Chapter 11
Noise and vibration

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11 Noise and vibration

This chapter summarises the noise and vibration assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full noise and vibration assessment is provided in Appendix G (Technical report – Noise and vibration).

11.1 Assessment approach

11.1.1 Overview

The assessment methodology for the construction and operational noise and vibration impact assessment involved:

- identifying a study area and noise catchment areas (NCAs) as detailed in Section 11.2.1 and shown in Figure 11-1
- classifying sensitive receivers as detailed in Annexure A of Appendix G (Technical report – Noise and vibration)
- characterising the existing noise environment based on attended and unattended noise measurements
- determining noise and vibration management levels in accordance with relevant guidelines and criteria
- developing representative construction scenarios
- modelling to quantify the potential construction and operational noise and vibration impacts for key project elements including:
  - ground-borne and airborne noise and vibration from construction of the project
  - airborne noise from vehicles on the surface road network during operation
  - airborne noise from operational ancillary infrastructure
- assessing the significance of potential impacts identified
- examining the proposed construction methodologies and identifying mitigation measures that would be required to minimise construction noise and vibration impacts
- identifying appropriate mitigation measures that would be implemented to manage identified operational noise impacts.

11.1.2 Construction assessment

Guidelines adopted for construction noise and vibration assessment

Guidelines adopted for the assessment of construction noise and vibration for the project are outlined in Table 11-1.

Table 11-1 Relevant guidelines adopted for the construction noise and vibration assessment

Assessment and Guideline(s)	Description
Airborne construction noise Interim Construction Noise Guideline (ICNG) (Department of Environment and Climate Change (DECC), 2009) Construction Noise and Vibration Guideline (for Road and Maritime Works) (Transport for NSW, 2022b)	The 'worst-case' noise levels from construction of the project are predicted and then compared to the Noise Management Levels (NMLs) to determine the likely impact of the project in accordance with the ICNG. Construction NMLs for residential receivers are summarised in Table 11-2 and for other sensitive receivers in Table 11-3.
Construction vibration <u>Heritage structures</u> German Standard DIN 4150 – Part 3 – Structural Vibration in Buildings – Effects on Structures (DIN 4150) <u>Non-heritage structures</u> Evaluation and Measurement for Vibration in Buildings Part 2, (British Standard (BS) 7385: Part 2-1993) (BS 7385) <u>Human comfort (tactile vibration)</u> Assessing Vibration: A Technical Guideline (AVATG)1 (Department of Environment and Conservation, 2006) <u>Human comfort (ground-borne noise)</u> Interim Construction Noise Guideline (ICNG) (DECCW, 2009) Construction Noise and Vibration Guideline (for Road and Maritime Works) (Transport for NSW, 2022b)	The effects of vibration in buildings can be divided into different categories, including: • loss of amenity due to perceptible vibration (human comfort) • where the integrity of the building may be compromised including structural or cosmetic damage • where impacts may affect sensitive scientific and medical equipment • where structures and utilities sensitive to vibration are encountered (such as heritage structures).
Construction traffic noise NSW Road Noise Policy (RNP) (DECCW, 2011)	An initial screening test is to be carried out by evaluating whether existing road traffic noise levels would increase by more than 2 dBA. Where the predicted noise increase is 2 dBA or less, then no further assessment is required. However, where the predicted noise level increase is greater than 2 dBA, and the predicted road traffic noise level exceeds the road category specific criterion, then noise mitigation should be considered for affected receivers. An increase of up to 2 dBA represents a minor impact that is barely perceptible to the average person.

Assessment and Guideline(s)	Description
Ground-borne construction noise Interim Construction Noise Guideline (ICNG) (DECC, 2009) Construction Noise and Vibration Guideline (for Road and Maritime Works) (Transport for NSW, 2022b)	Ground-borne noise is generated by vibrations arising from a ground-based source, typically underground mechanical equipment. The ground-borne noise goals for residences are: • evening (6pm to 10pm weekdays): 40 dBA $LA_{eq(15\text{-}minute)}$[1] • night-time (10pm to 7am): 35 dBA $LA_{eq(15\text{-}minute)}$ Ground-borne noise is generally less audible during the day time due to higher ambient noise levels and therefore typically only vibration criteria apply during the day time.
Sleep disturbance and awakening NSW Road Noise Policy (RNP) (DECCW, 2011) Noise Policy for Industry (NPfI) (NSW EPA, 2017)	The RNP has been used as the primary guidance relevant to the assessment of sleep disturbance and awakening. It recommends that the typical maximum noise level should not exceed the background noise level + 15 dB and that at levels above 55 dBA L_{max}[2] sleep awakening would be considered likely. The NPfI also outlines the following screening levels to identify where further investigation of sleep disturbance and awakening should be carried out: • $L_{eq,15min}$ 40 dBA or the prevailing rating background level[3] (RBL) plus 5 dB, whichever is greater, and/or • L_{Fmax} 52 dBA or the prevailing RBL plus 15dB, whichever is the greater. Therefore, sleep disturbance and awakening external noise screening levels of RBL+15 dB and L_{max} 65 dBA, whichever is most conservative (lowest) within each NCA have been adopted.
Blasting Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment and Conservation Council (ANZECC), 1990) Explosives − Storage and Use − Part 2: Use of Explosives (Australian Standard 2187: Part 2-2006) (AS 2187)	The NSW EPA has adopted this guideline as the basis for comfort criteria to minimise annoyance and discomfort to persons at noise sensitive sites as a result of blasting. The guidelines are not intended to provide structural damage criteria, but provide a conservative approach to the assessment of potential impacts on structures as minimising human annoyance and comfort would inherently minimise structural damage. Australian Standard 2187 is consistent with the ANZEC guidelines, however provides more detail with respect to criteria for human comfort and structural damage.

Table notes:

1. $L_{Aeq(period)}$ – the 'energy average noise level' evaluated over a defined measurement period (typically 15 minutes for construction noise or the relevant daytime, evening or night-time period for ambient noise monitoring)
2. L_{Amax} – the 'maximum noise level for an event, used in the assessment of potential sleep disturbance and awakening during night-time periods
3. Rating background level (RBL) or $L_{A90(period)}$ – the background noise level in the absence of proposed construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods and is used to set the $L_{Aeq(15minute)}$ NMLs for residential receivers

Table 11-2 Construction noise management levels (NMLs) for residential receivers

Time of day	NML, $L_{Aeq,15min}$, dBA[1]
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected: RBL + 10 dB
	Highly noise affected: 75 dBA
Outside recommended standard hours	Noise affected: RBL + 5 dB

Table notes:

1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 11-3 Construction noise management levels (NMLs) for other sensitive receivers

Receiver type	NML (external), $L_{Aeq,15min}$, dBA (when properties are in use)
Industrial premises	75 dBA
Offices, retail outlets	70 dBA
Educational institutions	45 dBA[1]
Place of worship	45 dBA[1]
Active recreation areas	65 dBA
Community centres	Depends on the intended use of the centre. Refer to the recommended “maximum” internal levels in AS2107 for specific uses.

Table notes:

1. Assumes an external to internal noise level reduction through a partially open window of 10 dBA.

Representative construction scenarios

Representative construction scenarios have been developed to assess the likely impacts during the various construction phases of the project. The representative construction scenarios are summarised in Table 11-4.

Table 11-4 Representative construction scenarios for the project

Construction scenario and key activities	Location	Work hours
Site establishment and enabling works Preliminary site investigations and preparatory works, vegetation clearing and establishment of site facilities and temporary traffic, environmental and safety controls. High noise generating plant would include excavators, bulldozers, chainsaws, vibratory rollers and dump trucks. Assessment of the construction water supply pipeline is included in Section 11.3.9.	Construction sites at: • Blackheath • Soldiers Pinch • Little Hartley	Standard construction hours

Construction scenario and key activities	Location	Work hours
Tunnel portal construction Excavation, stabilisation and excavation support, piling works, installation of tunnel portal infrastructure, waterproofing and dewatering and finishing works. High noise generating plant would include excavators, piling rigs, drilling rigs, roadheaders, grout mixers and pumps and concrete saws.	Tunnel portals (limited area within the construction sites) at: • Blackheath • Little Hartley	Standard construction hours
Tunnelling, tunnelling support activities, and associated works Tunnel excavation and installation of segment lining using tunnel boring machines (TBMs) and excavation of cross-passages, substations and the mid tunnel access shaft and caverns using roadheaders. Excavation of the TBM launch and retrieval sites and within tunnel civil finishing works, fit-out, testing and commissioning. Temporary storage of tunnel lining segments, concrete batching plant and mixing facilities, spoil handling and stockpiling areas within an acoustic shed, operation and maintenance of the water treatment plant and other water quality controls, installation and operation of fresh air ventilation, workforce amenities, offices and parking. High noise generating plant would include excavators, rock breakers and screening plants, piling and drilling rigs, shotcrete rigs, roadheaders, TBMs and grout mixer and pumps.	Within the tunnel and a limited area within the construction sites at: • Blackheath • Soldiers Pinch • Little Hartley	At Blackheath and Soldiers Pinch: standard construction hours. Underground and at Little Hartley: 24 hours per day, seven days a week.
Surface road upgrade works Earthworks, construction of stormwater drainage, road pavement works and construction of road furniture and surface finishing works. High noise generating plant would include excavators, dump trucks, vibratory rollers, concrete saws, piling and drilling rigs, shotcrete rigs, grout mixer and pumps and water trucks.	Construction sites at: • Blackheath • Little Hartley	Standard construction hours
Operational ancillary facilities works Construction of: • tunnel operations facility east of Blackheath • tunnel ventilation facilities at Blackheath and Little Hartley (ventilation outlet design option only) • tunnel fire suppression facilities • operational water treatment plant • electrical substations at Blackheath and Little Hartley. High noise generating plant would include dump trucks, concrete pumps, shotcrete rigs, water trucks and grout mixers and pumps.	Within the tunnel and construction sites at: • Blackheath • Little Hartley	Standard construction hours
Finishing works, testing and commissioning Installation of signage and other roadside furniture including lighting and electronic and static signage, new pavement and line marking, landscaping and revegetation work, site demobilisation and rehabilitation work. High noise generating	Within the tunnel and construction sites at: • Blackheath	Standard construction hours

Construction scenario and key activities	Location	Work hours
plant would include dump trucks, water trucks, road sweepers, line marking trucks and franna cranes.	• Soldiers Pinch • Little Hartley	

11.1.3 Operational assessment

The RNP requires assessment of two scenarios: the 'without project' scenario and the 'with project' scenario. Each of these scenarios must be considered at the time of opening and the design year, typically ten years after opening. For this project, the year 2030 has been assessed as the year of opening and 2040 for the design year.

