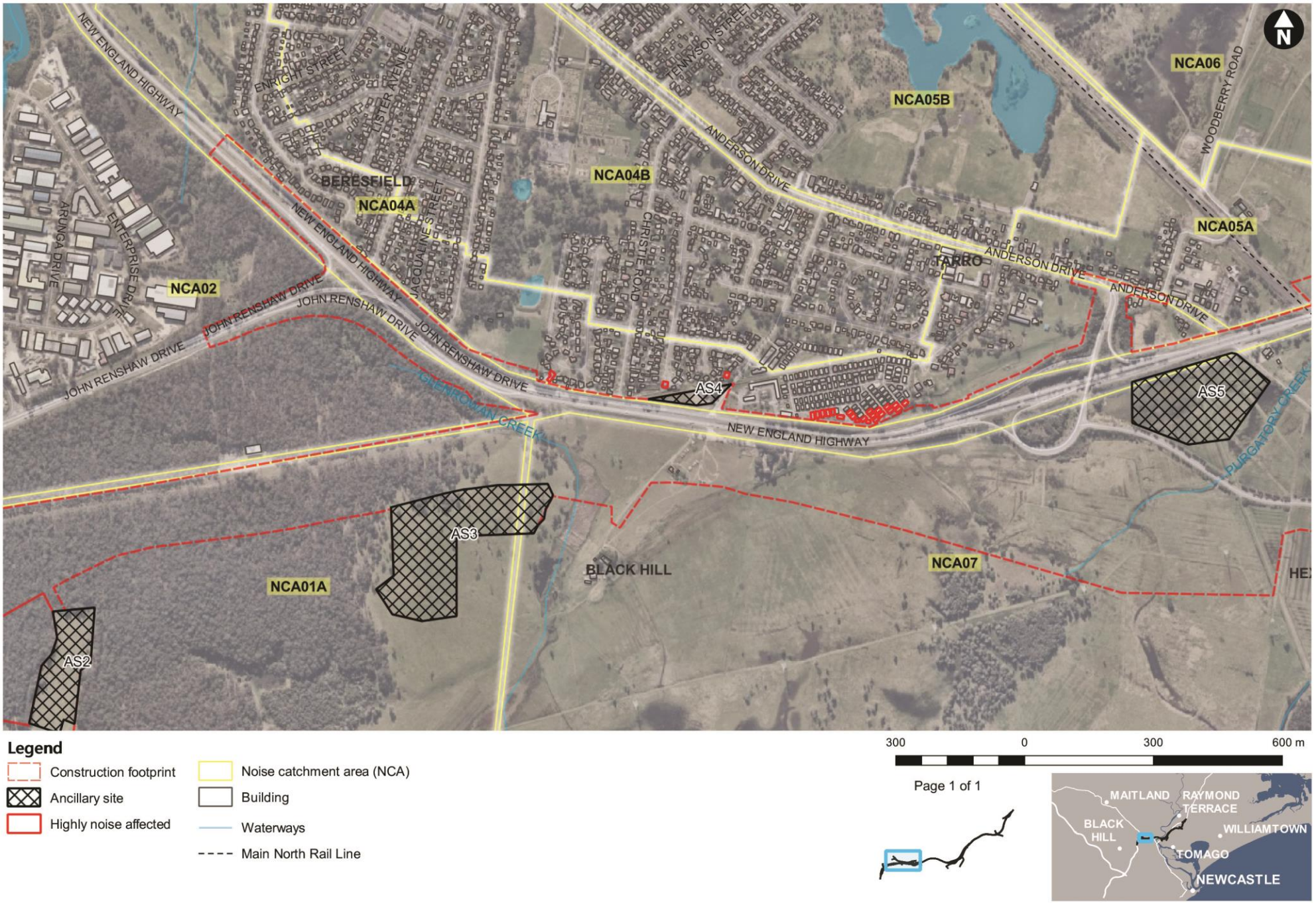

Figure 8-4 Predicted construction noise impacts – highly noise affected residential receivers

Other sensitive receivers

Twenty-one other sensitive receivers and associated buildings (such as classrooms, places of worship, childcare centres and recreation areas, refer to **Section 8.2.3**) would potentially be affected by construction noise from construction of the project. The locations of other sensitive receivers, and the number of other sensitive receivers predicted to exceed the relevant NML for each receiver type during each construction scenario, are provided in the Noise and Vibration Working Paper (**Appendix H**).

The receivers identified as exceeding the NML are:

- Tarro Public School (educational receiver), which consists of eight receiver buildings
- Pasadena Crescent Reserve Soccer Fields (active recreation receiver)
- Hunter Region Botanic Gardens (passive recreation receiver).

The key construction noise impacts associated with these other sensitive receivers are summarised as follows:

- Ancillary facility establishment and operation, batch plant operation (concrete and asphalt), and traffic management and control are not predicted to result in exceedances at any other sensitive receiver locations
- The majority of construction scenarios are predicted to result in exceedances of the NMLs at each of the receivers listed above, where 'Clearly audible' noise levels (i.e. 1 dB to 10 dB exceedance of NML) are typically predicted
- 'Moderately intrusive' noise levels (i.e. 11 dB to 20 dB exceedance of NML) are predicted at the Hunter Region Botanic Gardens during asphalt pavement work, pre-construction and site establishment work, clearing, grubbing and demolition work, utility work and bulk earthwork for cuttings
- The Hunter Region Botanic Gardens is predicted to experience 'Highly intrusive' noise levels (i.e. greater than 20 dB exceedance of NML) during peak and typical concrete pavement work.