Operational road traffic noise

Operational road traffic noise criteria

Operational road traffic noise criteria are based on the road development type which would affect the residential receiver. Where the criteria are exceeded due to the project, reasonable and feasible mitigation measures are required.

The operational road traffic noise assessment criteria applied to residential receivers are summarised in Table 11-5, and in Table 11-6 for non-residential receivers such as schools, places of worship and childcare facilities.

Table 11-5 Traffic noise assessment criteria – residential receivers

Road category	Type of project/land use	Assessment criteria (external)	
		Day (7am-10pm)	Night (10pm-7am)
Freeway/ arterial/ sub-arterial	Existing residences affected by noise from new freeways/arterial/sub-arterial road corridors.	55 dBA $L_{Aeq(15\ hr)}$	50 dBA $L_{Aeq(9\ hr)}$
	Existing residences affected by noise from redevelopment of existing freeways/arterial/sub-arterial roads. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments. Existing residences affected by noise from existing freeway/arterial/sub-arterial roads where no redevelopment is taking place.	60 dBA $L_{Aeq(15\ hr)}$	55 dBA $L_{Aeq(9\ hr)}$
	Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a Transition Zone[1].	55-60 dBA $L_{Aeq(15\ hr)}$	50-55 dBA $L_{Aeq(9\ hr)}$
	Existing residences affected by increases in traffic noise of 12 dBA or more from new freeway/arterial/sub-arterial roads[2].	42-55 dBA $L_{Aeq(15\ hr)}$	42-50 dBA $L_{Aeq(15\ hr)}$

Table notes:

1. The criteria assigned to a façade depend on the proportion of noise coming from the existing road. Please see Transport for NSWs' Road Noise Criteria Guideline (Transport for NSW, 2022j) for further information.
2. The criteria at each façade are determined from the existing traffic noise level plus 12 dBA.

Table 11-6 Traffic noise assessment criteria – other sensitive receivers

Existing sensitive land use	Assessment criteria	
	Day (7am-10pm)	Night (10pm-7am)
School classrooms	40 dBA (internal), $L_{Aeq(1\ hr)}$	-
Hospital wards	35 dBA (internal), $L_{Aeq(1\ hr)}$	35 dBA (internal), $L_{Aeq(1\ hr)}$
Places of worship	40 dBA) (internal), $L_{Aeq(1\ hr)}$	40 dBA (internal), $L_{Aeq(1\ hr)}$
Open space (active use)	60 dBA, $L_{Aeq(15\ hr)}$	-
Open space (passive use)	55 dBA, $L_{Aeq(15\ hr)}$	-
Child care facilities	Sleeping rooms 35 dBA (internal), $L_{Aeq(1\ hr)}$ Indoor play areas 40 dBA (internal), $L_{Aeq(1\ hr)}$ Outdoor play areas 55 dBA (external), $L_{Aeq(1\ hr)}$	-
Aged care facilities	-	Residential land use noise assessment criteria should be applied to these facilities.

Table notes:

1. For schools, places of worship and childcare facilities, the Road Noise Criteria Guideline (Transport, 2022j) criteria are based on internal noise levels.
2. A conservative minimum outside-to-inside attenuation of 10 dBA, on the basis of open windows for natural ventilation, has been assumed to allow for an external noise assessment at the other sensitive receivers.

Operational road traffic noise modelling scenarios

Operational road traffic noise levels for both daytime and night-time periods have been assessed for the following scenarios:

- Year 2030 'without project' scenario – a future network scenario for the year 2030 assuming the Upgrade Program would not be built
- Year 2030 'with project' scenario – a future network scenario for the year 2030 that incorporates all components of the Great Western Highway Upgrade Program
- Year 2040 'without project' scenario – a future network scenario for the year 2040 assuming the Upgrade Program would not be built
- Year 2040 'with project' scenario – a future network for the year 2040 that incorporates all components of the Great Western Highway Upgrade Program.

Operational noise from fixed facilities

Noise from operational ancillary facilities (fixed facilities) associated with the project has been assessed in accordance with the NPfI (NSW EPA, 2017) including consideration of:

- the intrusive noise impacts in the short term for residences (generally considered acceptable if the level of noise from the source does not exceed the background noise level by more than 5 dBA)
- maintaining noise level amenity for residences and other land uses (generally equal to the recommended amenity level minus 5 dBA).

Maximum road traffic noise levels

Maximum noise levels generated by road traffic using the project have been considered in accordance with the Environmental Noise Management Manual (Transport for NSW, 2015b). The

measured maximum noise level and the number of maximum noise level events have been used as an indicator of the potential for sleep disturbance.

11.2 Existing environment

The existing noise environment surrounding the project is dominated by traffic using the existing Great Western Highway. Existing noise levels are generally higher in the daytime, and in some areas during the evening. Night-time noise levels are generally low. The existing noise environment is characteristic of a quiet village setting for receivers located away from the Great Western Highway, with higher existing noise levels experienced by receivers along the Great Western Highway.

Based on 2018 yearly traffic count data from the Mount Victoria traffic station, on an average weekday there is an average of 5,500 to 5,800 vehicle movements on the Great Western Highway and on an average weekend day there is an average of 6,200 to 6,600 vehicle movements. During the weekday peak hour, about 80 to 85 per cent of traffic is made up of light vehicles and light vehicles with trailers and about 15 to 20 per cent of traffic count is made up of heavy vehicles (refer to Chapter 8 (Transport and traffic)).

Around Blackheath, the noise environment is dominated by road traffic noise from the existing Great Western Highway and other local roads. The Main Western Railway runs parallel to some sections of the Great Western Highway and therefore also contributes to the existing noise environment around the project.

Around Soldiers Pinch, the existing noise environment is dominated by traffic noise from the existing Great Western Highway and the railway line. This area is well to the south of Mount Victoria and includes a few isolated receivers, the closest being the recreational site of Browntown Oval.

At Mount Victoria, the existing acoustic environment transitions from road noise affected to a quiet village setting with distance from the Great Western Highway and the adjacent railway line, similar to around Blackheath.

Around Little Hartley, there are relatively few receivers with scattered commercial developments along the Great Western Highway and isolated rural residential properties. The relatively flat topography and few intervening structures in this area means that the effects of traffic noise from the existing Great Western Highway are generally experienced at a greater distance from the highway than in Mount Victoria or Blackheath.

11.2.1 Noise catchment areas and sensitive receivers

The area around the project has been divided into 14 NCAs (as shown in Figure 11-1), representing groups of noise sensitive receivers experiencing a similar existing noise environment. The NCAs have been identified around project noise sources, taking into account the nature and distribution of sensitive receivers, existing noise conditions and the anticipated level of impact that may occur during construction and operation of the project. Sensitive receivers have been categorised based on their use, as defined in the NPfI (NSW EPA, 2017) as follows:

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

Further discussion regarding the NCAs adopted for the assessment of the project, as well as the location of individual sensitive receivers identified for the project is provided in Section 2.3 of Appendix G (Technical report – Noise and vibration). Annexure A of Appendix G (Technical report – Noise and vibration) identifies all noise sensitive receivers.

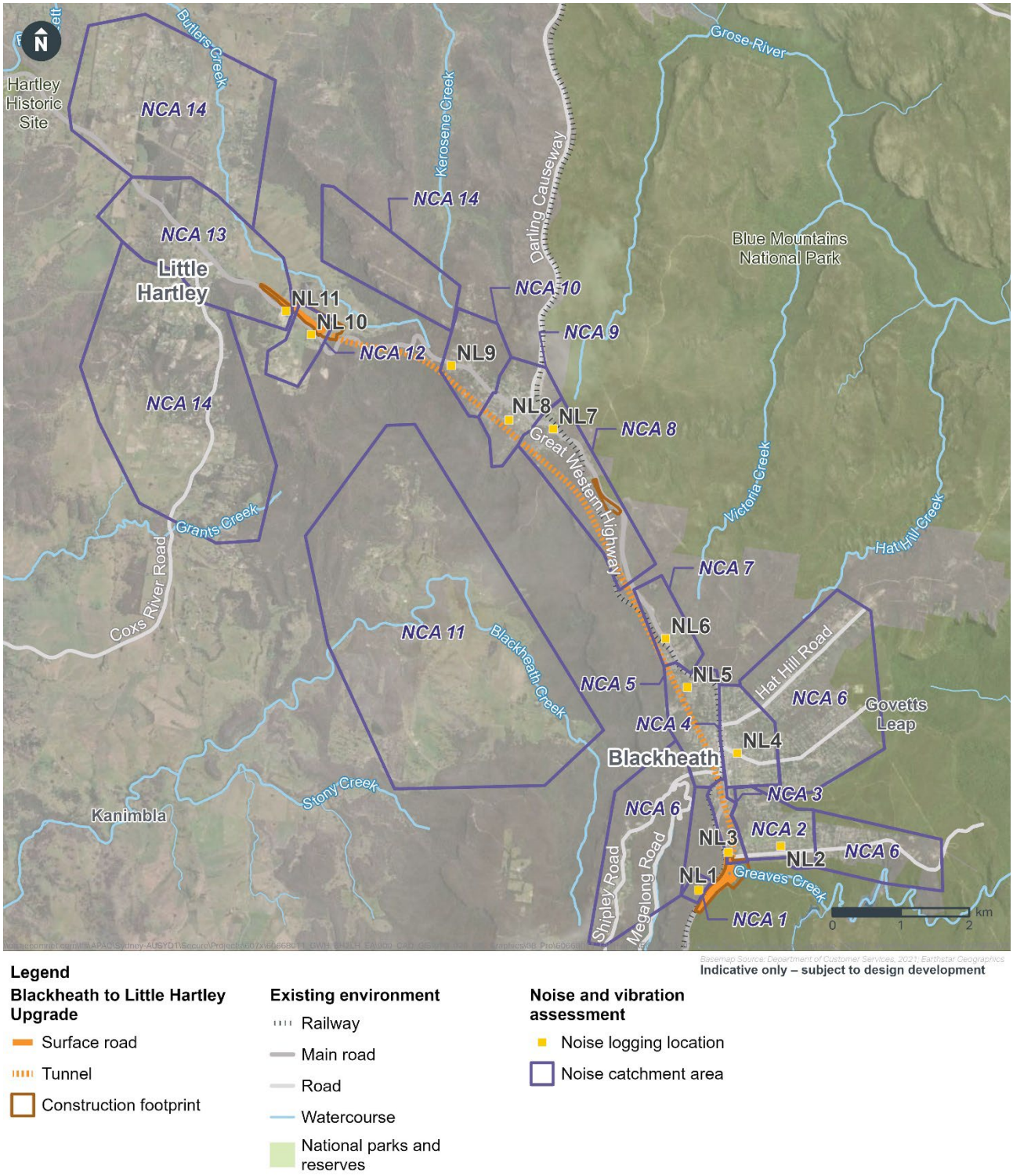

Figure 11-1 Noise catchment areas (NCAs) and monitoring locations (NLs)

11.2.2 Existing noise environment

Ambient noise measurements

Eleven noise monitoring locations were used to characterise the existing noise environment in the area surrounding the project and to identify sensitive receivers potentially impacted by the project. The noise monitoring locations selected for the assessment are representative of the existing background noise environment in each NCA and are shown in Figure 11-1.

Ambient noise measurements were collected from 9 to 21 December 2021, concurrently with traffic counts. Details of each noise logging location and the purpose of the noise logger are provided in Table 11-7. Weather data recorded during the noise monitoring survey periods was obtained from the Bureau of Meteorology weather station, located at Mount Boyce (ID063292).

Table 11-7 Noise logging locations and purpose

ID	Location	Purpose		
		Construction	Operational traffic	Operational fixed facilities
NL1	82 Station Street, Blackheath	✓	✓	✓
NL2	69A Brightlands Avenue, Blackheath	✓	-	✓
NL3	89 Great Western Highway, Blackheath	✓	✓	✓
NL4	56 Govetts Leap Road, Blackheath	✓	-	-
NL5	28 Kanimbla Road, Blackheath	✓	-	-
NL6	355 Great Western Highway, Blackheath	-	✓	-
NL7	149 Great Western Highway, Mount Victoria	-	✓	-
NL8	21 Kanimbla Valley Road, Mount Victoria	✓	-	✓
NL9	9 Great Western Highway, Mount Victoria	-	✓	-
NL10	2133 Great Western Highway, Little Hartley	-	✓	-
NL11	2187 Great Western Highway, Little Hartley	-	✓	-

Unattended background noise monitoring results

Table 11-8 summarises the representative L_{Aeq} ambient noise levels and the L_{A90} rating background noise levels for the existing environment at each noise monitoring location during the day, evening and night-time periods. The representative L_{Aeq} noise levels were determined by logarithmically averaging noise measurements in each time period for the entire duration of noise logging.

Table 11-8 Existing ambient (L_{Aeq}) and rating background (L_{A90}) noise levels

ID	Ambient noise (L_{Aeq}), dBA			Rating background noise (L_{A90}), dBA		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NL1	53	52	51	46	38	30 (29)[2]
NL2	49	48	43	35 (29)[2]	30 (25)[2]	30 (22)[2]
NL3	61	59	58	49	35	30 (24)[2]
NL4	59	56	52	40	35	32
NL5	49	49	47	39	37	30 (25)[2]
NL6	73	70	69	50	37	30 (26)[2]

ID	Ambient noise (L_{Aeq}), dBA			Rating background noise (L_{A90}), dBA		
	Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NL7	68	65	64	48	42	40
NL8	48	46	43	36	36	30 (25)[2]
NL9	64	60	61	45	37	30 (29)[2]
NL10	60	58	58	47	42	33
NL11	65	61	62	48	41	35

Table notes:

1. Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays and Public Holidays. Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday and Public Holidays. Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays
2. Where the rating background level is found to be less than 35 dBA during the daytime then it is set to 35 dBA. Where it is found to be less than 30 dBA during evening or night-time then it is set to 30 dBA in accordance with NSW NPfI

Road noise monitoring results

Existing traffic noise levels were measured at some of the noise monitoring locations and are summarised in Table 11-9.

Traffic counts were carried out during the ambient noise monitoring period. These results indicate that two-way volumes on the Great Western Highway varied between 5,000 and 10,000 vehicles per day. The heavy vehicle ratio was around 15 to 20 per cent during the day with the night-time heavy vehicle ratio being around double the daytime ratio. Average vehicle speeds were between 60 and 80 kilometres per hour. Further details of the road traffic counts completed for this assessment are included in Section 2.7 of Appendix G (Technical report – Noise and vibration).

Table 11-9 Existing road traffic noise levels

ID	Ambient road traffic noise level, dBA	
	Day[1] ($L_{Aeq,15\ hr}$)	Night[1] ($L_{Aeq,9\ hr}$)
NL1	53	51
NL3	61	58
NL6	72	69
NL7	67	64
NL9	63	61
NL10	60	58
NL11	64	62

Table notes:

1. Day is defined as 7:00 am to 10:00 pm. Night is defined as 10:00pm to 7:00am

11.2.3 Heritage and other sensitive structures

Heritage and other sensitive structures have the potential to be more susceptible to damage from vibration than standard buildings. An assessment of minimum separation distances from vibration intensive plant and equipment has identified that buildings and structures within 60 metres of such plant and equipment may be affected by vibration.

Table 11-10 lists the heritage items within 60 metres of project construction sites or the outer edge of the project tunnels. Further discussion of these heritage items and their values is provided in Chapter 17 (Non-Aboriginal heritage).

Table 11-10 Heritage items within 60 metres the construction sites and project tunnels

Heritage item	Heritage list and identifier	Proximity to project (≤60 metres)			
		Blackheath	Soldiers Pinch	Little Hartley	Tunnels[1]
Greater Blue Mountains Area	World Heritage List, National Heritage List		✓		
Greater Blue Mountains Area – Additional Values	Nominated Place – National Heritage List	✓	✓		
Soldiers Pinch	Blue Mountains LEP, MV009		✓		
Rosedale	Lithgow LEP, I024			✓	
Nioka	Lithgow LEP, I025			✓	
Blackheath Stockade and the Western Road – archaeological sites	Blue Mountains LEP, BH034				✓
Lookout Hill Heritage Conservation Area	Blue Mountains LEP, BH215				✓
St Mounts	Blue Mountains LEP, BH052				✓
Blackheath West Heritage Conservation Area	Blue Mountains LEP, BH214				✓
Guinness Lodge/Evanville	Blue Mountains LEP, BH059				✓
Tree Tops and garden	Blue Mountains LEP BH065				✓
Ban Tigh, Brewery site and Garden	Blue Mountains LEP BH060				✓
Osborne Cottage (site only)	Blue Mountains LEP, BH039				✓
Montana	Blue Mountains LEP, BH071				✓
Central Mount Victoria Heritage Conservation Area	Blue Mountains LEP, MV023				✓
Mitchell's Ridge Monument Reserve	Blue Mountains LEP, MV015				✓
Victoria Pass	Lithgow LEP, A183; Blue Mountains LEP, MV087				✓
Berghofer's Pass	Blue Mountains LEP, MY001				✓

Table notes:
1. 60 metres measured laterally from the project tunnel's outer edge

11.3 Potential impacts – construction

A summary of the main findings from the construction noise and vibration assessment is provided in the following sections. A detailed breakdown of the predicted noise levels is provided in Section 4.5 of Appendix G (Technical report – Noise and vibration). These results are prior to the application of mitigation and identified exceedances of NMLs would be reduced through reasonable and feasible mitigation measures.

11.3.1 Residential receivers

Table 11-11 presents the construction noise modelling results for residential receivers and outlines the number of receivers where the NMLs are likely to be exceeded during the day and night-time. The table also presents the number of receivers who are predicted to be highly noise affected (more than 75 dBA) for each NCA. A discussion of these results for each construction scenario is provided in Table 11-12 and shown in Annexure D of Appendix G (Technical report – Noise and vibration). Assessment of potential construction road traffic noise impacts is included separately in Section 11.3.5.

Generally, receivers in NCA2 would be the most affected by construction works around Blackheath and receivers in NCA13 the most affected by works around Little Hartley. Receivers in Mount Victoria and Kanimbla would be mostly unaffected by construction noise above NMLs, with the exception of five receivers in NCA8.

Up to 171 receivers would be noise affected at Blackheath during standard construction hours and up to 15 would be highly noise affected. Construction scenarios resulting in exceedances of the highly noise affected criteria in Blackheath include tunnelling and associated works, surface roadworks and finishing works.

Works associated with these scenarios are linear in nature and would be carried out progressively such that the duration of noise impacts experienced at any individual receiver would be substantially smaller than the total construction durations identified for each scenario. Further, these predicted impacts are conservative as they are representative of the worst case 15 minute period of construction activity, while the construction equipment is at the nearest location to each sensitive receiver location. The assessment scenario does not therefore represent the ongoing day to day noise impact at noise sensitive receivers for an extended period of time. No receivers at Blackheath would be noise affected outside of standard construction hours.