Commercial and industrial receivers

Predicted construction noise impacts in each NCA for commercial and industrial receivers is further outlined in the Noise and Vibration Working Paper (**Appendix H**). The key noise impacts associated with commercial and industrial receivers are summarised as follows:

- Construction noise impacts in NCA04A are predicted to be 'Clearly audible' (i.e. 1 dB to 10 dB exceedance of NML) during pre-construction and site establishment work, clearing, grubbing and demolition work, utility work, bridge and viaduct superstructure work (including bridge piling work) and roadside furniture and finishing work
- Construction noise impacts in NCA10, NCA12 and NCA14A are predicted to be 'Clearly audible' and 'Moderately intrusive' (11 dB to 20 dB exceedance of NML) during different construction scenarios and activities
- 'Highly intrusive' noise levels are predicted in NCA10 and NCA12 during pre-construction and site establishment work, ancillary facility establishment and operation, clearing, grubbing and demolition work, and utility work. These impacts occur when peak and/or typical activities are carried out
- Other NCAs either have no commercial or industrial receivers, or the receivers are of sufficient distance from the construction footprint to prevent exceedances.

Sleep disturbance

The project has the potential for sleep disturbance impacts during construction, as outlined in **Section 8.2.3**. Sleep disturbance impacts on residential receivers affected by the project are discussed further in the Noise and Vibration Working Paper (**Appendix H**) and summarised as follows:

- NCA04A and NCA04B have the highest number of residential receivers that would exceed the sleep disturbance screening level. This is because NCA04A and NCA04B have the highest number of residential receivers located close to the construction footprint
- Residential receivers located within NCA05A and NCA05B are predicted to exceed the sleep disturbance screening level, however, fewer exceedances are expected due to the distance between the NCAs and construction activities
- NCA01A, NCA01B, NCA07, NCA08, NCA09 and NCA14A show low numbers of residential receivers exceeding the sleep disturbance screening level
- Utility work causes highest number of exceedances of the sleep disturbance screening level.

Sleep disturbance impacts are dependent on a number of factors, including the existing facade performance of affected residential receiver buildings. Noise mitigation measures that would be used to attenuate L_{Aeq} noise levels would also attenuate maximum (L_{Amax}) noise levels, resulting in compliance of the sleep disturbance screening levels at some residential receivers. The assessed sleep disturbance impacts of the project are therefore a conservative estimate and are likely to be less in reality.

8.4.4 Construction ground-borne noise

Construction can cause ground-borne noise impacts in nearby buildings when vibration-generating equipment is in use. Ground-borne noise impacts should be considered where the ground-borne noise levels are likely to be higher than airborne noise (i.e. noise transmitted through the air) in internal areas of the affected buildings. This may occur where a building near the construction footprint has high performing facades which sufficiently attenuate the airborne noise component.

The majority of receivers are sufficiently distant from the work for ground-borne noise impacts to be minimal. Where residential receivers are located near construction work, airborne noise levels would typically be dominant over the ground-borne noise component.

Ground-borne noise arising from the project is therefore not expected to impact on sensitive receivers and has not been assessed further.

8.4.5 Construction road traffic noise

As outlined in **Section 8.3**, the existing acoustic environment of the project is mostly influenced by noise from users of major arterial roads (including large numbers of light and heavy vehicles) and local transport activities, particularly in commercial and industrial areas.

Construction traffic has the potential to increase road traffic noise levels at receivers located near the construction traffic routes. Where feasible and reasonable, haulage routes associated with the construction of the project would use the existing motorway, and arterial and sub-arterial roads.

Construction traffic associated with the project is not expected to increase traffic noise levels by more than 2 dB(A) on most of the roads along the proposed construction traffic routes. However, increases of up to 5.9 dB(A) during the night time period have been predicted along Masonite Road in Heatherbrae when accessing AS16, AS17, AS18 and AS19. It is noted that only commercial and industrial premises are located along Masonite Road, with no residential or other sensitive receivers. Therefore, although an increase in traffic noise levels of more than 2 dB(A) is predicted, no sensitive receivers would be impacted by construction road traffic noise.

Predicted construction road traffic noise increases for day and night periods are identified in the Noise and Vibration Working Paper (**Appendix H**).

8.4.6 Construction vibration impacts

Residential and commercial / industrial structures

Based on the recommended minimum working distances presented in **Table 8-7**, an assessment of potential vibration impacts was carried out, with a summary of the results provided in **Table 8-24**. The assessment is relevant to all residential and commercial / industrial use buildings, and other similar type structures in the vicinity of construction.

Table 8-24 Potential vibration impacts for residential and commercial / industrial structures

NCA	Approx. distance to nearest buildings from work (metres)	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
NCA01A	160m – 180m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA01B	590m – 610m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA02	70m – 80m	Commercial / Industrial	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA03	1150m – 1200m	Commercial / Industrial	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA04A	10m – 15m	Residential	Medium risk of structural damage	High risk of adverse comment	Vibration monitoring may be considered
NCA04B	80m – 90m	Residential	Very low risk of structural damage	Low risk of adverse comment	Vibration monitoring may be considered
NCA05A	100m – 110m	Residential / Commercial / Industrial	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA05B	300m – 310m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA06	1350m – 1400m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA07	35m – 40m	Residential	Low risk of structural damage	Medium risk of adverse comment	Vibration monitoring may be considered
NCA08	40m – 45m	Residential	Low risk of structural damage	Medium risk of adverse comment	Vibration monitoring may be considered
NCA09	55m – 60m	Residential	Very low risk of structural damage	Low risk of adverse comment	Vibration monitoring may be considered

NCA	Approx. distance to nearest buildings from work (metres)	Type of nearest sensitive buildings	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
NCA10	5m – 10m	Industrial	Low risk of structural damage	Medium risk of adverse comment	Vibration monitoring may be considered
NCA11	70m – 80m	Recreational structure	Very low risk of structural damage	Low risk of adverse comment	Vibration monitoring may be considered
NCA12	10m – 15m	Industrial	Low risk of structural damage	Low risk of adverse comment	Vibration monitoring may be considered
NCA13	290m – 300m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA14A	10m – 15m	Commercial	Low risk of structural damage	Low risk of adverse comment	Vibration monitoring may be considered
NCA14B	520m – 540m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required
NCA14C	460m – 480m	Residential	Very low risk of structural damage	Very low risk of adverse comment	Not required

Buried water, sewer and gas pipelines

As outlined in **Chapter 5**, a number of buried water, sewer mains and the Hunter Water Corporation Chichester Trunk Gravity Main (CTGM) are located within the construction footprint at Black Hill, Tarro, Tomago, Heatherbrae and Raymond Terrace. Additionally, high and medium pressure gas mains are located within the construction footprint near the proposed Tomago interchange at the Pacific Highway and Old Punt Road. During construction, vibration intensive plant and equipment (including hydraulic rock breakers / hammers, vibratory pile drivers, bored piling rigs and vibratory rollers) could be used near the water and gas pipelines. However, in accordance with the vibratory level limits for metal flanged buried pipework (as outlined in DIN 4150-3), the vibration intensive plant and equipment likely to be used on site are not expected to impact on these utilities.