Up to 37 receivers would be noise affected at Little Hartley during standard construction hours and up to two would be highly noise affected. Up to 34 receivers would be noise affected outside of standard construction hours. While noisy work would be scheduled to be undertaken during standard hours as far as possible, other occurrences such as traffic management may be a factor in scheduling noisy work or vibration generating construction activities as out of hours work. As with construction noise predictions at Little Hartley, this assessment is representative of the worst-case 15 minute period of construction activity, while the construction equipment is at the nearest location to each sensitive receiver location with multiple pieces of plant and equipment operating at the same time. The assessed scenario does not represent the ongoing day to day noise impact at noise sensitive receivers for an extended period of time.

Given the separation distances between each of the Blackheath, Soldiers Pinch and Little Hartley construction sites it is unlikely that any one receiver would be affected by construction noise from more than one construction site.

Table 11-11 Number of residential receivers where noise levels may exceed the NMLs for all construction scenarios

Scenario	Number of residential buildings where noise levels may exceed NMLs							
	Standard construction hours			Outside of standard construction hours (night)				Highly affected
	1-10 dB[1]	11-20 dB[2]	> 20 dB[3]	1-5 dB[4]	6-15 dB[1]	16-25 dB[2]	> 25 dB[3]	> 75 dBA
NCA1 (Blackheath)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	1	0	0	-	-	-	-	0
Tunnelling and associated works	2	2	0	-	-	-	-	0
Surface roadworks	1	3	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	2	0	0	-	-	-	-	0
NCA2 (Blackheath)								
Site establishment	60	12	2	-	-	-	-	0
Tunnel portal construction	59	0	0	-	-	-	-	0

Scenario	Number of residential buildings where noise levels may exceed NMLs							
	Standard construction hours			Outside of standard construction hours (night)				Highly affected
	1-10 dB[1]	11-20 dB[2]	> 20 dB[3]	1-5 dB[4]	6-15 dB[1]	16-25 dB[2]	> 25 dB[3]	> 75 dBA
Tunnelling and associated works	94	18	4	-	-	-	-	2
Surface roadworks	112	19	5	-	-	-	-	2
Operational facilities	32	5	1	-	-	-	-	0
Finishing works	19	3	2	-	-	-	-	1
NCA3 (Blackheath)								
Site establishment	14	6	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	12	8	10	-	-	-	-	12
Surface roadworks	12	9	10	-	-	-	-	13
Operational facilities	8	2	0	-	-	-	-	0
Finishing works	9	9	1	-	-	-	-	3
NCA4 (Blackheath)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA5 (Blackheath)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA6 (Blackheath)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA7 (Blackheath)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0

Scenario	Number of residential buildings where noise levels may exceed NMLs							
	Standard construction hours			Outside of standard construction hours (night)				Highly affected
	1-10 dB[1]	11-20 dB[2]	> 20 dB[3]	1-5 dB[4]	6-15 dB[1]	16-25 dB[2]	> 25 dB[3]	> 75 dBA
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA8 (Mount Victoria)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	5	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA9 (Mount Victoria)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA10 (Mount Victoria)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA11 (Kanimbla)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	-	-	-	-	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0
NCA12 (Little Hartley)								
Site establishment	2	2	1	-	-	-	-	0
Tunnel portal construction	4	2	1	-	-	-	-	0

Scenario	Number of residential buildings where noise levels may exceed NMLs							
	Standard construction hours			Outside of standard construction hours (night)				Highly affected
	1-10 dB[1]	11-20 dB[2]	> 20 dB[3]	1-5 dB[4]	6-15 dB[1]	16-25 dB[2]	> 25 dB[3]	> 75 dBA
Tunnelling and associated works	0	2	1	8	2	1	2	1
Surface roadworks	10	0	3	-	-	-	-	1
Operational facilities	1	0	3	-	-	-	-	1
Finishing works	0	2	1	-	-	-	-	1
NCA13 (Little Hartley)								
Site establishment	11	0	0	-	-	-	-	0
Tunnel portal construction	8	0	0	-	-	-	-	0
Tunnelling and associated works	6	6	0	10	3	10	1	0
Surface roadworks	12	5	7	-	-	-	-	1
Operational facilities	1	0	0	-	-	-	-	0
Finishing works	5	6	1	-	-	-	-	0
NCA14 (Little Hartley)								
Site establishment	0	0	0	-	-	-	-	0
Tunnel portal construction	0	0	0	-	-	-	-	0
Tunnelling and associated works	0	0	0	0	0	0	0	0
Surface roadworks	0	0	0	-	-	-	-	0
Operational facilities	0	0	0	-	-	-	-	0
Finishing works	0	0	0	-	-	-	-	0

Table notes:
1. Clearly audible
2. Moderately intrusive
3. Highly intrusive
4. Noticeable

Table 11-12 Summary of the construction noise modelling results for residential receivers

Construction scenario	Potential residential receiver impact discussion
Site establishment and enabling works	• the highest noise generating equipment for this construction scenario would be an excavator with a rock hammer • NCA2 would be the most noise affected during this construction scenario • around 110 receivers during standard construction hours may experience noise levels above the NML • no receivers are expected to be highly noise affected • noise levels would be moderately intrusive at up to 20 receivers and highly intrusive at up to three receivers during standard construction hours.
Tunnel portal construction	• the highest noise generating equipment for this construction scenario would be an excavator with a rock hammer and a piling rig

Construction scenario	Potential residential receiver impact discussion
	• NCA2 would be the most noise affected during this construction scenario • around 75 receivers during standard construction hours may experience noise levels above the NML • 19 receivers are expected to be highly noise affected • noise levels would be moderately intrusive at up to two receivers and highly intrusive at one receiver during standard construction hours • as surface road upgrade works are expected to be staged, the actual number of affected receivers would be limited at any single point in time.
Tunnelling and associated works	• the highest noise generating equipment for this scenario would be an excavator • NCA2 and NCA3 would be the most noise affected during this construction scenario • this scenario is predicted to generate the greatest number of NML exceedances • around 170 receivers during standard construction hours and 37 receivers outside standard construction hours may experience noise levels above the NMLs (noting that night-time tunnelling and associated works would occur at the Little Hartley construction site only) • 15 receivers are expected to be highly noise affected • noise levels would be moderately intrusive at up to 36 receivers and highly intrusive at up to 15 receivers during standard construction hours • night-time mitigation measures would be required for around 19 receivers with perceptions ranging from ‘clearly audible’ to ‘highly intrusive’ • around 18 receivers would experience ‘noticeable’ construction noise and would require notification of night-time works.
Surface road upgrade works	• the highest noise generating equipment for this scenario would be an excavator with a rock hammer and a piling rig • NCA2, NCA3 and NCA13 would be the most noise affected during this construction scenario • around 208 receivers during standard construction hours may experience noise levels above the NMLs • 17 receivers are expected to be highly noise affected • noise levels would be moderately intrusive at up to 36 receivers and highly intrusive at up to 25 receivers during standard construction hours • as surface road upgrade works are expected to be staged, the actual number of affected receivers would be limited at any single point in time.
Operational ancillary facilities works	• the highest noise generating equipment for this scenario would be a grout mixer and pump • NCA2, NCA3 and NCA13 would be the most noise affected during this construction scenario • around 69 receivers during standard construction hours may experience noise levels above the NML • seven receivers are expected to be highly noise affected • noise levels would be moderately intrusive at up to 27 receivers and highly intrusive at up to six receivers during standard construction hours • as construction of the operational ancillary facilities works are expected to be staged, the actual number of affected receivers would be limited at any single point in time.

Construction scenario	Potential residential receiver impact discussion
Finishing works, testing and commissioning	• the highest noise generating equipment for this scenario would be dump trucks • NCA2 and NCA3 would be the most noise affected during this construction scenario • around 60 receivers during standard construction hours may experience noise levels above the NMLs • five receivers are expected to be highly noise affected • noise levels would be moderately intrusive at up to 20 receivers and highly intrusive at up to six receivers during standard construction hours • night-time mitigation measures would be required for around 150 receivers with perceptions ranging from 'clearly audible' to 'highly intrusive' • around 130 receivers would experience 'noticeable' construction noise and would require notification of night-time works.

11.3.2 Sleep disturbance

Table 11-13 presents the number of residential receivers where noise levels are predicted to exceed the sleep disturbance criteria and the awakening reaction criteria for each NCA during the tunnelling and associated works scenario.

Noise levels at around 19 residential receivers at Little Hartley in NCA12, NCA13 and NCA14 are predicted to exceed the sleep disturbance screening level during the tunnelling and associated works scenario due to use of an excavator. This includes three dwellings where noise levels exceed the awakening threshold. No exceedances of sleep disturbance screening levels are predicted for receivers at Blackheath and Mount Victoria.

Table 11-13 Number of residential receivers where noise levels may exceed sleep disturbance criteria for night works (tunnelling and associated works scenario)

Location	Number of residential buildings where noise levels may exceed the sleep disturbance screening level and/or the awakening reaction level	
	Sleep disturbance screening level $L_{A1(1\ minute)}$, dBA	Awakening reaction level $L_{A1(1\ minute)}$, dBA
NCA12 (Little Hartley)	5	2
NCA13 (Little Hartley)	14	1
NCA14 (Little Hartley)	0	0

11.3.3 Other receivers

Construction noise is not expected to exceed the NMLs at non-residential receivers.

11.3.4 Overlapping construction activities

While most construction activities within each construction site are expected to occur at distinct scheduled times and at different locations, it is possible that noisy construction activities for the project may occur at the same time in close proximity to each other. In these cases, it is possible that an increase of up to 3 dBA of the highest noise level predicted for any construction scenario may occur (assuming that at any one location equal noise levels from two construction scenarios are experienced). Given the separation distances between each of the three construction sites it is unlikely that any one receiver would be affected by construction noise from more than one construction site.

11.3.5 Construction road traffic noise

For the purposes of the construction road traffic noise assessment, the following assumptions have been made to develop a worst case construction traffic scenario:

- all construction sites would be operational at the same time
- all construction vehicles would be on the road network at the same time (representing a worst case construction traffic noise scenario)
- other non-project traffic volumes are based on forecast traffic flows for 2026 prior to the project being constructed.

Construction road traffic noise would be generated by vehicles associated with the construction of the project, including heavy vehicles transporting spoil and light vehicle movements generated by construction workers.

The estimated peak and average vehicle movements required for construction are outlined in Section 4.6 of Appendix G (Technical report – Noise and vibration). Construction is expected to result in about 1,180 light vehicles and 900 heavy vehicles per day, during peak construction periods and about 460 light vehicles and 320 heavy vehicles per day, during average construction periods.

Daytime movements

A summary of the forecast 2026 traffic volumes, the additional traffic contributed by construction of the project, and the resultant relative change in noise levels for daytime construction traffic movements for peak and average construction periods are presented in Table 11-14 and Table 11-15 respectively.

These findings indicate that daytime average and peak construction traffic scenarios would not result in relative increases of more than 2 dBA and therefore construction traffic is expected to be barely or not perceptible at all to noise sensitive receivers.

Table 11-14 Forecast 2026 traffic volumes and additional (project) traffic during peak construction, and relative noise level change – daytime

Location	Route/direction	2026 traffic (hourly)		2026 additional project traffic (hourly)		Relative noise increase dBA
		Light	Heavy	Light	Heavy	
Blackheath	Great Western Highway east of Evans Lookout Road	507	65	43	2	0.3
	Great Western Highway west of Ridgewell Road	870	129	53	9	0.3
Soldiers Pinch and Mount Victoria	Great Western Highway east of Harley Avenue	761	129	50	18	0.5
	Great Western Highway west of Mount York Road	670	120	51	23	0.6
Little Hartley	Great Western Highway east of Coxs River Road	605	114	23	56	1.2
	Great Western Highway west of Coxs River Road	294	56	14	45	1.7

Table 11-15 Forecast 2026 traffic volumes and additional (project) traffic during average construction, and relative noise level change – daytime

Location	Route/direction	2026 traffic (hourly)		2026 additional project traffic (hourly)		Relative noise increase dBA
		Light	Heavy	Light	Heavy	
Blackheath	Great Western Highway east of Evans Lookout Road	507	65	17	1	0.1
	Great Western Highway west of Ridgewell Road	870	129	20	3	0.1
Soldiers Pinch and Mount Victoria	Great Western Highway east of Harley Avenue	761	129	20	5	0.1
	Great Western Highway west of Mount York Road	670	120	20	6	0.2
Little Hartley	Great Western Highway east of Coxs River Road	605	114	9	19	0.5
	Great Western Highway west of Coxs River Road	294	56	6	16	0.7

Night-time movements

A summary of the forecast 2026 traffic volumes, the additional traffic contributed by construction of the project, and the resultant relative change in noise levels for night-time construction traffic movements for peak and average construction periods are presented in Table 11-16 and Table 11-17 respectively.

Increases in road traffic noise of greater than 2 dBA (2.2 dBA and 2.6 dBA) have been identified west of the Little Hartley construction site access on the Great Western Highway for the night-time peak construction traffic volume scenario. These relative increases in noise are associated with traffic movements to and from the Little Hartley construction site. No exceedances are expected in the night-time average construction traffic volume scenario.

As discussed above, both the average and peak construction traffic scenarios are conservative and worst case, noting the assumptions that all construction sites would be operational at the same time, and all construction vehicles would be on the road network at the same time. In practice, these assumptions are unlikely to occur, and as such, the peak construction scenario represents an overestimate of potential traffic noise impacts. In the unlikely event that peak construction activities occur at the same time, it is anticipated that it would be for a short duration. The overall noise impact of construction traffic would be somewhere between the predicted relative increases associated with average construction volumes and peak construction volumes. Additionally, there are a limited number of receivers at this section of the proposed access roads that would be affected by this relative noise increase due to the low density of receivers located along the Great Western Highway near the Little Hartley construction support site.

Table 11-16 Forecast 2026 traffic volumes and additional (project) traffic during peak construction, and relative noise level change – night-time

Location	Route/direction	2026 traffic (hourly)		2026 additional project traffic (hourly)		Relative increase dBA
		Light	Heavy	Light	Heavy	
Blackheath	Great Western Highway east of Evans Lookout Road	34	15	15	1	0.6
	Great Western Highway west of Ridgewell Road	58	29	60	2	1.1
Soldiers Pinch and Mount Victoria	Great Western Highway east of Harley Avenue	51	29	55	4	1.2
	Great Western Highway west of Mount York Road	45	27	51	6	1.3
Little Hartley	Great Western Highway east of Coxs River Road	40	26	48	15	2.2
	Great Western Highway west of Coxs River Road	20	13	5	12	2.6

Table 11-17 Forecast 2026 traffic volumes and additional (project) traffic during average construction 2026 – night-time

Location	Route/direction	2026 traffic (hourly)		2026 additional project traffic (hourly)		Relative increase dBA
		Light	Heavy	Light	Heavy	
Blackheath	Great Western Highway south of Evans Lookout Road	34	15	6	0	0.2
	Great Western Highway west of Ridgewell Road	58	29	23	1	0.4
Mount Victoria	Great Western Highway east of Harley Avenue	51	29	20	1	0.4
	Great Western Highway west of Mount York Road	45	27	20	1	0.4
Little Hartley	Great Western Highway south of Coxs River Road	40	26	19	5	0.9
	Great Western Highway north of Coxs River Road	20	13	2	4	1.0

11.3.6 Construction vibration

Minimum working distances

Construction vibration may be generated due to the vibration intensive plant and equipment being used during some stages of the project. To achieve the vibration criteria identified in Table 11-1, a series of minimum working distances have been calculated for various vibration intensive plant and equipment. The minimum working distances are detailed in Section 4.7 of Appendix G (Technical report – Noise and vibration).

If these minimum working distances are complied with, no adverse impacts from vibration intensive works are likely in terms of human response or cosmetic damage to buildings. Equipment size would be selected by the construction contractor and would take into account the minimum working distances (i.e. the distance between the vibration intensive plant and equipment used in a particular construction site and the nearest receiver/ building). If vibration intensive works are

required within these minimum working distances, mitigation measures to control excessive vibration would be implemented as outlined in Section 11.5.

The most vibration intensive equipment anticipated to be used during construction would be a large hydraulic hammer. Use of a large hydraulic hammer at the nearest point to sensitive receiver locations has identified approximately eight residential receivers and four sheds where vibration could exceed the cosmetic damage criteria, and 30 residential receivers and five sheds where the human comfort criteria could be exceeded. The NCAs that these receivers fall into are presented in Table 11-18.

Table 11-18 Number of receivers within minimum working distances

NCA	Cosmetic damage	Human response
NCA1 (Blackheath)	-	-
NCA2 (Blackheath)	1	4
NCA3 (Blackheath)	6	19
NCA4 (Blackheath)	-	-
NCA5 (Blackheath)	-	-
NCA6 (Blackheath)	-	-
NCA7 (Blackheath)	-	-
NCA8 (Mount Victoria)	-	-
NCA9 (Mount Victoria)	-	-
NCA10 (Mount Victoria)	1 (4 sheds)	3 (4 sheds)
NCA11 (Kanimbla)	-	4 (1 shed)
NCA12 (Little Hartley)	-	-
NCA13 (Little Hartley)	-	-
NCA14 (Little Hartley)	-	-

Both the Rosedale (Lithgow LEP, I024) and the Nioka (Lithgow LEP, I025) heritage items are around 30 to 40 metres from the Little Hartley construction site when measured from boundary to boundary. However, the heritage buildings/ structures associated with these items are slightly further away from the construction site (around 70 to 80 metres for Nioka, and around 60 to 70 metres for Rosedale). Use of a large hydraulic hammer at the boundary of the Little Hartley construction site would be at the limit of the minimum working distance from the Rosedale homestead, and there would be potential, although a very low risk, of cosmetic damage to the homestead under these circumstances. Specific mitigation measures to address this risk have been identified as part of the non-Aboriginal heritage assessment presented in Chapter 17 and Appendix M (Technical report – Non-Aboriginal heritage).

Heritage items within 60 metres of the Soldiers Pinch and Blackheath construction sites (refer to Section 11.2.3) do not include heritage buildings or structures, and potential damage due to construction vibration would not arise at those locations.

Vibration from tunnelling

Vibration associated with the use of TBMs has been considered for properties located above the tunnel alignment. It has been assumed that two TBMs would be operating concurrently for the purpose of this assessment. The number of receivers where the human comfort criteria is exceeded is provided in Table 11-19 and shown in Annexure G of Appendix G (Technical report – Noise and vibration). The structural damage criteria would not be exceeded by the tunnelling activities. The preferred and maximum criteria relate to how sensitive people may be to the vibration generated.

Table 11-19 Vibration – number of receivers where the human comfort criteria are exceeded

Criteria	Human comfort peak particle velocity criteria		Number of receivers where human comfort criteria is exceeded	
	Evening	Night-time	Evening	Night-time
Preferred	0.28 mm/s	0.2 mm/s	76	149
Maximum	0.56 mm/s	0.4 mm/s	18	32

Tunnelling would progress at a rate of around 70 to 90 metres per week. It is likely that vibration would be discernible for up to five days at each affected receiver with potential exceedances occurring for up to around two days. Tunnelling advance rates would reduce around the portals, which may increase the duration of exposure for receivers in these areas. As tunnelling moves towards and away from each receiver the vibration levels experienced would increase and decrease respectively.