Electrical and telecommunication utilities

Numerous buried low and high voltage electrical lines, and optical fibre cables are located within the construction footprint. Based on the vibratory limits for buried electrical cables and telecommunication infrastructure outlined in **Section 8.2.3**, the vibration intensive plant and equipment likely to be used on site are not expected to impact on these utilities. Nevertheless, further assessment and consultation with utility providers would be carried out during detailed design.

For aboveground high voltage electrical transmission lines, vibration impacts to the associated structures such as the stanchions and associated footings are not referred to in the nominated standards, policies and guidelines. Nevertheless, the stanchions and associated footings would be significant as other impacts such as wind loads encountered by the stanchions would be a major factor in their design. Therefore, the vibration limits nominated for buildings would not be applicable for these structures and higher limits would likely be relevant. As a result, the vibration intensive plant and equipment likely to be used on site are not expected to cause adverse impacts to the stanchions and associated footings.

Heritage structures

Heritage within or near the construction footprint comprises Aboriginal and non-Aboriginal heritage (refer to **Chapter 12** (Aboriginal cultural heritage) and **Chapter 17** (non-Aboriginal heritage)). Non-Aboriginal heritage within the construction study area comprises above ground structures and below ground archaeological sites, while Aboriginal heritage within the construction study area comprises surface and subsurface (below ground) artefacts. Below ground archaeological sites (non-Aboriginal heritage) and both surface and subsurface artefacts (Aboriginal heritage) are not subject to potential vibration impacts and so are not considered further in this assessment.

Heritage items with the potential to be impacted by construction vibration are identified in **Table 8-25**.

All identified heritage items are typically located outside of the minimum working distances provided in **Table 8-7**. Given that the closest construction activities to the Hannell Family Vault comprise of ancillary facility activity at AS8 (where vibratory equipment is not expected to be used) vibration intensive plant and equipment associated with the proposed construction activities are not expected to cause cosmetic damage to the nearest affected heritage listed structures.

Table 8-25 Heritage items with the potential to be impacted by construction vibration

Heritage item[1]	Heritage item name	NCA	Location	Approx. distance to vibration intensive work[2]
Item 1	Hannell Family Vault (I179)	NCA08	398B Maitland Road, Hexham	Greater than 100m
Item 3	Glenrowan Homestead (residence)	NCA07	51 New England Highway, Black Hill	85m
Item 4	Residence (I548)	NCA04A	29 Eastern Avenue, Tarro	75m
Item 7	Tarro Substation (I546)	NCA04A	6A Anderson Drive, Tarro	100m
Item 8	Pumping Station (I550)	NCA05A	3 Woodberry Road, Tarro	Greater than 100m
Item 9	Newcastle Crematorium (I34)	NCA04B	176 Anderson Drive, Beresfield	Greater than 500m
Item 10	Our Lady of Lourdes Church (I547)	NCA04A	42 Anderson Drive, Tarro	Greater than 250m

1. Heritage item number specified in **Chapter 17** (non-Aboriginal heritage). Numbers in parenthesis represent listed heritage ID number on relevant local environment plan
2. Distances presented represent distance to construction work areas where vibration intensive plant and equipment would be operating

Based on the results presented in **Table 8-25**, heritage listed structures are unlikely to be impacted by vibration from the construction activities. However, heritage listed structures that are within 100 metres from vibration intensive work would be considered on a case by case basis and further investigation will be carried out during detailed design to confirm the structural integrity (i.e. structurally sound or unsound) of all potentially affected structures. Management measures for potential vibration impacts to heritage items are presented in **Section 8.6**.

8.4.7 Construction blasting noise and vibration

The overpressure and vibration levels generated by blasting are dependent on site specific factors, local ground conditions and the blast design. If required, blasting would occur during construction of the cutting in the Black Hill area, south of John Renshaw Drive, and likely impact on receivers within NCA01A, NCA01B, NCA02, NCA04A and NCA07. Potential construction blasting impacts on these NCAs are described in the Noise and Vibration Working Paper (**Appendix H**).

The need for blasting would be determined as part of the pre-construction and detailed design stages of the project. If blasting is required, site specific noise and vibration investigations would be carried out, which would consider charge and blast configuration design. Analyses would be carried out to identify actual buffer zones associated with the project, and assist in identifying appropriate measures to limit overpressure and vibration to acceptable levels at critical locations. Blast charge and blast configurations would be identified to ensure that the blast management levels are not exceeded.

If required, a Blast Management Plan would be developed before construction, as outlined in **Section 8.6**. The strategy will design appropriate blast charges and configurations in order to achieve compliance with the established management levels for blast overpressure and ground vibration, and comply with relevant guidelines.

8.5 Assessment of potential operational impacts

8.5.1 Operational road traffic noise predictions – impacts without mitigation

As outlined in **Section 8.2.4**, operational road traffic noise impacts have been assessed for the 'No Build' and 'Build' scenarios for both the opening and design years (2028 and 2038 respectively). These scenarios do not include any noise mitigation measures, other than the existing measures (e.g. existing noise barriers) and those that are incorporated into the road design.

The number of receiver buildings that have been predicted to exceed the NCG noise criteria levels for the 'No-Build' (without the project) and 'Build' (with the project) unmitigated scenarios for the opening year and design year are shown in **Table 8-26**. It is noted that if a receiver building is predicted to exceed the NCG noise criteria, it may not necessarily be eligible for additional noise mitigation. Eligibility for additional noise mitigation measures is subject to the processes and criteria discussed in **Section 8.2.4**.