Tunnelling vibration has also been assessed at the heritage items identified in Section 11.2.3. Only three heritage items are expected to experience vibration from project tunnelling:

- the north east corner of the Blackheath West Heritage Conservation Area (Blue Mountains LEP, BH214) would experience peak particle vibration of ≤2.8 mm/s. This is less than the minimum vibration criterion (3 mm/s at 10Hz, building foundation) specified in the guidelines listed in Table 11-1
- a small area in the south west corner of the Ban Tigh, Brewery site and Garden (Blue Mountains LEP BH060) would experience peak particle vibration of >3 mm/s, however the part of this heritage item that would be affected by vibration is not occupied by a heritage building or structure
- a small area in the south east corner of the Osborne Cottage (site only) (Blue Mountains LEP, BH039), would experience peak particle vibration of >3 mm/s, however this heritage item does not include heritage buildings or structures.

Vibration generated by project tunnelling would therefore not affect the structural integrity or pose a risk of cosmetic damage to heritage buildings or structures.

11.3.7 Ground-borne noise

Ground-borne noise occurs when vibration is generated and propagated through the ground, and ‘breaks out’ as audible noise when the vibration reaches the ground surface at a building or other enclosed space. Ground-borne noise may be generated by the operation of TBMs during construction. The use of roadheaders to construct tunnel cross passages would generate less vibration than TBMs and would therefore cause lower levels of ground-borne noise.

The ground-borne noise assessment results are provided in Table 11-20 and are shown in Annexure G of Appendix G (Technical report – Noise and vibration). Receivers located at Blackheath (between Evans Lookout Road and Radiance Avenue) and one receiver at Little Hartley are predicted to experience ground-borne noise levels which exceed the ground-borne noise criteria. This is because these receivers are near shallower sections of the tunnel closer to the tunnel portal.

Table 11-20 Ground-borne noise – number of receivers where the criteria are exceeded

Ground-borne noise criteria	Exceedance of criteria, dBA		
	<10	10-20	>20
Evening – 40 dBA	109	18	0
Night-time – 35 dBA	259	35	0

Tunnelling would progress at a rate of around 70 to 90 metres per week. It is likely that ground-borne noise would be discernible for up to five days at each affected receiver with potential exceedances occurring for up to around two days. Tunnelling advance rates would reduce around the portals, which may increase the duration of exposure for receivers in these areas. As tunnelling moves towards and away from each receiver the noise levels experienced would be increasing and decreasing respectively.

It is noted that there is no daytime criterion for ground-borne noise. However, ground-borne noise is likely to be masked during the daytime due to higher levels of ambient airborne noise and daytime noise levels would be consistent with predicted levels at evening and night-time.

11.3.8 Blasting

Controlled blasting may be undertaken (if required) at cross passage locations along the length of the tunnel at depths greater than 25 metres where the geology is more stable. Blasting methods can reduce exposure to noise and vibration for residents and businesses above the tunnels and can also shorten excavation timeframes. The exact location and depths of blasting would be confirmed during design development.

Impacts created by blasting are largely dependent on the blast methodology, including the size of the charge, spaces between charge and timing between charges which results in a large variability in the vibration generated by a blast. The maximum charge sizes have been calculated to meet the human comfort criterion for sensitive structures such as residential theatres and schools and are outlined in Section 4.9 of Appendix G (Technical report – Noise and vibration). The criteria for structural vibration limits and ranges of human perception to vibration from blasting activities are presented in Table 3-13 and Table 4-18 of Appendix G (Technical report – Noise and vibration) respectively. The structural vibration criteria are higher than the human comfort limit adopted for sensitive structures due to blasting.

Even if the criteria are met it is likely that some nearby residents may experience ground borne noise and vibration for around 15 seconds during each blast.

Prior to blasting activities, a certified blast engineer would carry out small-scale controlled trial blasts to confirm how the local ground conditions respond to controlled blasting. Following this a Controlled Blast Management Plan would be prepared. The blasts would be designed to meet the blast criteria specified in Section 3.5.1 of Appendix G (Technical report – Noise and vibration).

11.3.9 Water supply

The preferred option for water supply for the project includes a new pipeline (around 14 kilometres in length) between Lithgow to Little Hartley. Construction of the water supply pipeline would take around 18 months to complete and would generally occur during standard construction hours, however due to the nature of the roads along the selected route, some locations may require night works to avoid traffic impacts associated with road closures during the day.

Noise logging conducted along the Great Western Highway indicates that background noise levels during standard construction hours are expected to be relatively high along the proposed pipeline route, and therefore noise impacts are not expected to be significant at receivers next to the alignment. Where background noise levels are lower at receivers located at greater distances from the alignment construction noise levels would also be reduced due to distance loss.

Where out of hours work is required, the out of hours works procedure developed as part of the Construction Noise and Vibration Management Plan (CNVMP) would be followed. Equipment required may include: backhoe, front end loader, jackhammer, dump truck, diamond saw, concrete truck, low loader, compressor, generator, vacuum truck, excavator and rock breaker. Sound power levels for this equipment are presented in Table 4-4 of Appendix G (Technical report – Noise and vibration) and result in an overall sound power level of 120 dBA. Construction may occur concurrently at several locations along the route and construction activities would move progressively along the pipeline route. Key construction activities are outlined in Chapter 5 (Construction).

The progressive nature of the works means that no one receiver is expected to be impacted by more than around three weeks at a time, and therefore a quantitative assessment of the works is not required in accordance with the ICNG (DECC, 2009). Potential construction noise impacts associated with the water supply pipeline have been calculated using Transport's *Construction and Maintenance Noise Estimator Tool* to determine distance buffers for additional noise mitigation measures. Additional mitigation measures are recommended by the construction and maintenance noise estimator and typical distances from the work where they should be applied.

This assessment is provided in Section 4.10 of Appendix G (Technical report – Noise and vibration). Where an exceedance of the construction NML is identified, additional noise mitigation measures are proposed (refer to Table 4-20 of Appendix G (Technical report – Noise and vibration). Additional mitigation measures may include providing a respite period, alternative accommodation, individual briefings and other measures where required. Further assessment may be required during ongoing design development, particularly if out of hours works are proposed for the water supply connection.

Vibration impacts to nearby residential receivers are expected to be minimal provided that the minimum working distances outlined in Section 11.3.6 are maintained.

11.4 Potential impacts – operation

11.4.1 Road traffic noise

Operational road traffic noise levels have been predicted for the 2030 and 2040 'without project' and 'with project' scenarios (see Section 11.1.3). Noise modelling results are provided in Annexure H and Annexure I of Appendix G (Technical report – Noise and vibration) and have been summarised as follows:

- the 'Design Year' (2040) would result in reduced noise levels at a large number of sensitive receivers where the tunnel provides an alternative to the existing surface road
- road traffic noise levels are predicted to exceed the L_{Aeq} controlling noise criterion at a total of 30 sensitive receivers which are primarily located in proximity to the surface works components of the project at Blackheath and Little Hartley. Of these:
  - noise levels are predicted to increase by more than 2 dBA at one sensitive receiver (2200 Great Western Highway, Little Hartley)
  - for the majority of sensitive receivers, noise levels are predicted to increase by less than 2 dBA
  - noise levels are predicted to equal or exceed the cumulative limit at two sensitive receivers in Little Hartley (ie ≥ $L_{Aeq(15\ hr)}$ or $L_{Aeq(9\ hr)}$ noise criterion + 5 dBA)
  - no noise sensitive receivers have been identified as being acutely affected (i.e. ≥ $L_{Aeq(15\ hr)}$ 65 dBA or $L_{Aeq(9\ hr)}$ 60 dBA)
- two sensitive receivers located on the Great Western Highway at Little Hartley would be eligible for the consideration of feasible and reasonable noise mitigation measures as the noise levels at these receivers exceed the cumulative noise limit. The location of these receivers is shown in Annexure J of Appendix G (Technical report – Noise and vibration) and include:
  - 2209 Great Western Highway, Little Hartley
  - 2200 Great Western Highway, Little Hartley (this receiver has previously been identified for operational noise treatment as part of the Little Hartley to Lithgow Upgrade).

For these receivers, noise barriers are unlikely to be reasonable given that the receivers are not located in groups of four or more (in accordance with the Noise Mitigation Guideline (Transport for NSW, 2015a)). The use of a low noise pavement, such as Open Graded Asphalt (OGA), may provide a reduction of around 3 dBA. This option may reduce the need for at-receiver noise

treatments and would be investigated as the design develops, taking into account whole-of-life engineering considerations and the overall social, economic and environmental effects.

Noise levels would reduce at around 2,000 residential receivers adjacent to the existing Great Western Highway, where the tunnel provides an alternative to the existing surface road. This is due to the reduced traffic volumes and heavy vehicle percentages that would use the existing Great Western Highway as a result of the project. In the 2040 'without project' daytime scenario, it is predicted that 18,416 vehicles (14 per cent heavy vehicles) would use the Great Western Highway, west of Evans Lookout Road. This is predicted to reduce to 8,800 vehicles, (six per cent heavy vehicles) in the 2040 'with project' daytime scenario. In the 2040 'without project' night-time scenario, it is predicted that 1,507 vehicles (35 per cent heavy vehicles) would use the Great Western Highway, west of Evans Lookout Road. This is predicted to reduce to 663 vehicles (17 per cent heavy vehicles) in the 2040 'with project' daytime scenario.

11.4.2 Maximum noise level assessment

Maximum noise levels are generally caused by truck engine braking events due to changes in gradient, and/or the presence of intersections, however loud exhausts and horns may also contribute. Maximum noise level events have been considered at NL3 - 89 Great Western Highway, Blackheath and at NL10 – 2133 Great Western Highway, Little Hartley. These locations are considered to be representative of receivers along the surface road components of the project.