Table 8-26 Number of receiver buildings exceeding the NCG noise criteria without mitigation

NCA	2028 'No-Build'		2028 'Build'		2038 'No-Build'		2038 'Build'	
	Day	Night	Day	Night	Day	Night	Day	Night
NCA01A	13	14	14	18	13	16	18	20
NCA01B	0	0	0	0	0	0	0	0
NCA02	1	1	1	1	1	1	1	1
NCA04A	249	249	280	258	279	275	323	321
NCA04B	19	27	52	59	29	41	81	101
NCA05A	30	27	30	30	30	30	30	30

NCA	2028 'No-Build'		2028 'Build'		2038 'No-Build'		2038 'Build'	
	Day	Night	Day	Night	Day	Night	Day	Night
NCA05B	10	0	10	1	10	1	11	7
NCA07	2	2	2	2	2	2	2	2
NCA09	1	1	1	1	1	1	1	1
NCA12	7	7	7	7	7	7	7	7
NCA13	2	6	4	5	2	6	6	6
NCA14A	104	115	115	131	112	123	137	156
NCA14B	0	5	3	7	2	6	7	22
NCA14C	56	85	60	79	70	101	81	114
Total	**494**	**539**	**579**	**599**	**558**	**610**	**705**	**788**

1. Includes residential and non-residential sensitive receivers
2. NCA03, NCA06 and NCA08 are located outside the operational study area for operational traffic noise and are not included in this table
3. No sensitive (residential and non-residential) receivers are located within NCA10 and NCA11 and are therefore not included this table

As shown in **Table 8-26**, receivers in NCA04A would experience the highest number of exceedances of the NCG noise criteria. This is expected given that the receivers in NCA04A are in a suburban setting and are located close to the project. A high number of receiver buildings in NCA14A, which is located next to the Pacific Highway in Heatherbrae, are also predicted to exceed the NCG noise criteria.

Change in traffic noise levels due to the project

The assessment identified that:

- Some receivers are predicted to experience a decrease in traffic noise levels when the project is operational, mainly due to traffic using the project and bypassing the existing roads near these receivers. On average, the project is predicted to result in reduced traffic noise for about 10 per cent of receivers
- The project is predicted to typically increase traffic noise levels by no more than 2 dB(A) at the majority of receivers surrounding the project, which is considered to be a minor impact. An average of about 82 per cent of receivers within the NCAs are predicted to experience traffic noise level increases of less than 2 dB(A), which is described by the RNP as a minor impact and is barely perceptible
- Some receivers may experience increases of more than 2 dB(A) in traffic noise levels due to traffic from the project moving closer to these residences or increasing the exposure to more traffic lanes. An average of about eight per cent of receiver buildings within the NCAs are predicted to experience increases in traffic noise of more than 2 dB(A) due to the project.

For the majority of receiver buildings within the operational study area (refer to **Figure 8-1**), there is either a reduction or relatively minor change in traffic noise levels due to the project. As such, any requirement for additional noise mitigation is likely to be a result of the existing high noise levels from road traffic.

Further information on the number of receivers in each NCA that are predicted to experience changes in traffic noise when comparing the 'No Build' and 'Build' scenarios is provided in the Noise and Vibration Working Paper (**Appendix H**).

Receivers triggered for consideration of additional noise mitigation

Where road traffic noise levels at receivers are predicted to be above the NCG criteria, the requirement for additional noise mitigation is determined using guidance from the NMG, as outlined in **Section 8.2.4**.

Receivers triggered as requiring consideration of additional noise mitigation for the 2038 design year ‘Build’ scenario are summarised in **Table 8-27**.

Table 8-27 Number of receiver buildings impacted due to the project for design year 2038

NCA [1]	Total Number of residences assessed	Day period – number of receiver buildings				Night period – number of receiver buildings				Requiring consideration of additional noise mitigation [6]
		Exceed NCG noise criteria level [2]	> 2 dB(A) Increase and exceed NCG criteria [3,4]	Exceed cumulative noise limit	Experience acute noise levels (≥ 65 dB(A))[5]	Exceed NCG noise criteria level [2]	> 2 dB(A) Increase and exceed NCG criteria [3,4]	Exceed cumulative noise limit	Experience acute noise levels (≥ 60 dB(A)) [5]	
NCA01A	42	8	6	2	0	8	1	2	0	8
NCA01B	29	0	0	0	0	0	0	0	0	0
NCA02	1	1	0	1	0	1	0	0	0	1
NCA04A	425	103	0	94	71	85	0	83	79	103
NCA04B	615	4	1	2	0	4	3	0	0	4
NCA05A	31	2	2	0	0	2	2	0	0	2
NCA05B	36	0	0	0	0	0	0	0	0	0
NCA07	2	1	0	1	0	1	1	1	1	1
NCA09	1	1	0	1	0	1	0	1	1	1
NCA12	7	6	2	6	0	6	2	6	0	6
NCA13	9	2	2	0	0	2	1	0	0	2
NCA14A	180	50	34	29	6	59	28	34	8	59
NCA14B	84	1	2	0	0	2	1	0	0	2
NCA14C	209	0	0	0	0	0	0	0	0	0
Total	**1671**	**179**	**49**	**136**	**77**	**171**	**39**	**127**	**89**	**189**

1. NCA03, NCA06 and NCA08 located outside the operational study area for operational traffic noise, and no sensitive (residential and non-residential) receivers in NCA10 and NCA11; hence, not included this table
2. NCG noise criteria level based on 'New Road', 'Redeveloped Road', 'Transition Zone' or 'Relative Increase' criteria as per RNP
3. Greater than 2 dB(A) increase based on comparison between 'Build' scenario and 'No-Build' scenario for the design year 2038
4. Exceedance of NCG noise criteria AND increase of more than 2 dB(A) are required to be eligible for noise mitigation
5. Acute noise levels due to contribution from the project only
6. A receiver building qualifies for noise mitigation if it falls under any of the three NMG noise mitigation triggers (i.e. greater than 2 dB(A) increase, exceed cumulative or acute noise) or a multiple of triggers
7. An individual receiver building is considered as a single receiver for the purposes of this assessment, i.e. one double-storey residential building = one receiver building.