Figure 11-2 provides a summary of the existing typical and maximum number of maximum noise level events recorded over the measurement period at NL3 – 89 Great Western Highway, Blackheath, which is located around 45 metres to the west of the railway line. The existing maximum noise levels at this location were typically between 67 and 80 dBA. While the area is largely controlled by road traffic noise, it cannot be confirmed that noise associated with each maximum noise level is attributable to road traffic. Other noise sources may include the operation of the nearby railway. Figure 11-2 indicates that the area is already exposed to maximum noise level events that have the potential for awakening reactions.

Figure 11-3 provides a summary of the existing typical and maximum number of maximum noise level events recorded over the measurement period at 2133 Great Western Highway, Little Hartley. Maximum noise levels were typically between 65 to 70 dBA. While the area is controlled by road traffic noise, it cannot be confirmed that noise associated with each maximum noise level is attributable to road traffic, other sources may include local fauna.

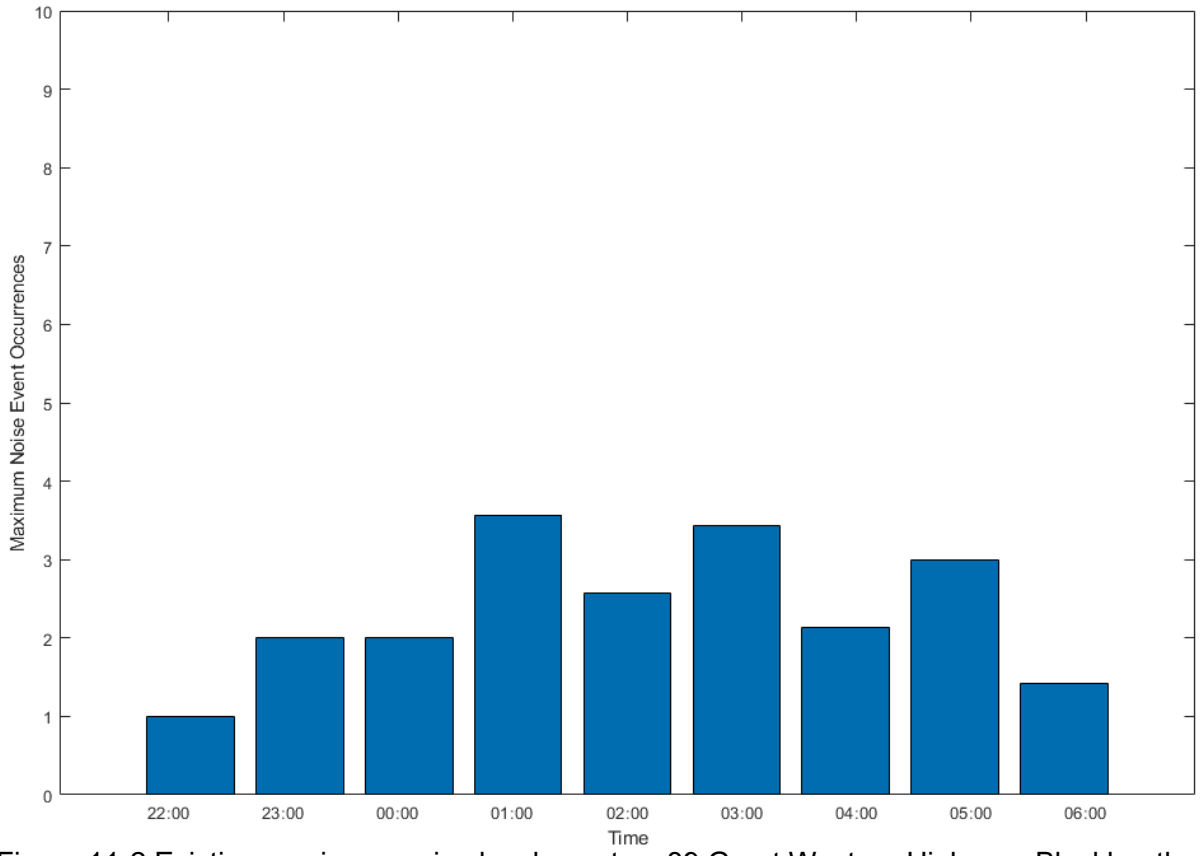

Figure 11-2 Existing maximum noise level events – 89 Great Western Highway, Blackheath

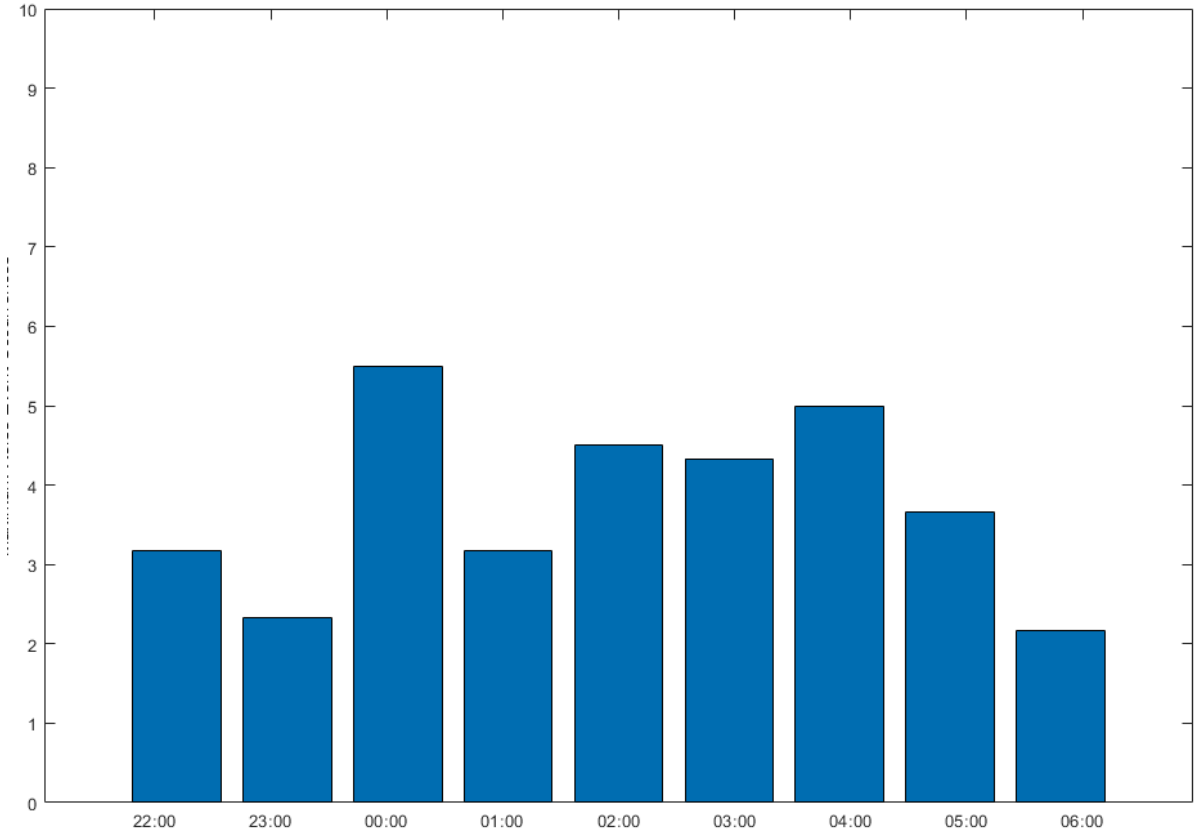

Figure 11-3 Maximum noise level events – 2133 Great Western Highway, Little Hartley

The current gradient of the existing Great Western Highway at Mt Victoria exceeds 10 per cent and is a key area for maximum noise events associated with heavy vehicle braking, particularly in a westbound (downhill) direction. The project would reduce heavy vehicle movements along the

existing Great Western Highway, proving a more efficient tunnel alternative, thereby reducing the frequency of maximum noise events at the surface.

In the 2040 'without project' night-time scenario, it is predicted that 1,507 vehicles would use the Great Western Highway west of Evans Lookout Road, whereas this would reduce to 663 vehicles in the 2040 'with project' scenario westbound of the Blackheath portal on the existing Great Western Highway alignment. The number of vehicles using the Great Western Highway eastbound of the Blackheath portal is predicted to increase from 19,081 in the 'without project' night-time scenario to 23,320 for the 'with project' night-time scenario in 2040. The number of vehicles using the Great Western Highway west of Little Hartley is predicted to increase from 11,974 in the 'without project' scenario to 14,092 for the 'with project' scenario in 2040.

Given that a substantial proportion of traffic would use the tunnel, there would be an anticipated reduction in the number of maximum noise events that would affect residential receivers between Blackheath and Little Hartley. Receivers located directly to the east of the Blackheath portals and west of the Little Hartley portals may experience higher road traffic noise levels due to a general increase in traffic volumes. However due to reduced congestion and improved gradient and alignment, the number of maximum noise events (and maximum noise levels generally) would likely be reduced.

11.4.3 Fixed facilities noise

The key fixed facilities forming part of the project that would emit noise would include:

- ventilation equipment (for both the ventilation outlet design option and the portal emissions design option)
- substations (including at Little Hartley)
- water treatment plant
- emergency pumps
- operational ancillary facilities (including the tunnel operations facility at Blackheath).

The arrangement of fixed facilities for the project are shown in Chapter 4 (Project description). Most of this equipment would be located within the tunnel itself, or directly adjacent to the tunnel portals at Blackheath and Little Hartley.

An overview of the fixed facility noise model scenarios is presented in Table 11-21. The sound power levels under these conditions are provided in detail in Section 5.1 of Appendix G (Technical report – Noise and vibration). The fixed facility noise assessment has considered the operation of the project under normal traffic conditions, low speed traffic conditions and emergency operating conditions and has considered these traffic scenarios for the two ventilation design options.

For each ventilation design option, the worst-case operational conditions have been assumed whereby all equipment and plant are operating simultaneously during the most stringent night-time period.