As shown in **Table 8-27**, 189 receiver buildings (around 11 per cent of the 1671 assessed) are eligible for consideration of additional noise mitigation in accordance with the NMG requirements outlined in **Section 8.2.4**.

The 189 receiver buildings were identified based on the following assumptions:

- The predicted 'With project' (Build) traffic noise levels in the design year (2038) would exceed the NCG project road noise criteria and would also increase by more than 2 dB(A) as a result of the project at 49 and 39 receiver buildings during the day and night periods, respectively
- The cumulative limit (5 dB(A)) above the NCG project road criterion) would be exceeded at 136 and 127 receiver buildings during the day and night periods, respectively
- There are 77 and 89 receiver buildings predicted to experience acute day $L_{Aeq(15hour)}$ greater than or equal to 65 dB(A) or night $L_{Aeq(9hour)}$ greater than or equal to 60 dB(A)) noise levels due to the project during the day and night periods, respectively.

Some receiver buildings eligible for consideration for additional noise mitigation may fall into more than one of the NMG noise mitigation triggers and have multiple triggers. For example, an eligible receiver building may exceed the cumulative noise limit and also be exposed to acute noise levels.

Other sensitive receivers

Of the 189 receiver buildings identified as being eligible for consideration for additional noise mitigation, 21 receiver buildings are associated with the following other sensitive (non-residential) receivers:

- NCA02: Saint Mary & Saint George Coptic Orthodox Church (place of worship)
- NCA04A: Our Lady of Lourdes Primary School (educational)
- NCA04A: Our Lady of Lourdes Church (place of worship)
- NCA04A: Tarro Public School (educational)
- NCA04B: Newcastle Memorial Park (place of worship)
- NCA04B: Tarro Uniting Church of Australia (place of worship).

The above other sensitive receivers were identified based on the predicted traffic noise levels exceeding the cumulative limit and/or experiencing acute noise levels due to the project.

8.5.2 Operational road traffic noise predictions – impacts with mitigation

Operational noise impacts on noise sensitive receivers have been predicted with quieter pavement surfaces, noise barriers and at-property noise treatments, in accordance with the NMG criteria outlined in **Section 8.2.4**. The following sections describe the operational road traffic noise mitigation measures that have been assumed for the purposes of the assessment and the receivers triggered for consideration of additional noise mitigation. Final noise mitigation treatment would be carried out in accordance with Transport guidelines.

Quieter pavement surfaces

For the purpose of this assessment and in accordance with the NMG, the following quieter pavements have been considered as the first form of noise mitigation to be implemented:

- Open graded asphalt along the upgraded section of the New England Highway, which would achieve a 2 dB(A) noise reduction compared to dense graded asphalt
- Low noise diamond grinding of the concrete pavements along sections of the main carriageways of the project, which would reduce the noise from the concrete pavement equivalent to that of dense graded asphalt.

To investigate the potential benefits of implementing quieter pavements, a comparison of the number of receiver buildings with and without mitigation in the form of quieter pavements was carried out for design year 2038 traffic noise modelling scenarios.

By implementing the proposed quieter pavements, the number of receiver buildings eligible for consideration of additional noise mitigation reduces from 189 to 161 (about a 15 per cent reduction). In addition to the number of receiver buildings being reduced, quieter pavements would also provide an overall noise reduction at all receivers within the operational study area.

The final road pavement surface used for the project will be investigated further during detailed design and would be subject to various requirements besides acoustic benefits, including structural integrity, skid resistance, water dispersion, maintenance, safety and design life.

Noise barriers

The location of noise barriers proposed for the project, where barriers are considered to be a reasonable and feasible noise mitigation option, are shown on **Figure 8-5**. These noise barriers have undergone the NMG barrier analysis, with results of the analysis and recommended reasonable and feasible barrier heights for each location summarised in **Table 8-29**.

The barrier heights indicated in **Table 8-29** are based on the height above the local ground where the proposed barrier is to be located. Receiver counts presented in **Table 8-29** refer to receiver points, where a receiver point is representative of each habitable floor level of a residence. For example, a double storey residence would be represented by two receiver points.

Based on feasibility constraints (including integration with existing noise barriers, interactions with existing utilities, established landscaping and vegetation, heritage, landscape character, visual amenity and constructability), the project would adopt the assessed alternative height for barriers NB.02 (about 3.8 metres) and NB.03 (about four metres).

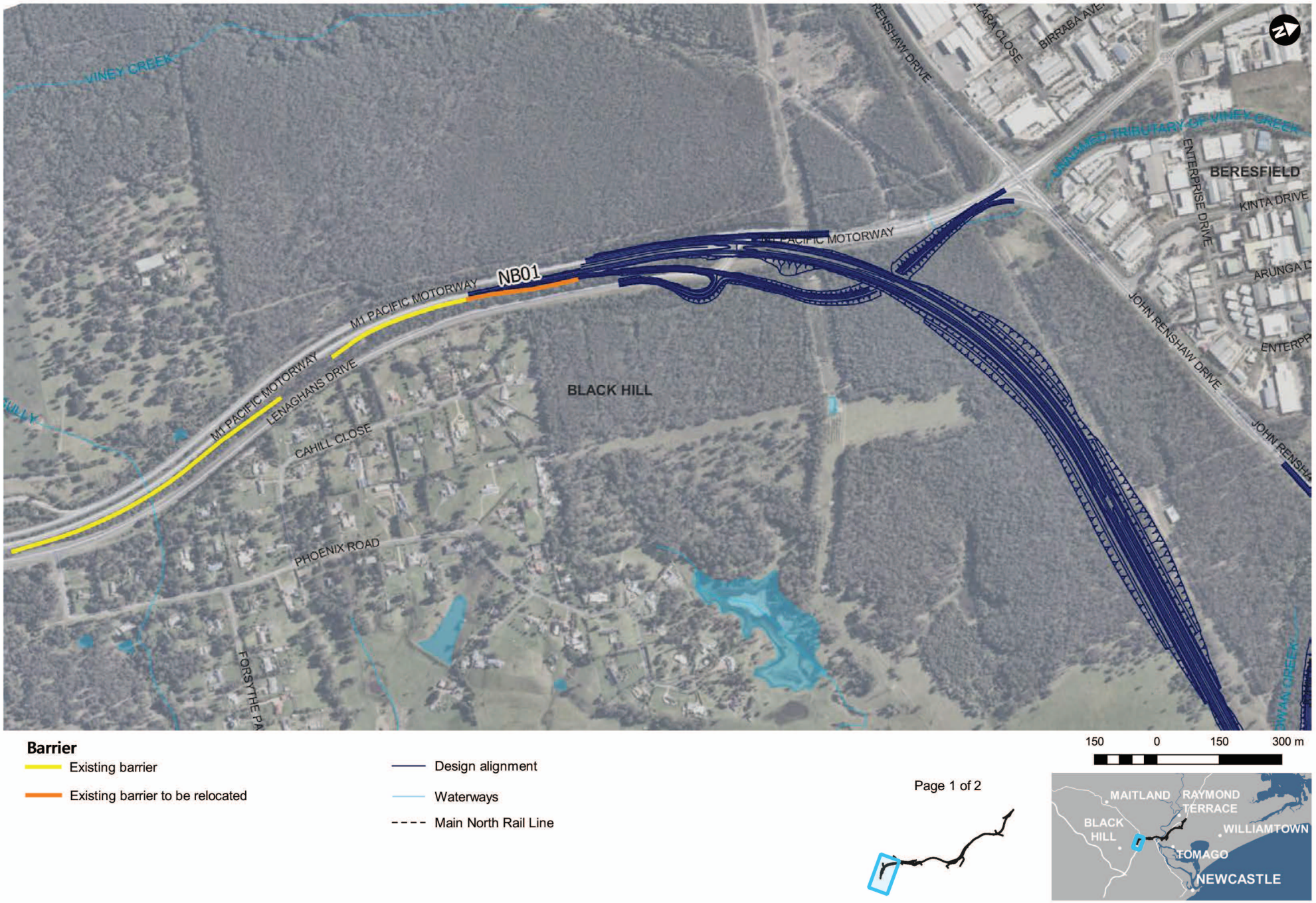

Figure 8-5 Proposed noise barriers considered for NMG analysis (map 1 of 2)

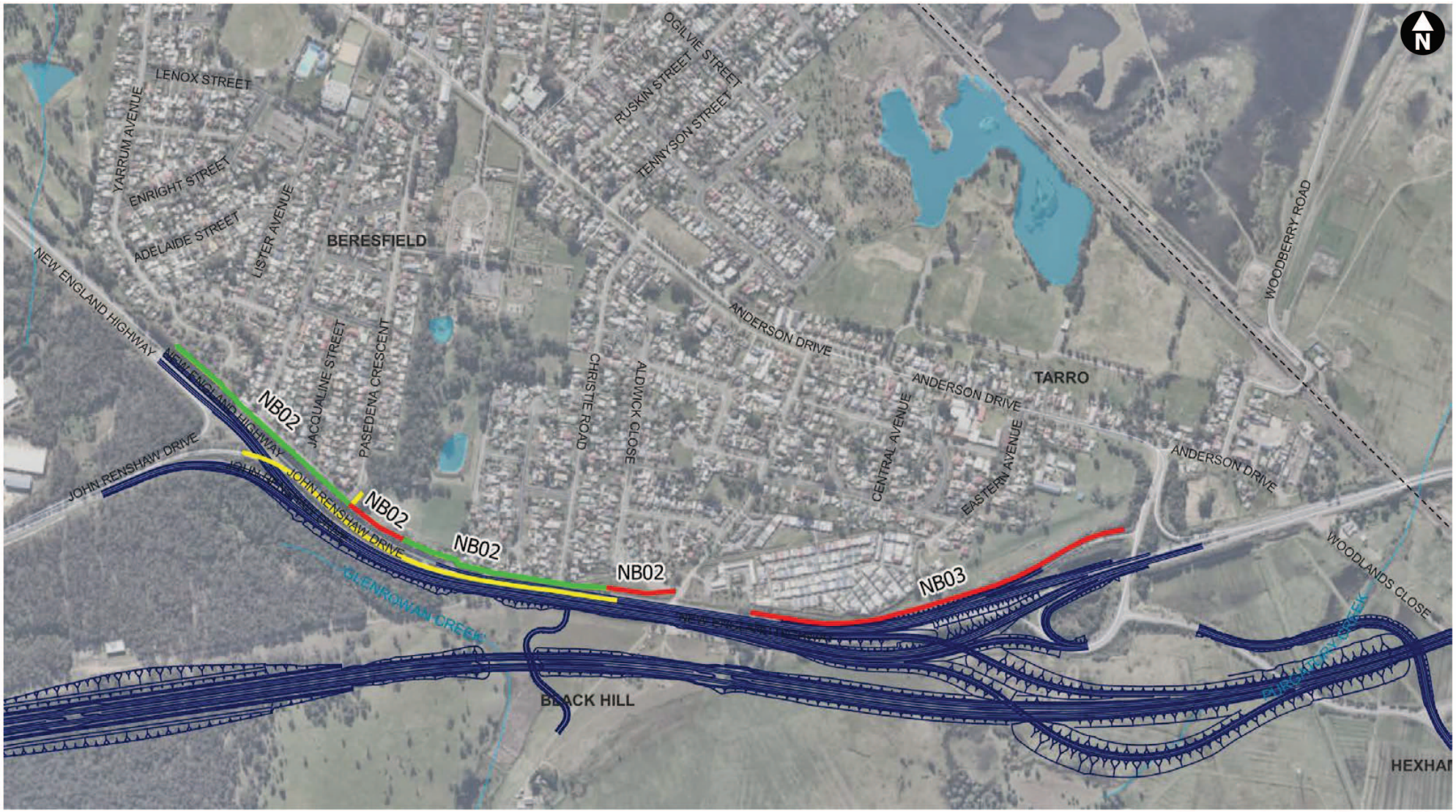

Figure 8-5 Proposed noise barriers considered for NMG analysis (map 2 of 2)