Table 11-21 Operational infrastructure - noise model night-time scenarios

Scenario	Ventilation design option	Ventilation scenario	Ventilation noise sources	Other noise sources
1	Portal emissions	Normal traffic	0 jet fans operating eastbound 0 jet fans operating westbound	Water treatment plant, workshop activities, carpark noise, substation
2		Low flow traffic	135 jet fans operating eastbound 53 jet fans operating westbound	

Scenario	Ventilation design option	Ventilation scenario	Ventilation noise sources	Other noise sources
3		Emergency	66 jet fans operating eastbound 75 jet fans operating westbound	Water treatment plant, workshop activities, carpark noise, substation, emergency pump exhaust
4	Ventilation outlet	Normal traffic	1 jet fan operating eastbound 1 jet fan operating westbound 5 axial fans operating in each ventilation building	Water treatment plant, workshop activities, carpark noise, substation
5		Low flow traffic	136 jet fans operating eastbound 54 jet fans operating westbound 5 axial fans operating in each ventilation building	
6		Emergency	67 jet fans operating eastbound 75 jet fans operating westbound 5 axial fans operating in each ventilation building	Water treatment plant, workshop activities, carpark noise, substation, emergency pump exhaust

The detailed fixed facility noise modelling results are provided in Section 5.2 of Appendix G (Technical report – Noise and vibration). These results are summarised in Table 11-22.

Table 11-22 Fixed facilities noise modelling results

Scenario	Ventilation design option	Scenario	Number of receivers experiencing noise criteria exceedances	
			At Blackheath	At Little Hartley
1	Portal emissions	Normal traffic	1 (exceedance up to 1 dBA)	0
2		Low flow traffic	1 (exceedance up to 1 dBA)	0
3		Emergency	14 (exceedances up to 4 dBA)	0
4	Ventilation outlet	Normal traffic	3 (exceedances up to 1 dBA)	2 (exceedances up to 2 dBA)
5		Low flow traffic	4 (exceedances up to 2 dBA)	4 (exceedances up to 4 dBA)
6		Emergency	19 (exceedances up to 5 dBA)	4 (exceedances up to 4 dBA)

Exceedances in the ventilation outlet design option are mainly due to jet fans located near the Blackheath and Little Hartley exit portals (used to force exhaust gases against the flow of traffic). To reduce the noise levels emanating from the tunnel portals, quieter jet fans could be used or the use of attenuators could be investigated. In addition to this, most exceedances would occur under emergency scenarios, where traffic flow would be reduced or stopped completely. For these scenarios, most exceedances at Blackheath are caused by the emergency pump exhaust which would operate under emergency conditions only. The portal ventilation option would lead to exceedances at a lower number of neighbouring properties with overall lower noise impact.

Besides the fire pump driver located at Blackheath, all other non-ventilation related operational equipment and activities are not expected to impact on noise sensitive receivers located near to the operational facilities.

11.5 Environmental mitigation measures

This section outlines the relevant performance outcomes and mitigation measures to be implemented to manage potential noise and vibration associated with the project. Development of the mitigation measures has considered feedback collected during community engagement undertaken during preparation of the environmental impact statement (EIS). The key issues raised by the community including those related to potential noise and vibration impacts, and where these issues are addressed in the EIS are outlined in Appendix C (Community engagement).

The mitigation measures below describe how specific mitigation measures would be designed in consultation with the community, particularly affected sensitive receivers. Tailored mitigation measures would be confirmed during ongoing design development and detailed construction planning and would be developed in consultation with affected receivers.

The below measures are expected to control the potential impacts from the project as far as practicable. Residual impacts are, however, expected to remain, particularly when noise or vibration intensive activities are being carried out near sensitive receivers. Residual impacts would be evaluated during further design development and would be mitigated using the processes identified in the CNVMP.

11.5.1 Performance outcomes

Performance outcomes have been developed that are consistent with the SEARs for the project. The performance outcomes for the project are summarised below in Table 11-23 and identify measurable, performance-based standards for environmental management.

Table 11-23 Performance outcomes for the project – noise and vibration

SEARs desired performance outcome	Project performance outcome	Timing
Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on acoustic amenity, and adverse impacts on the structural integrity of buildings and items including Aboriginal places and environmental heritage. Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community. Increases in noise emissions and vibration affecting environmental heritage as defined in the *Heritage Act 1977* during operation of the project are effectively managed.	Construct the project to avoid or minimise exceedances of applicable noise management levels. If exceedances of noise management levels cannot be reasonably and feasibly avoided, develop and apply situation-specific construction noise mitigation and management measures.	Construction
	Construct the project to avoid or minimise exceedances of applicable structural integrity (including for sensitive structures and heritage items) and human comfort vibration standards. If exceedances of vibration standards cannot be reasonably and feasibly avoided, develop and apply situation-specific vibration mitigation and management measures.	Construction
	Design the project to minimise the magnitude and extent of material adverse changes to road traffic noise (≥2dB(A)) at existing sensitive receiver locations during operation of the project.	Design

11.5.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential noise and vibration impacts as a result of the project are detailed in Table 11-24. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 11-24 Environmental mitigation measures – noise and vibration

ID	Mitigation measure	Timing
NV1	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared as part of the Construction Environmental Management Plan (CEMP) in consultation with relevant stakeholders. The CNVMP will be prepared consistent with the *Construction Noise and Vibration Guideline (for Road and Maritime Works)* (Transport for NSW, 2022b) and will include: • identification of potentially significant noise and vibration generating construction activities and locations based on detailed design and construction planning, and associated potentially affected noise and vibration sensitive receivers • details of construction noise management levels and vibration goals applicable to each sensitive receiver or group of receivers • identification of feasible and reasonable measures to be implemented during construction to minimise noise and vibration impacts, such as working hours, staging, placement and operation of work sites, parking and storage areas, temporary noise barriers, haul road maintenance and controlling the location and use of vibration generating equipment • details of specific measures to be applied in circumstances where construction noise management levels and/ or vibration goals will not be met at noise sensitive receivers • a monitoring program to monitor and assess the performance of construction activities against the applicable construction noise management levels and vibration goals • arrangements for consultation with potentially affected noise and vibration sensitive receivers, including notifications of planned construction works and complaint handling procedures • a procedure for considering and managing construction activities outside standard construction hours, including approval processes, activity planning and scheduling, receiver notification and engagement procedures, and mitigation and management measures.	Construction
NV2	The procedure for considering and managing construction activities outside standard construction hours (refer to NV1) will consider activities that will be carried out 24 hours per day, seven days per week, including: • underground construction, including tunnel boring machine and roadheader tunnelling methodology and construction of roads and other infrastructure within tunnels • spoil handling within the tunnels and acoustic shed • spoil haulage • tunnel fit-out including mechanical and electrical fit-out • mechanical and electrical fit-out of operational buildings • emergency work.	Construction

ID	Mitigation measure	Timing
NV3	Noise sensitive receivers likely to be affected by noise or vibration in excess of the applicable construction noise management level or vibration threshold will be notified of the relevant construction activities prior to the commencement of those activities. The notification will include details of: • the relevant construction activities • the anticipated construction period and construction hours • contact information for a construction management stakeholder interface • complaint and incident reporting and how to obtain further information. Feedback provided by affected noise sensitive receivers will be considered when developing a final mitigation strategy to manage construction noise impacts.	Construction
NV4	Construction activities at Blackheath and Soldiers Pinch will be carried out during standard construction hours where feasible and reasonable. Construction activities with the potential to generate high noise levels (75 dB(A) L_{Aeq} at receiver) and/or vibration levels will be scheduled during less sensitive time periods where feasible and reasonable. Any construction activity carried out outside standard construction hours at Blackheath and Soldiers Pinch will be subject to the out of hours construction activity procedure detailed in the CVNMP, including consultation with the affected local community.	Construction
NV5	Following detailed design, the owners of properties identified for architectural treatment to mitigate operational traffic noise impacts will be consulted in relation to the potential early application of architectural treatments in cases where those properties are also likely to experience construction noise impacts in excess of applicable construction noise management levels. If agreed with the property owner, the architectural treatment will be applied as early as possible to mitigate construction noise impacts.	Design and construction
NV6	Construction activities will be planned and carried out to minimise noise and vibration impacts on sensitive receivers. Where relevant, this may include application of the following types of measures to individual construction sites and activities: • construction sites will be configured to maximise the distance and/ or provide shielding between noisy plant and equipment and sensitive receivers, where feasible and reasonable • site sheds, earth bunds and hoarding will be positioned to provide shielding between noisy plant and equipment and sensitive receivers, where feasible and reasonable • materials/ deliveries will be loaded and unloaded as far as practicable from sensitive receivers, and/ or loading/ unloading areas will be shielded • construction sites will be configured to minimise the need for reversing vehicles, particularly for regular/ repeatable movements • non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on construction vehicles and mobile plant regularly used on site	Design and construction

ID	Mitigation measure	Timing
	• vibration intensive equipment will be selected based on the structural damage minimum working distances. The use of less vibration intensive methods of construction or equipment will be considered where feasible and reasonable.	
NV7	Where the use of vibration intensive equipment within the relevant minimum working distance from a building or structure cannot be avoided, a detailed inspection of the building or structure will be carried out prior to the commencement of the vibration intensive work. A written and photographic report will be prepared to document the condition of building or structure, and a copy of the report will be provided to the relevant landowner or land manager.	Construction
NV8	A framework will be developed and implemented for coordinating construction planning and traffic management with adjacent Great Western Highway upgrade projects to minimise potential cumulative construction noise and vibration impacts where practicable.	Design and construction
NV9	During detailed design, options to minimise jet fan break out noise from tunnel portals (such as jet fan selection or use of noise attenuation devices) would be investigated, with the aim of not exceeding applicable controlling noise criteria at affected receivers where feasible and reasonable.	Design
NV10	Within 12 months of commencement of operation of the project, a post-construction operational compliance assessment will be carried out in accordance with Chapter 6 of *Road Noise Model Validation Guideline* (Transport for NSW, 2022e).	Operation