Table 8-28 Summary of NMG noise barrier analysis

Barrier ID	NMG noise barrier analysis						Alternative barrier height (metres) [2, 3]	Comments
	Barrier considered	Approx. length (metres)	Design height (metres) [1, 3]	Total number of benefitting receivers [4]	Triggered receivers with no barrier [4]	Remaining triggered receivers with design barrier [4]		
NB.01	Existing barrier (relocated)	265	-	5	3	3	Retain relocated existing noise barrier	A barrier in this location would not provide acoustic benefits to impacted receivers as the number of receivers identified for at-property treatment would not reduce by two thirds at any barrier height (i.e. no initial design barrier height). Therefore, the existing noise barrier with the same top of barrier height (2.5m) is to be relocated. Increasing the height of the relocated barrier in this location is not reasonable and feasible and is not recommended.
NB.02	Existing barriers (about 3.8m) + new barriers	1105	7	172	36	10	3.8m (consistent with existing barrier heights)	Design barrier height of 7m would provide more than 10 dB(A) insertion loss as required for barriers over 5m. Maintaining the same 3.8m barrier height as the existing barriers would provide more than 5 dB(A) insertion loss as required for barriers 5m and under. Although the design barrier height of 7m would achieve the insertion loss requirements, an alternative barrier height consistent with the lower existing noise barriers may be considered. Constraints affecting the feasibility of the barrier such as the integration with existing structures, removal of vegetation (e.g. well established urban/native trees) as well as urban design and visual amenity impacts would be further investigated during further design development. It is noted that this noise barrier consists of existing barriers and new barriers to fill in the gaps between the existing barriers.

Barrier ID	NMG noise barrier analysis						Alternative barrier height (metres) [2, 3]	Comments
	Barrier considered	Approx. length (metres)	Design height (metres) [1,3]	Total number of benefitting receivers [4]	Triggered receivers with no barrier [4]	Remaining triggered receivers with design barrier [4]		
NB.03	New	741	8	56	35	19	4	Design barrier height of 8m would provide more than 10 dB(A) insertion loss as required for barriers over 5m. The alternative barrier height of 4m achieves the required insertion loss of 5 dB(A) for barriers 5m and under. Therefore, the alternative barrier height of 4m has been considered and would provide a reasonable balance between addressing noise impacts and visual amenity impacts for nearby receivers. Constraints affecting the feasibility of the barrier such as removal of vegetation (e.g. well established urban/native trees) as well as urban design and visual amenity impacts would be further investigated during further design development.

1. Calculated noise barrier height following the process described in Section 8 of the NMG without considering urban design, visual impacts and/or engineering constraints
2. Alternative noise barrier height determined based on urban design, visual impacts and/or engineering constraints
3. Height of barrier based on the height above the local ground where the proposed barrier is to be located
4. Receiver counts based on receiver points, where a receiver point is representative of each habitable floor level of a residence. For example, a double storey residence would be represented by two receiver points.

Receiver buildings considered for at property noise treatment

Following the NMG noise barrier analysis, any residual residential and non-residential sensitive receivers triggered for additional noise mitigation and still exceeding the relevant NCG traffic noise criteria would be considered for at-property treatment. A summary of the number of receiver buildings identified as being eligible for consideration of at-property treatment based on the design barrier and alternative barrier heights is presented in **Table 8-29**.

Receiver buildings identified as potentially eligible for at-property treatment are presented in the Noise and Vibration Working Paper (**Appendix H**).

Table 8-29 Number of receiver buildings potentially eligible for at-property noise mitigation treatment

NCA	Design barrier height		'Alternative' barrier height	
	Number of residential receiver buildings[1, 2]	Number of non-residential receiver buildings[1, 2]	Number of residential receiver buildings[1, 3, 4]	Number of non-residential receiver buildings[1, 3, 4]
NCA01A	4	0	4	0
NCA01B	0	0	0	0
NCA02	0	1	0	1
NCA04A	44	18	85	18
NCA04B	0	2	0	2
NCA05A	1	0	1	0
NCA05B	0	0	0	0
NCA07	1	0	1	0
NCA09	1	0	1	0
NCA12	6	0	6	0
NCA13	2	0	2	0
NCA14A	38	0	38	0
NCA14B	1	0	1	0
NCA14C	0	0	0	0
Total	**98**	**21**	**139**	**21**

1. A receiver building represents the individual building outlines as shown in Appendix D of the Noise and Vibration Working Paper (**Appendix H**)
2. Based on the implementation of quieter pavements and the design barrier heights nominated in **Table 8-28**
3. Based on the implementation of quieter pavements and the alternative barrier heights nominated in **Table 8-28**
4. Only receiver buildings in NCA04A, NCA04B and NCA05A are protected by the 'alternative' barrier.

The number of receivers considered for at-property treatment would be confirmed during detailed design. Additional investigations to consider at-property noise treatments are outlined in **Section 8.6**.

Other sensitive receivers

From **Table 8-29** the non-residential receiver buildings identified as being eligible for consideration of at-property treatment are associated with the following other sensitive receivers:

- NCA02: Saint Mary & Saint George Coptic Orthodox Church (place of worship)
- NCA04A: Our Lady of Lourdes Primary School (educational)
- NCA04A: Our Lady of Lourdes Church (place of worship)
- NCA04A: Tarro Public School (educational)
- NCA04B: Newcastle Memorial Park (place of worship)
- NCA04B: Tarro Uniting Church of Australia (place of worship).

It is noted that the introduction of quieter pavements and noise barriers do not provide sufficient benefits to the above other sensitive receivers and associate receiver buildings to allow traffic noise impacts to comply with the corresponding NCG project road criterion. This is due to these receivers being located at distances greater than 100 metres from the traffic noise source, resulting in marginal noise mitigation benefits.

Furthermore, given that other sensitive receivers are assessed against internal noise criteria, further investigation during further design development would be required for non-residential receiver buildings considered for at-property treatment to confirm the extent of noise impact and eligibility for consideration of noise mitigation. This is because the difference in noise from outside to inside can increase to more than 30 dB(A) depending on the building construction type, location of the room within the building, window type and whether the use of the space requires the window to be fully opened, slightly opened or closed.

8.5.3 Maximum noise level assessment

Maximum noise levels across the project were assessed based on the results of noise monitoring carried out for the project (**Section 8.3.2**) and the methodology presented in **Section 8.2.4**.

Maximum noise levels range from 68 dB(A) and 87 dB(A), with the highest noise levels typically recorded at locations near or adjacent to the M1 Pacific Motorway, New England Highway and the Pacific Highway.

The project is predicted to potentially change maximum noise levels and events (refer to **Section 8.2.4**) at the following NCAs:

- NCA01A: receivers to the east of the M1 Pacific Motorway may experience an increase in maximum noise levels and the number of events compared to the existing situation. This is due to the widening of the M1 Pacific Motorway and the introduction of the Black Hill interchange moving traffic closer to receivers in this NCA. Receivers in the northern section of this NCA may also experience increases in maximum noise levels and number of events due to the introduction of new carriageways to the north
- NCAs 04A, 04B and 05A: receivers to the north of the New England Highway may experience a reduction in the number of maximum noise level events due to vehicles using the project's new carriageways, and the widening of the New England Highway toward the south. However, maximum noise levels would likely remain the same as the northern side of the New England Highway would remain the same as the existing
- NCAs 14A and 14B: receivers to the west of the Pacific Highway and the project may experience a reduction in the number of maximum noise level events due to vehicles travelling along the project east of the Heatherbrae industrial precinct.

For NCAs where maximum noise levels and the number of events would increase due to the project, the affected receivers may be considered for additional noise mitigation measures. With the implementation of noise mitigation measures, there would be an overall reduction in road traffic noise levels, including L_{Amax} noise levels.

8.6 Environmental management measures

The environmental management measures that will be implemented to minimise the noise and vibration impacts of the project, along with the responsibility and timing for those measures, are presented in **Table 8-30**.

Table 8-30 Management measures (noise and vibration)

Impact	Reference	Environmental management measure	Responsibility	Timing
General construction noise and vibration	NV01	A Construction Noise and Vibration Management Plan (CNVMP) would be prepared for the project to mitigate and manage noise and vibration impacts. The CNVMP would include: • All potential significant noise and vibration generating activities associated with the activity • Measures to be implemented during construction to minimise noise and vibration impacts, such as restrictions on working hours, respite periods, staging, placement and operation of ancillary facilities, temporary noise barriers, haul road maintenance, and controlling the location and use of vibration generating equipment • A monitoring program to assess performance against relevant noise and vibration criteria • Process for the implementation of respite periods to provide residents with respite from ongoing impact • Arrangements for consultation with affected receivers, including notification and complaint handling procedures • Contingency measures to be implemented in the event of noncompliance with noise and vibration criteria.	Contractor	Prior to construction/ construction
	NV02	Where reasonable and feasible, implementation of recommended operational noise mitigation would be carried out within 12 months of construction activities commencing.	Transport / Contractor	Prior to construction/ construction
Vibration impacts to residential and commercial structures	NV03	Where vibration generating activities will be carried out within minimum working distances for cosmetic damage, vibration monitoring will be carried out. Where monitoring indicates cosmetic damage criteria are exceeded, alternative low vibration work practices will be investigated and implemented.	Contractor	Construction
Vibration impacts to utilities	NV04	Where works are within 25m of utilities consultation will be carried out with the relevant utility authorities to establish site specific mitigation measures to manage potential vibration impacts.	Contractor	Construction

Impact	Reference	Environmental management measure	Responsibility	Timing
Vibration impacts to heritage structures	NV05	Heritage items within 100m of vibration intensive work are to be considered on a case by case basis and further investigation would be carried out during detailed design to confirm the structural integrity (i.e. structurally sound or unsound) of all potentially affected structures. Where items are considered sensitive to vibration, appropriate vibration criteria would be determined after detailed inspections have been completed.	Contractor	Prior to construction/ construction
Blasting	NV06	If blasting is to be included as part of the construction work, the CNVMP would include a Blast Management Plan (BMP). The BMP would be prepared in consultation with the EPA, demonstrating that all blasting and associated activities would be carried out in a manner that would not generate unacceptable noise and vibration impacts or pose a substantial risk impact to residences and sensitive receivers.	Contractor	Prior to construction/ construction
Operational road traffic noise impacts	NV07	Operational noise and vibration mitigation measures would be identified in an Operational Noise and Vibration Review (ONVR). Requirements for mitigation measures, including quieter noise pavements, noise barriers, and at-property treatments, would be reviewed as part of the ONVR and as the detailed design progresses. Detailed information on floorplans and facade construction for school classrooms, places of worship and childcare centres determined to exceed the applicable Noise Criteria Guideline (NCG) (Roads and Maritime Services 2015c) internal noise criteria will be obtained during design development. The implementation of treatments would be carried out in accordance with the Noise Mitigation Guideline (NMG) (Roads and Maritime Services 2015d).	Transport / Contractor	Detailed design/ construction/ prior to operation
Operational road traffic noise impacts	NV08	Within 12 months of starting project operation, actual operational noise performance would be compared to predicted operational noise performance to analyse the effectiveness of the operational road traffic noise mitigation measures. Additional reasonable and feasible mitigation would be considered where any additional receivers are identified as qualifying for consideration of noise mitigation under the NMG.	Transport / Contractor	Operation

Impact	Reference	Environmental management measure	Responsibility	Timing
Impacts from Out of Hours Works	NV09	An Out of Hours Work Procedure will be included as part of the CNVMP. The procedure will follow the approach in Roads and Maritime Services' Construction Noise and Vibration Guideline (Roads and Maritime Services 2016b) and include, but not be limited to: • Scheduling of noise intensive or high noise impact work to evening periods where feasible • Use of alternative plant and equipment and/or construction techniques to minimise noise • Notification and consultation requirements including preparation of a 'look ahead' program for likely out of hours work • Use of temporary noise barriers • Respite periods • Representative noise monitoring • Offers of reasonable and temporary alternative accommodation or an act of good will • Use of negotiated agreements.	Contractor	Construction